BIOARCHAEOLOGICAL ANALYSIS OF TRAUMA AT SMITH'S KNOLL

BIOARCHAEOLOGICAL ANALYSIS OF TRAUMA IN A SKELETAL SAMPLE FROM SMITH'S KNOLL HISTORIC CEMETERY

By LAURA LOCKAU, B.A.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree Master of Arts

McMaster University MASTER OF ARTS (2012) Hamilton, Ontario (Anthropology)

TITLE: Bioarchaeological Analysis of Trauma in a Skeletal Sample From Smith's Knoll Historic Cemetery

AUTHOR: Laura Lockau, B.A. (University of Alberta)

SUPERVISOR: Professor M.B. Brickley

NUMBER OF PAGES: xi, 254

Abstract

The Smith's Knoll collection is composed of the disarticulated, fragmentary, and commingled remains of battle dead from the War of 1812. Historical and archaeological context of this site can be well established, making it particularly valuable in helping to unveil the conditions experienced by individuals in the past. In this thesis, the Smith's Knoll collection was analyzed for evidence of postcranial perimortem traumatic skeletal lesions. Further context for these injuries was provided through comparison with contemporaneous skeletal and surgical collections, historical documentary sources, and other bioarchaeological studies on violence and warfare in the past.

Injuries associated with fractures, sharp force, and musket trauma were observed in the postcranial elements of the collection. Although the overall prevalence of lesions is low, the majority of observed lesions can be attributed to sharp force trauma. Sharp force injuries are present in fourteen of the ribs as well as one fibula, one femur, one carpal, one vertebra, and one ulna. Musket injuries are present in three innominates and one scapula, and perimortem fractures are present in one rib and one scapula. The sharp force injuries can be further differentiated into those most likely caused by the bayonet, found in the torso, and those most likely caused by the sword, found in the extremities. Musket trauma is present in the form of impact from both musket balls and buckshot. Importantly, this is the first study to identify buckshot lesions on archaeological skeletal material.

The results of the analysis of Smith's Knoll demonstrate the value of examining postcranial lesions in relation to violence in the past, which has frequently been overlooked in bioarchaeology. As well, this collection illustrates that fragmented, disarticulated, and commingled collections, despite their limitations, have much to contribute to knowledge of interpersonal violent conflicts, both in prehistory and in the more recent past.

Acknowledgements

I would like to thank my supervisor, Dr. Megan Brickley, for the opportunity to complete this project. Thank you to my committee: to Dr. Tracy Prowse for her valuable comments and suggestions, and to Dr. Ann Herring for her excellent input.

Many thanks to Keyence Corporation for the loan of the digital microscope used to complete my microscopic analyses. Thank you to the City of Hamilton, Planning and Economic Development Department, Tourism and Culture Division, for providing funding for the cataloguing and re-analysis of the Smith's Knoll skeletal collection.

Thank you to all of those who assisted in the research process, especially Ana-Maria Dragomir, Madeleine Mant, and Rebecca Gilmour for their cataloguing assistance, and Lelia Watamaniuk for her database wizardry. I would like to thank all of those who assisted with the experimental work completed as part of this project, including those mentioned above as well as Lori D'Ortenzio, Ron Dale with Parks Canada, the staff at Fort George, and the members of the Niagara Regional Sportsmen's Gun Club.

I would also like to acknowledge the funding I received from the Social Sciences and Humanities Research Council and the Ann Poucher Windsor Queen Elizabeth II Graduate Scholarship in Science and Technology, both of which greatly assisted me in the completion of this project.

I am grateful to my parents, Jim and Janet Lockau, for their assistance and encouragement. I would also like to express my gratitude to the members of my graduate student cohort for all of their support, and for being such amazing friends and colleagues. Thanks to KB, LW, AN, MM, RS, ME, MG, MB, KC, JS, and especially Kyle.

TABLE OF CONTENTS

Abstract iii
Acknowledgements iv
Table of Contents v
List of Tables viii
List of Figures ix
Declaration of Academic Achievement xi

Chapter 1: Introduction **1**
Chapter 2: Materials **6**
2.1 The Smith's Knoll Skeletal Sample 6
2.2 Previous Analyses (1998, 2000) 9
2.3 Current Analysis (2011) 12
Chapter 3: Bioarchaeological Trauma Studies **16**
3.1 Establishing timing of the injury in relation to death 18
3.2 Determining proximate cause 27
3.2.1 Fractures 28
3.2.2 Blunt force trauma 30
3.2.3 Sharp force trauma 30
3.2.4 Projectile trauma 32
3.3 Determining ultimate behavioral cause 34
3.4 Sources of bias 38
3.5 Bioarchaeological analyses of battle-related trauma in 19th century North American contexts 43
Chapter 4: The Battle of Stoney Creek in the War of 1812 **47**
4.1 Causes leading to the outbreak of war, 1812 47
4.2 The beginning of the Niagara campaign, May 1813 51
4.2.1 Fort George 52
4.2.2 Sacket's Harbor 54
4.3 The battle of Stoney Creek 56
4.3.1 Events of the battle 57
4.3.2 Events following the battle 63
4.3.3 Injuries sustained during the battle 64
4.3.4 Significance of the battle of Stoney Creek 66
4.4 The end of the Niagara campaign, June-July 1813 67
4.5 The end of the war, peace 1814 69
Chapter 5: Methods **71**
5.1 Cataloguing 71
5.2 Analysis of traumatic lesions 76
5.2.1 Macroscopic analysis 77
5.2.2 Microscopic analysis 79
5.2.3 Quantitative analysis 80
5.2.4 Statistical analysis 83

5.3 Experimental analyses 84
5.3.1 Preliminary visit to Fort George 84
5.3.2 Musket injuries to the iliac crest 87
5.3.3 Bayonet and/or sword injuries to the lower leg 90
Chapter 6: Results **95**
6.1 Analysis of traumatic lesions by element 95
6.1.1 Quantitative analysis 95
6.1.1.1 Statistical analysis 98
6.1.2 Qualitative analysis 100
6.1.2.1 Carpals and Tarsals 100
6.1.2.2 Femora 101
61.2.3 Fibulae 102
6.1.2.4 Patellae 103
6.1.2.5 Ulnae 104
6.1.2.6 Vertebrae 105
6.1.2.7 Innominates 106
6.1.2.8 Scapulae 109
6.1.2.9 Ribs 111
6.1.2.10 Clavicles 115
6.1.2.11 Phalanges 116
6.1.2.12 Unidentified fragments 117
6.2 Analysis of traumatic lesions by lesion type 117
6.2.1 Sharp force trauma 119
6.2.2 Fractures 121
6.2.3 Musket trauma 122
6.3 Experimental analysis of traumatic skeletal lesions 124
6.3.1 Preliminary visit to Fort George 124
6.3.2 Musket injuries to the iliac crest 126
6.3.3 Bayonet and/or sword injuries to the lower leg 132
6.4 Summary of the results 135
Chapter 7: Discussion **137**
7.1 Analysis of perimortem traumatic lesions 137
7.1.1 Types of lesions present in the sample 138
7.1.2 Distribution of lesions present in the sample 146
7.1.3 Prevalence of lesions present in the sample 153
7.1.3.1 Statistical analysis of prevalence values 158
7.1.4 Severity of lesions present in the sample 159
7.1.5 Lesions absent from the sample 161
7.1.6 Experimental analyses 164
7.2 Consideration of the Smith's Knoll sample in historical context 166
7.2.1 Battle of the Little Bighorn, Montana, USA, 1876 166
7.2.2 Snake Hill, 1814 172
7.2.3 Surgical collections from the first half of the 19th century 176
7.2.4 Historical accounts of the battle of Stoney Creek 181

7.3 Consideration of the Smith's Knoll sample in the context of bioarchaeological studies of violence 184
7.3.1 Methodology of quantitative analyses 184
7.3.2 Contributions to the bioarchaeological conceptualization of warfare in the past 187
7.3.3 Contributions to the bioarchaeological conceptualization of violence in the past 191
7.4 Limitations of the Smith's Knoll sample 194
Chapter 8: Conclusions **198**
References Cited **205**
Appendices **214**
Appendix I: Detailed breakdown of fragments included in prevalence calculation categories by element 214
Appendix II: Additional photographs documenting potential perimortem lesions 251

LIST OF TABLES

Chapter 2

Table 2.1: Age profile determined during the previous analysis 9
Table 2.2: Age profile determined during the current analysis 14

Chapter 6

Table 6.1: Prevalence of perimortem traumatic lesions 97
Table 6.2: Prevalence of traumatic lesions including both perimortem and indeterminate 97
Table 6.3: Chi-square values for prevalence calculation methods 99
Table 6.4: Prevalence of traumatic lesions by type of trauma 118
Table 6.5 Measurements of the diameter and spread of experimental and archaeological buckshot injuries 127
Table 6.6: Measurements of the diameter of experimental and archaeological musket-ball injuries 128

LIST OF FIGURES

Chapter 2

Figure 2.1: Excavation plan of the Smith's Knoll site 7

Chapter 4

Figure 4.1: Map of the Niagara frontier 52

Chapter 5

Figure 5.1: Preparation of the replica buttocks to be used in the musket experiment 87
Figure 5.2: Sample tray from musket experiment, showing pork chop and scapula packages covered with pork belly 87
Figure 5.3: Shooting of the trays during the musket experiment 88
Figure 5.4: Replica leg number one 91

Chapter 6

Figure 6.1: Perimortem traumatic lesion prevalence values by element 98
Figure 6.2: Perimortem slice mark on SK1807 100
Figure 6.3: Digital microscope image of SK1807 101
Figure 6.4: Indeterminate lesion on SK1827 101
Figure 6.5: Digital microscope image of SK0320 102
Figure 6.6: Digital microscope image of SK0122 102
Figure 6.7: Perimortem cut mark on SK0129 103
Figure 6.8: Digital microscope image of SK0129 103
Figure 6.9: Second digital microscope image of SK0129 103
Figure 6.10: Perimortem slice mark on SK1361 104
Figure 6.11: Perimortem damage on SK0147 105
Figure 6.12: Perimortem cut mark on SK2078 106
Figure 6.13: Digital microscope 3D image of SK2078 106
Figure 6.14: Musket injury on SK1178 107
Figure 6.15: Buckshot injuries on SK1161 107
Figure 6.16: Digital microscope image of buckshot injury on SK1161 107
Figure 6.17: Musket injury on SK1147 108
Figure 6.18: Musket and buckshot injuries on SK1147 108
Figure 6.19: Musket injury on SK1917 110
Figure 6.20: Closer view of musket injury on SK1917 110
Figure 6.21: Digital microscope image of SK1990 110
Figure 6.22: Perimortem fracture of SK1990 110
Figure 6.23: Perimortem cut marks on SK0324 111
Figure 6.24: Digital microscope image of SK0327 112
Figure 6.25: Second digital microscope image of SK0327 112
Figure 6.26: Digital microscope image of SK0335 112
Figure 6.27: Perimortem cut mark on SK0336 113

Figure 6.28: Digital microscope image of SK0338 113
Figure 6.29: Perimortem fracture of SK0322 113
Figure 6.30: Digital microscope image of SK0322 114
Figure 6.31: Indeterminate cut marks on SK1101 115
Figure 6.32: Digital microscope image of SK1101 115
Figure 6.33: Second digital microscope image of SK1101 115
Figure 6.34: Indeterminate cut marks on SK0978 116
Figure 6.35: Digital microscope image of SK0978 117
Figure 6.36: Perimortem lesion element count prevalence values by type of trauma 118
Figure 6.37: Perimortem lesion individual count prevalence values by type of trauma 119
Figure 6.38: Distribution of potentially perimortem traumatic lesions 120
Figure 6.39: Tomahawk utilized during Fort George experimental work 124
Figure 6.40: Curved cavalry sabre utilized during Fort George experimental work 125
Figure 6.41: Socket bayonet utilized during Fort George experimental work 125
Figure 6.42: Replica Brown Bess musket used during experimental work 126
Figure 6.43: Replica War of 1812 period ammunition 126
Figure 6.44: Diameters of experimental and archaeological buckshot and musket ball lesions with corresponding ranges of fire 128
Figure 6.45: Digital microscope images of experimental and archaeological buckshot lesions 129
Figure 6.46: Experimental musket ball lesion, Tray 4 130
Figure 6.47: Digital microscope image of sword lesion on experimental leg number two 132
Figure 6.48: Digital microscope image of bayonet lesion on experimental leg number three 133

Chapter 7

Figure 7.1: ‘India’ pattern musket with socket bayonet, c. 1800 from Kaufman (2003, 178) 140
Figure 7.2: British light cavalry sword and scabbard from Kaufman (2003, 192) 141
Figure 7.1: Musket injury to the patella from Kaufman (2003:119) 151
Figure 7.2: Musket injury to the femur from Kaufman (2003: 103) 151
Figure 7.3: Musket injury to the tibia from Kaufman (2003: 126) 163
Figure 7.4: Musket injury to the iliac crest from Kaufman (2003: 154) 178

Declaration of Academic Achievement

The following is a declaration that the content of the research in this document has been completed by Laura Lockau, recognizing the contributions of Dr. Megan Brickley and Dr. Tracy Prowse. The content of the thesis was critically evaluated by both Dr. Brickley and Dr. Prowse. Dr. Brickley additionally obtained funding for this project and assisted Laura Lockau in designing the experimental work completed as part of this research.

Chapter 1: Introduction

Skeletal remains provide one of the most important and direct sources of evidence for the occurrence of violence in the past, and warfare as a context in which interpersonal violence is known to occur has been the focus of significant bioarchaeological examination (e.g. Walker 2001; Ortner 2003; Knüsel et al. 2007). The occurrence of warfare-related skeletal assemblages associated with well-established context and substantial documentary evidence is relatively rare, although such sites do exist. Examples include mass graves associated with the battle of Towton in England (Fiorato et al. 2000) and the battle of Aljubarrota in Spain (Cunha and Silva 1997), as well as remains securely linked to the battle of the Little Bighorn in the United States (Scott et al. 1989), among others. A few such sites also exist that are securely associated with the War of 1812. Smith's Knoll, a southern Ontario archaeological site, contains the remains of soldiers who were killed during the battle of Stoney Creek in 1813. The aim of this thesis is to consider perimortem traumatic lesions observed within the Smith's Knoll sample, and therefore linked to the battle of Stoney Creek. This analysis examines the elements of the Smith's Knoll collection for skeletal evidence of perimortem injuries sustained during the battle, focusing on elements of the postcranial skeleton. The skeletal trauma observed is then considered in the context of the conflict during which it was sustained and the history of the site after deposition of the remains, as well as of previous bioarchaeological studies of violence and warfare in the past.

The Smith's Knoll assemblage contains the disarticulated, commingled, and fragmented remains of soldiers who died on the battlefield during the battle of Stoney Creek. This battle occurred during the Niagara campaign of the War of 1812 and represented an important turning point in the war, marking the furthest point of American penetration into Upper Canada and turning the tide of the campaign in favor of the British (Sutherland 2001; Elliott 2009). Historical evidence indicates that this battle was also notable in its lack of typical combat strategy; conducted as a night raid on the American camp, the conflict was chaotic, close-range, and likely a unique experience for the soldiers involved. Examination of the perimortem traumatic lesions on the remains of these individuals represents an additional form of evidence contributing to a more nuanced interpretation of events experienced during the battle.

Each of the 2701 fragments present in the Smith's Knoll collection were individually catalogued and examined for evidence of lesions associated with sharp force, fracture, and musket trauma both macroscopically and using a digital microscope. Qualitative and quantitative analyses were then performed on the lesions observed within the assemblage, including the evaluation of the types present and absent, patterns of distribution, severity, and calculation of prevalence values based on element and individual counts. The injuries present in the collection were compared with those observed in other roughly contemporaneous archaeological and surgical skeletal samples, historical accounts of the battle itself, and lesions experimentally created using replica weapons and faunal skeletal elements. In addition to perimortem traumatic lesions attributable to sharp force injury with the bayonet and sword, musket trauma, and

perimortem fracture, a significant amount of postmortem damage was observed in the skeletal remains. Due to the presence of documentary information regarding the post-depositional history of site use, this damage and its potential effects in masking or mimicking perimortem lesions can be considered in the context of taphonomic processes known to have occurred at the site, including farming, looting, exhumation and reburial of the remains, and environmental processes.

A link between interpersonal violent conflict and cranial lesions has been relatively securely established based on clinical and forensic evidence, and has been corroborated archaeologically in many assemblages (Merbs 1989; Jurmain 1999; Walker 2001; Ortner 2003; Lovell 2008). As such, much of the bioarchaeological examination of trauma in the past focuses on cranial trauma and relegates many postcranial lesions to the realm of accidental injury. However, the observation of skeletal remains from battle sites often reveals significant evidence of violence-related postcranial injury (e.g. Scott et al. 1989; Litt et al. 1993; Cunha and Silva 1997), and Smith's Knoll is no exception in this regard. Cranial trauma was also observed at the site and has been dealt with during previous analyses of the Smith's Knoll material (Liston 2000), therefore the current analysis is focused on the lesions observed in the postcranial elements of the assemblage, and provides an indication of the value of postcranial injury in evaluating violent behaviors in the past.

Bioarchaeological analysis of the evidence for violent activity in fragmented commingled remains is relatively rare, likely due to the difficulties associated with adapting osteological techniques for use on this type of sample (Knüsel and Outram

2004). The fragmentary nature of collections like Smith's Knoll limits the information that can be gathered therein, and affects the quantitative methods that can be used. While it is necessary to acknowledge the limitations and biases of the sample, the Smith's Knoll skeletal material has clear value for the analysis of traumatic lesions and their association with violence and warfare during the first half of the nineteenth century.

This thesis will present the results of the analysis of perimortem sharp force, fracture, and musket lesions found in the postcranial elements of the Smith's Knoll skeletal collection in the context of relevant historical, bioarchaeological, and taphonomic evidence. Detailed information about unique features and limitations of the sample, as well as the results of previous analyses of this skeletal material, are provided in Chapter 2. Chapter 3 presents an overview of bioarchaeological studies of violence and warfare, including the progression of theoretical and methodological developments relevant to the current analysis. Information on the historical context of the site is given in Chapter 4, which outlines the development of the War of 1812, events of the Niagara campaign, and specific features of the battle of Stoney Creek itself. Chapter 5 details the methods utilized during the analysis of perimortem trauma in the skeletal material, both qualitative and quantitative. The experimental procedures performed in order to create comparative lesions are also detailed here. The results of these various analyses are presented in Chapter 6. Chapter 7 contains a discussion of the significance of these results in terms of the interpretation of soldier experience during the battle of Stoney Creek as well as what can be inferred regarding the appearance of interpersonal violence in the skeletal record. Within this treatment of the results, specific features of the appearance and patterning of

lesions observed in the collection are discussed, and the lesions are considered in the context of documentary evidence and skeletal remains from other contemporaneous archaeological sites and a surgical collection. Emphasis is placed on the value of the information contained within this collection and its potential to contribute to bioarchaeological understandings of warfare and violence more generally in the past.

Chapter 2: Materials

2.1 The Smith's Knoll skeletal sample

The Smith's Knoll sample consists of the disarticulated, fragmentary, and commingled remains of individuals who were presumably soldiers killed during the battle of Stoney Creek and buried on the battlefield following the conflict. The remains were excavated over the course of two field seasons in 1998 and 1999 by RGS Archaeological Services, and were originally analyzed after the 1998 field season by then-PhD student Clare McVeigh and after the 1999 field season by Dr. Maria Liston (Griffin-Short 1998, 2000). Following these analyses, the remains were stored within a stone monument; in May of 2011 the plastic boxes containing the remains were removed from the monument by the City of Hamilton and brought to McMaster University. Subsequent comprehensive recording and re-analysis of this material by Dr. Megan Brickley, myself, and undergraduate research assistant Ana-Maria Dragomir has employed new techniques to provide additional information on the sample, allowing for more informed interpretations based on the skeletal evidence.

The individuals that comprise the Smith's Knoll sample were buried quickly after the battle of Stoney Creek, as is suggested by the lack of evidence for coffins. Sometime after the original post-battle burial of the remains, they were removed from the ground and reburied in a large trench along with domestic material (see Figure 2.1). The artifacts found with the remains consisted of metal, glass, and ceramic artifacts that can mostly be dated to the period between 1860 and 1904, suggesting that the remains were re-deposited

after this period (Griffin-Short 2000). Unfortunately because of this re-deposition information on the original location, orientation, and arrangement of the burials has been lost. As well, disturbance of the remains led to extensive commingling, making the determination of the exact number of individuals and the assignment of separate elements to discrete individuals impossible. The lack of intact burials therefore limits the amount of information that can be gained from the skeletal remains.

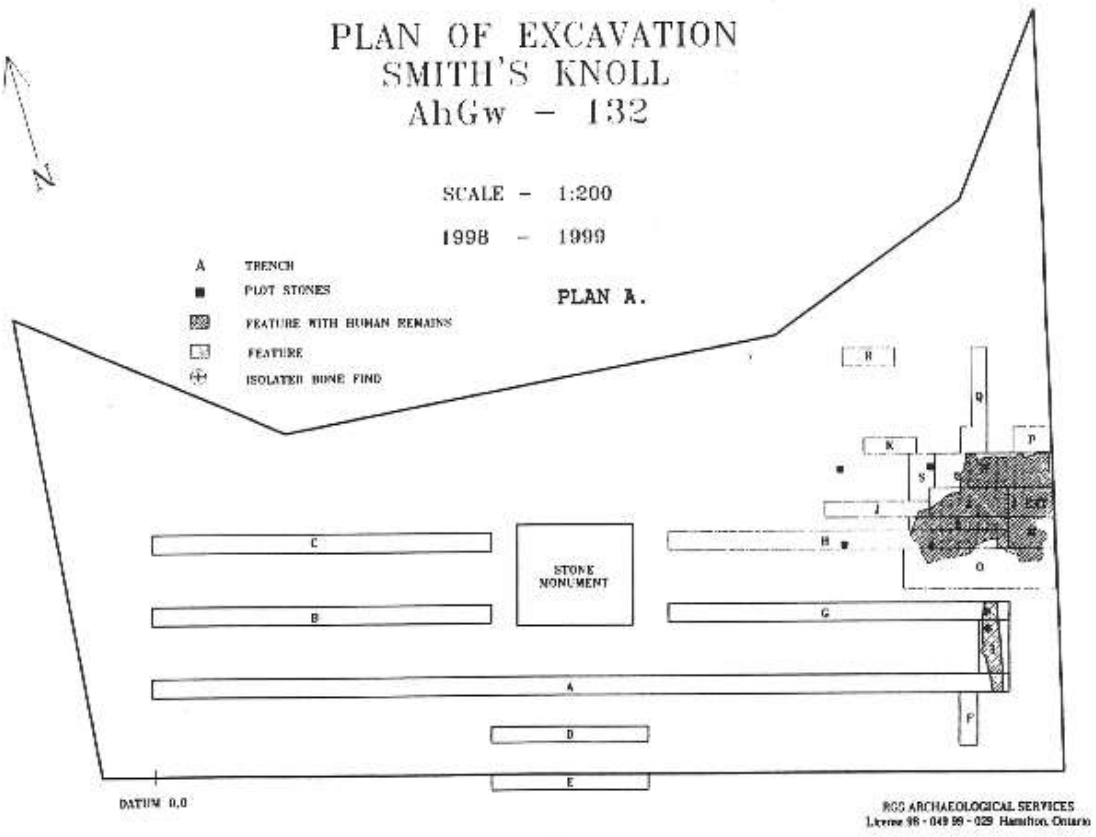

Figure 2.1. Excavation plan of the Smith's Knoll site, showing the location of the excavated trenches. Shaded areas represent features containing human remains. The remains were stored from 2000 to 2011 within the stone monument at the center of the diagram, and will be stored there again following the current analysis. Image taken from Griffin-Short (2000: 48).

After the battle of Stony Creek, the land on which the soldiers were buried changed hands several times, leading to several associated changes in land use. It is known that the property was farmed; as established by Haglund et al. (2002) processes associated with farming can have significant taphonomic effects in the form of postmortem trauma as well as breakage and fragmentation associated with soil compaction from heavy machinery. The site had been looted for artifacts such as military buttons that were associated with the burials, and 22 bodies were also removed by a physician for phrenology studies (Griffin-Short 2000). As phrenology studies necessarily involve the cranium it is likely that cranial elements were selectively removed, thereby affecting the representation of various elements and introducing new biases into the sample. The skeletal material was further disturbed by construction immediately prior to excavation, which in itself can be a significant source of damage to skeletal remains if not done carefully. The aforementioned human activities, along with environmental taphonomic processes, certainly would have affected the preservation and condition of the remains, contributing to the fragmentation and disarticulation seen in the sample today. The surviving fragments show significant evidence of postmortem trauma, some of which clearly occurred long before their discovery and some of which may be associated with more recent processes such as excavation and handling. Many of the elements are also quite heavily weathered, with the cortex damaged or even completely missing. The postmortem changes that have occurred have had a significant effect on the ability of researchers to identify the fragments by element as well as to identify and assess the presence of pathological and traumatic lesions.

2.2 Previous analyses (1998, 2000)

The original analysis of the sample by then-PhD student Clare McVeigh was completed in 1998, solely on the skeletal material excavated during the first field season. Based on the mandibular and dental remains, she determined the minimum number of individuals to be eight males, the majority of whom likely have been young adults between 18 and 30 years of age as the majority (n=21) of ageable fragments were estimated to belong to this group (McVeigh 1998). Nine elements were determined to have come from older individuals over 45 years of age, and only three elements came from mature adults between the ages of 30 and 45 (McVeigh 1998). Little pathology was noted at this point other than one healed antemortem metatarsal fracture and dental caries.

The first analysis of the entire excavated sample, stated to consist of 770 identified elements, was performed by Dr. Maria Liston (2000). She determined that there were at least 24 individuals represented, all of them being male as determined by sex determination procedures utilizing the cranium and the pelvis. Age was also originally determined using the morphological features of the pelvis, namely the pubic symphysis and auricular surface; Liston (2000) found that the majority of individuals present belonged to the middle age category, between 30 and 44 years of age (see Table 2.1).

Table 2.1. Age profile of the Smith's Knoll sample (Liston 2000)

Age Range (years)	Number
25-29	3
30-34	4
35-39	4
40-44	3
45-49	1
Total	15

Results of previous age estimation (Liston 2000) based on the pubic symphysis and auricular surface.

The sample was also evaluated at this time for the presence of pathological lesions and perimortem injuries. Well-healed antemortem fractures were found in five elements (one ulna, two tibiae, one fibula, and one metatarsal), and non-specific evidence for infection was found in several tibiae (Liston 2000). Liston (2000) also found significant evidence to indicate perimortem injury within the sample, in the form of musket wounds and sharp force trauma attributed to bayonet wounds. Evidence for bayonet trauma was found in the form of v-shaped cuts in three fibulae and one clavicle, as well as v-shaped cuts and longitudinal splits in 30 rib fragments (Liston 2000). When compared with historical accounts of the battle, Liston (2000) found the sharp force trauma present to be consistent with first-hand accounts indicating hand-to-hand fighting.

Musket ball injuries were discovered in four cranial fragments and in one scapula and one ilium (Ibid.). In order to better contextualize the firearm injuries in the Smith's Knoll cranial fragments, experimental work was performed on porcine crania that were shot from 20, 10, and five meters, as well as at contact. Liston (2000) stated that the entry and exit wounds produced were most similar to the experimental trials shot at five meters and contact, and therefore concluded that the wounds were most likely close-range. Due to the inaccuracy of muskets from this period and the nature of the battle conditions, she suggested that it was unlikely that shots during battle would result in so many fatal wounds and therefore the lesions seen in the cranial fragments were likely the result of deliberate shots following the battle, in other words of mercy killing (Liston 2000). Liston's (2000) report states that this scenario is consistent with her experimental results. However, based on the variability in musket ammunition behavior displayed during our

experimental analysis (see Section 6.3.2) and the large number of primary sources cited by Elliott (2009) that directly mention musket wounds to the head during War of 1812 battles, there is no reason to suspect that these injuries could not have occurred during the battle of Stoney Creek itself.

Liston's (2000) report on the Smith's Knoll material concluded that this sample comprised a fairly healthy group of generally older soldiers with evidence of mild to moderate disease stress. She surmised that this was to be expected in an "invasion force", as these soldiers were on the move rather than occupying a fort long-term or participating in a siege (Liston 2000). Based on the older age profile and the stated general good health of the sample, Griffin-Short (2000) concluded rather dubiously that the skeletal evidence supported a British rather than an American origin for these individuals. However, stable isotope analysis performed by Blyth (2003) concluded that these individuals were more likely to have an American origin based on the analysis of oxygen isotopes in tooth enamel samples. Although at other contemporaneous sites archaeological evidence has been extremely helpful in determining the likely nationalities of the individuals in skeletal samples (Litt et al. 1993), the disturbed burial context of the Smith's Knoll remains, lack of discrete burials, and presence of many military buttons from both British and American uniforms (Griffin-Short 2000) means that the archaeological evidence is inconclusive at this site. The question of whether the soldiers in the Smith's Knoll sample were British, American, or both remains to be settled; stable isotope analyses on dental and skeletal samples currently being performed by Matthew Emery at McMaster University will hopefully contribute additional evidence in this regard.

The previous two analyses were completed in a contract archaeology environment rather than an academic one. The environment of analysis can be quite important in determining the results of a study (Grauer 2008), which is evident based on the nature of the previous analytical results. The conclusions made by Drs. McVeigh and Liston were most likely restricted by the time restraints placed on analysis, possible lack of funding for complex analytical techniques, and possibly also a lack of permission for the application of destructive techniques. When analysis occurs under contract archaeology, the results are often simply appended to the archaeological site report, and may remain unpublished; this has heretofore been the case for the Smith's Knoll skeletal material.

2.3 Current analysis (2011)

The Smith's Knoll sample was re-analyzed over the summer and autumn of 2011, and each of the fragments in the collection was inventoried. During the process of recording, the number of identifiable fragments in the sample was found to be 2701 rather than 770 as originally stated (Griffin-Short 2000). As there was no new skeletal material excavated after the archaeological report was published, it is unclear why this difference exists. The discrepancy may be related to differential definitions of "identified elements", as specific information regarding which fragments were included in the original count is not provided in the field reports (Griffin-Short 2000). In addition to recording detailed information for each fragment that could be identified by skeletal element, some basic information was also recorded for the fragments that could not be precisely identified. Each of these fragments was placed into a general category based on the type of element

or bone present, and information on size and surface preservation was recorded; these fragments, which had previously been ignored, were included in the analysis based on the suggestion by Outram (2001) that even "indeterminate" fragments still contain valuable information about the sample from which they are derived.

Age at death was re-evaluated using the auricular surface based on the standards set out by Buikstra and Ubelaker (1994) as had been done previously, but additionally using epiphyseal fusion as an age indicator. With the addition of the more recent technique of epiphyseal fusion sequencing (e.g. Scheuer and Black 2000; Schaefer and Black 2007) it was possible to determine the age at death for a few more fragments than could be previously placed into an age category. As well, the most recent age estimations suggest that the individuals in this sample were younger when they died than had been previously determined (see Tables 2.1 and 2.2). Several elements were found to be from individuals from a younger age category than had even been included in the earlier site report, and far more individuals present were placed in younger and fewer in older age categories. The previously determined age profile was important evidence used by Griffin-Short (2000) to support the conclusion that these individuals represent the remains of British soldiers. However, although on average British soldiers may have been older than their American counterparts both armies most likely had very similar age ranges (Elliott 2009). Given the very small sample size of the Smith's Knoll material, the average age at death of the soldiers buried at Smith's Knoll cannot provide reliable information on the identity of these individuals, as a comparison of the age distribution in this small sample with the average ages of soldiers in either army will not be meaningful.

Table 2.2. Age profile of the Smith's Knoll sample (current analysis, 2011)

Age Category	Approximate Range of Age at Death	Number
Adolescent	16-20	5
Young Adult	21-34	8
Mature Adult	35-44	4
Total		17

Results of 2011 age estimation based on the auricular surface and epiphyseal fusion.

Preliminary analysis of pathological lesions in the Smith's Knoll sample indicates that there is evidence for non-specific pathological changes in several individuals, in most cases at a low level of severity and a fairly advanced stage of healing. These non-specific changes are indicative of systemic infection or general stress within the body, and given the presence of perimortem and antemortem trauma and the soldierly occupation of these individuals previous trauma is very possibly the causative factor in many cases. However, the analysis of pathological and traumatic lesions is normally discussed in terms of prevalence by individual (Ortner 2003); the lack of complete individuals in this sample places a significant limitation on the conclusions and interpretations that can be made based on the skeletal lesions present. Analysis of skeletal pathological lesions in the Smith's Knoll sample is to be completed by Dr. Megan Brickley.

The disarticulated, commingled, and fragmentary Smith's Knoll skeletal sample presents several challenges that complicate attempts at osteological and paleopathological analysis. The lack of complete individuals and discrete burials limits what can be said regarding the prevalence of traumatic injuries, and multiple injuries that may have affected single individuals have been rendered invisible. The site has been heavily disturbed by human and environmental taphonomic processes, resulting in fragmentation and poor preservation, postmortem trauma that may destroy or mask previous lesions, and

biases in the representation of skeletal elements. However, a thorough knowledge of the processes that may have affected this sample as well as a good understanding and acknowledgement of its limitations make paleopathological analysis both possible and useful; despite the condition of the skeletal elements present, this sample still provides a unique opportunity to investigate skeletal markers of trauma associated with the battle of Stoney Creek.

Chapter 3: Bioarchaeological Trauma Studies

Evidence of traumatic injury to the skeleton is often cited as one of the most prevalent paleopathological lesions encountered in archaeological samples (Lovell 1997, 2008; Ortner 2003). These lesions have the potential to reveal much information regarding conditions of life in the past, including the types of risks that people may have been exposed to and the ways in which they interacted with their physical and social environments (Ortner 2003; Brickley and Smith 2006; Lovell 2008). Through the investigation of injuries and their associated morbidity and mortality, bioarchaeologists can evaluate behavior in past populations and the environmental and sociocultural factors that may have influenced it (Larsen 1999). In order to access information on sociocultural factors potentially related to the occurrence of trauma in past populations, a close consideration of contextual evidence is essential. Biocultural and bioarchaeological assessments of trauma therefore incorporate skeletal, historical, ethnographic, archaeological, and all other available lines of evidence to increase our understanding of injury experiences in past populations (Goodman and Leatherman 1998); by combining different forms of data with varying biases and considering the archaeological and sociocultural context of the remains, a more complete picture of past behaviors can be developed than would be possible using skeletal evidence alone. Analysis of traumatic lesions in the Smith's Knoll sample will be considered in the context of historical accounts of events during the battle of Stoney Creek to reveal the full range of possibilities for injuries that may have been sustained, an approach that has been

relatively common in the literature for other early historical battle sites such as the battle of the Little Bighorn and Snake Hill (e.g. Scott et al. 1989; Liston and Baker 1996; Willey and Scott 1996; Novak 2000; Williamson et al. 2003; Murphy et al. 2010). Skeletal evidence for trauma provides a direct source of evidence regarding injury in the past and can be extremely valuable in giving an indication of the types of perimortem injuries experienced by soldiers and the weapons they used, especially when evaluated in combination with other sources of evidence such as documented historical accounts.

Throughout the history of bioarchaeological trauma analysis, the focus of investigation has undergone several shifts. Original analyses of skeletal traumatic lesions were mostly in the form of descriptive case studies outlining individual, often unique or extraordinary, lesions. Beginning with Lovejoy and Heiple (1981), most researchers shifted to the use of a paleoepidemiological approach with a focus on quantitative analysis and patterns of trauma within an archaeological sample rather than individual cases (Jurmain 1999; Lovell 2008). With this shift toward a more interpretive approach bioarchaeological research questions began to examine trends at levels above the individual, such as within the population and larger region, as well as looking at how these pathological lesions reflect socio-cultural interactions (Walker 2001; Brickley 2006). Lovejoy and Heiple (1981) also performed a systematic analysis of fracture frequency within their skeletal sample, utilizing specific methods and clearly defined criteria for the inclusion or exclusion of each element within the calculated frequencies. Along with the increased use of well defined and standardized methods came an increased concern with the comparability of results from different sites; this became a

major factor in research design and the focus of investigation was able to expand even further as researchers were able to consider the results of analysis at surrounding sites near and far in addition to their own. Method choice is very important not only because of its effect on the comparability of data gleaned from different sites, but also because inclusion criteria may exclude some bones with traumatic lesions, decreasing the fracture frequency and thereby affecting interpretations (Judd 2002).

3.1 Establishing timing of the injury in relation to death

Osteological trauma analysis attempts to determine lesion timing and relevance to mortality, the proximate cause of the lesion, and its ultimate behavioral cause (intentional or incidental). Therefore, the first major question that bioarchaeologists attempt to answer is the timing of the injury that produced a skeletal lesion relative to the death of the individual (Sauer 1998). Injuries can be broadly divided into three intervals of occurrence: antemortem or prior to death, perimortem or around the time of death, and postmortem or after death. While antemortem and postmortem injuries can be fairly clearly differentiated, the perimortem interval is much more difficult to define, so much so that some bioarchaeologists have begun to question the usefulness of the term 'perimortem.' Duhig and Martinsen (2007) suggest that a new term, 'paramortem,' be introduced to refer to any events that occur close in time to the death of an individual but extend beyond the death event itself to include other trauma occurring to the body when it is no longer living but still considered to retain its "personhood." This may be especially relevant with phenomena such as overkill.

Antemortem lesions are identified as such due to the presence of positive evidence of healing. As healing processes can only proceed while the individual is alive, evidence that healing has begun is a definitive indication that an injury occurred prior to death. Fracture healing is not normally visible macroscopically in bone until about one to three weeks after the injury (Lovell 2008). The healing process involves hematoma formation and inflammation followed by the formation of a callus of woven bone joining the two ends, which is gradually strengthened and replaced by mature lamellar bone. Continuous remodeling of the fracture site changes its appearance over time, so that many years after the original injury the lesion may no longer be visible (Ortner 2003; Roberts and Manchester 2005; Lovell 2008). This is especially true if the injury occurred at a young age. There is a significant amount of individual variation in the timing of the healing process, based on factors such as age and health status. Older individuals, or those with lower bone quality due to various pathological conditions, may have a significantly decreased rate of healing. Due to the fact that signs of healing are not visible in dry bone until at least one week after the occurrence of the injury, an injury that occurred several days before the death of the individual often cannot be differentiated from one that occurred at the time of death or was closely associated with the death event (Roberts and Manchester 2005). This is one of the factors that serve to increase the length of the perimortem interval as well as to intensify the ambiguity surrounding this period.

Perimortem injuries are differentiated from postmortem injuries based on the differential fracture characteristics of fresh and dry bone. With increasing time after death and deposition of the body, bone steadily loses moisture content and its organic collagen

component and as such begins to behave less like a viscoelastic substance and more like a brittle material (Johnson 1985; Sauer 1998; Lovell 2008). As the proportions of the organic and mineral components of bone begin to shift, the behavior of the bone in response to impact and injury changes to reflect the properties of the more dominant material; this occurs not as a sudden shift from fresh to dry fracture characteristics, but rather along a continuum involving many intermediate stages with mixed characteristics (Johnson 1985). This means that perimortem fracture characteristics can persist into an interval after death in which significant moisture is retained (Wieberg and Wescott 2008). When broken, fresh bone tends to produce sharp edges, smooth fracture surfaces, radiating fracture lines, jagged surfaces of broken ends, and edges that may lift or flake. Beveling, as seen with projectile injuries, is also a good indicator of perimortem timing (Knüsel 2005). Dry bone, however, tends to produce rough fracture surfaces, squared edges, and smaller fragments (Lovell 1997, 2008; Outram et al. 2005). However, the utility of these general characteristics in differentiating perimortem from postmortem fractures has been questioned and they may not prove useful in all cases (Wheatley 2008).

Additional evidence used to indicate the timing of a lesion includes looking at the coloration around the lesion. Fractures made nearer the time of death are more likely to be stained a similar color to the rest of the bone, whereas newer breaks and cuts result in edges and surfaces that are a lighter color due to shorter exposure to the burial environment (Haglund et al. 2002; Ubelaker 2002; Wheatley 2008). Evidence suggests that the best way to assess timing of a lesion is through the observation of a number of

characteristics including color variation, fracture morphology, and microscopic characteristics (Wieberg and Wescott 2008).

In general postmortem damage becomes much easier to identify as such the longer the time interval between death and injury, as bone loses collagen and takes on more aspects of a mineral rather than an organic substance. At earlier stages in the wet-dry continuum, differentiation is more difficult. The rate of this gradual transformation of bone from one form to another can be quite variable, especially depending upon the burial environment. Rates of desiccation are greatly affected by the climate including temperature and humidity, as well as by the length of exposure before burial and by characteristics of the burial environment itself such as moisture levels (Sauer 1998). Microenvironmental differences within a burial context may also be relevant; for example Moraitis et al. (2009) suggest that burial conditions in different parts of a mass grave may be quite variable, with moisture retention being much greater in the core. This may lead to difficulties in detecting differences in the length of the perimortem interval between elements even within the same sample. The variability in the amount of time taken to progress from perimortem to postmortem interval has led some researchers to suggest that "perimortem" be conceptualized more as a classification of the condition of the bone, rather than as an interval of chronological time (Galloway 1999; Wheatley 2008).

Due to ambiguities in both the amount of time needed for bone to demonstrate evidence of healing processes and the amount of time needed for bone to lose moisture and organic content and thus take on new fracture characteristics, the length of the perimortem interval is extremely difficult to assess. This perimortem time period extends

at least one week prior to death as well as for an unknown and variable period after the individual has died and the body begins to decompose (Lovell 1997, 2008). Wieberg and Wescott (2008) suggest that there is significant ambiguity in fracture characteristics sustained up to five months following death, and that the precision of timing estimation is reduced for lesions occurring during this period. This presents interpretive difficulties for the bioarchaeologist. Even if a lesion can be securely identified as occurring in the perimortem period, the meaningfulness of this classification may be of questionable value in determining the circumstances leading to the death of the individual. As a "perimortem" lesion may have occurred days before death or most likely up to days or weeks after death, direct relation to the actual death event cannot be securely established. Therefore, this perimortem problem introduces further uncertainty into behavioral interpretations, and provides another reminder of the necessity for caution.

Once the bioarchaeologist has established the likely timing of the injury that produced a given lesion, he or she can begin to get at its possible significance. Lesions associated with different periods of time in relation to the death of an individual provide information about different aspects of the body's experience during life, around the time of death, and after death and deposition. Whereas some choose to conceptualize the body differently during and after life with death as the event separating two disparate phases of its existence, newer embodiment perspectives are beginning to encourage conceptualizing the body as having a continuous experience from formation until eventual destruction, with death as only one event on the timeline (Sofaer 2006). The suggested introduction of a 'paramortem' time interval as discussed above (Duhig and Martinsen 2007) also

encourages an expansion of the period during which traumatic injuries can have significance to the individual as a person. In violent encounters the phenomenon of overkill has been quite frequently described, this refers to the infliction of trauma far beyond what is required to cause the death of an individual and is seen in homicide cases as well as battle situations (Rogers 2004; Simmons 2007). Overkill is often observed on the remains of those killed in the heat of battle, especially during close hand-to-hand combat (Kaufman 2003), making this phenomenon potentially relevant to the Smith's Knoll sample. Traumatic lesions that may be related to the occurrence of overkill in the sample therefore would have occurred during this 'paramortem' period.

Lesions associated with antemortem injuries provide information on experiences of the living individual. Due to differences in the speed of healing between individuals as well as between various elements within a single individual, the timing of an injury that has begun to heal cannot be firmly established (Ortner 2003; Lovell 2008). As well, multiple lesions within the skeleton cannot be clearly differentiated into those that occurred in the course of single or multiple injury events. All that can be reliably concluded is often that the injury occurred prior to death; in some cases where healing has just begun one may be able to state that the injury occurred relatively near the time of death but this period of time cannot be quantified. This seriously limits the amount of information that can be extracted from such lesions.

Lesions associated with perimortem injuries, on the other hand, provide information on experiences that occurred soon before, during, or soon after the events that led to the death of an individual. It may be possible to narrow down the timing of the

lesion within the perimortem interval by considering the location and possible complications of the causative injury through comparison with clinical data. For example, many very extensive cranial injuries that would have resulted in serious damage to the meninges, brain, and cerebral blood vessels would almost certainly not be survivable (Novak 2000). This suggests that such an injury would have occurred either at the time of death and be related to the cause of death of the individual, or would have had to occur soon after death. On the other hand, these interpretations should be made with caution as quite serious injuries have been found with evidence of healing, indicating that the limit of what can have been survived in the past may be higher than commonly expected (Novak 2000).

Lesions associated with postmortem damage provide taphonomic information regarding what has happened to the skeleton after the death of the individual. Taphonomy encompasses biostratinomy or the effects of processes that take place between death and burial, as well as diagenesis or the effects of processes that take place between burial and recovery (Johnson 1985; Darwent and Lyman 2002); therefore taphonomic processes are those that affect remains from the time of death until they are discovered and analyzed. Postmortem damage can be related to features of the depositional environment such as animal activity, trampling, soil compacting, freeze and thaw cycles, sun damage, and erosion by wind, sediment, or water (Haglund et al. 2002). It can also be related to human activity at the deposition site such as farming, looting of burials, and secondary burial treatments (Ubelaker 2002). Additional damage can occur during the excavation, storage, and analysis of remains. With so many processes potentially contributing to postmortem

alterations of skeletal elements, their cumulative effects can produce a very complex pattern of damage that may be extremely difficult to interpret (Morlan 1984; Symes et al. 2002). Many closely related taphonomic processes produce very similar patterning on the appearance of remains, a phenomenon referred to as taphonomic equifinality (Knüsel et al. 2007). A good knowledge of the depositional history of a site goes a long way towards reconstructing the post-depositional taphonomic history of the sample, and therefore discerning possible taphonomic processes that may have contributed to any postmortem damage of the remains.

Postmortem damage may contribute to the destruction of elements or to extreme fragmentation that impedes their correct identification. Postmortem damage is especially important to understand because these processes have been found to both mimic pathology and to mask it (Wenham 1989; Knüsel and Outram 2004; Calce and Rogers 2007; Lovell 2008), potentially confounding interpretations of traumatic lesions. It is typically very difficult to remove this taphonomic overprint, which can bias, blur, or constrain paleopathological interpretations (White 1992). Particularly relevant to the visibility of sharp force lesions in the skeleton is the removal of the cortical surface due to weathering processes that begin to occur after the removal of soft tissue, as removal of the cortex destroys evidence of cut marks on the surface. Perimortem trauma can also interact with postmortem processes; injuries that occur around the time of death may weaken the skeleton and make it more susceptible to post-depositional fracture (Morlan 1984). This may once again negatively affect the visibility of perimortem traumatic lesions in the skeleton, as postmortem alteration of elements that have already undergone perimortem

trauma can change the appearance and confound detection of these lesions. Samples in which multiple perimortem cranial wounds are common illustrate this well. Plastic deformation of the vault bones following trauma will change the shape of the bones permanently, confounding reconstruction attempts (Berryman and Symes 1998). Also, the fragmentation resulting from the weakened vault may result in small pieces that are difficult to interpret and reconstruct. Reconstruction is often critical in the interpretation of cranial trauma (Novak 2000). Therefore, an inability to complete this process combined with the difficulty of differentiating perimortem and postmortem fracture edges may lead to lowered visibility of perimortem wounds in the vault, exacerbating the under-estimation of injuries (Williamson et al. 2003).

Postmortem fragmentation due to processes such as trampling, compaction, and excavation damage may introduce further sources of bias into the skeletal sample. The greater the level of fragmentation, the higher the possibility that pieces of bone will be difficult or impossible to identify by element and that lesions will not be visible and identifiable as such. It has been suggested that fragmentation processes both before and after burial do not affect all skeletal elements equally, but rather preferentially affect larger, less dense elements and those that are more cylindrical in shape (Darwent and Lyman 2002). Differential preservation is a related source of bias that affects the representation of various skeletal elements in the identifiable sample (Jurmain 1999; Judd 2002). Preservation again impacts identifiability, as well as whether useful portions of bones such as those important to aging and sexing procedures or those containing pathological or traumatic lesions will survive to be analyzed. As with the fragmentation

processes described above, pathological lesions may predispose to poor preservation by decreasing the strength of bone tissue.

3.2 Determining proximate cause

The next major question that remains to be established is the category of trauma to which the lesion belongs, and thus the proximate cause of the injury. Once the timing of the injury and therefore the period of experience to which the information gained will relate has been established, the lesion needs to be evaluated in detail. Traumatic skeletal lesions can be divided into several broad categories based on the type of injury that led to their formation. These categories can then be related to the type of force with which an injury is associated. Injuries that are visible in the skeleton include fracture, dislocation, and penetrating injuries; these different types of lesions can result from different types of force such as blunt force trauma, sharp force trauma, and projectile wounds (Larsen 1999; Ortner 2003). The diagnostic characteristics needed to identify the type of lesion present, as well as those that aid in associating it with a probable cause and evaluating the injury experience based on possible soft tissue complications, come from clinical and forensic research. The studies that contribute these comparative data are based on autopsy samples, living patient populations, forensic case reports, and experimental work largely involving animal bone and in a few cases human bone from cadavers (Alunni-Perret et al. 2005; Alunni-Perret et al. 2010).

3.2.1 Fractures

A fracture can be defined as a break in the continuity of a bone, either complete or incomplete (Lovell 1997, 2008; Ortner 2003). There are many different types of fractures that can be classified based on the shape and general appearance of the lesion as well as its orientation with respect to the long axis of the bone. The type of fracture produced in any situation will depend on the type of force applied to the bone, which interacts with the biomechanical properties of bone and the morphological properties of the element affected (Lynn and Fairgrieve 2009). The strength of a bone and its resistance or susceptibility to fracture varies throughout the skeleton and is governed by several factors including microstructure (Johnson 1985). Forces causing fracture can be either direct or indirect, and the severity of the break produced will differ based on the type of force as well as its direction and magnitude. Direct trauma tends to produce fracture types such as transverse, penetrating, and comminuted whereas indirect trauma tends to produce oblique, spiral, and impacted fracture types. Lesions can also result from more subtle forces such as the lower-impact repetitive forces that cause stress or fatigue fractures, or can occur secondarily to a pathological condition that weakens bone, termed a pathological fracture (Ortner 2003; Lovell 2008).

Fracture analysis begins with a detailed description of the lesion, which is important in order to establish the type of fracture and therefore the type of force that may have caused it and any aspects of the bone involved that may have affected the appearance and propagation of the injury (Larsen 1999). It is important to note not only the type of fracture but also aspects of its appearance that indicate severity and possible

complications. Clinical analysis of an injury relies mainly on the evaluation of soft tissue lesions, and at the time that the fracture occurred associated soft tissue injuries would presumably have had serious consequences for the injury experience of the individual involved. Fractures may be accompanied by complications such as hemorrhage, extensive soft tissue damage, nerve disruption or damage, excessive inflammation, and infection (Ortner 2003). These associated conditions may contribute to death at the time of injury or in the days and weeks following the event, and at the very least will affect the injury experience of the individual concerned.

Following such description, the type of force leading to the creation of the lesion must be considered. There is a close correlation between the appearance of a skeletal lesion and the characteristics of the weapon that produced it; working backward from the appearance of the lesion helps in differentiating various mechanisms of injury (Love and Symes 2004; Daegling et al. 2008; Sansoni et al. 2009; Shaw et al. 2011). However despite this association it must be remembered that not all wounds from a single weapon will look the same. Lesions may differ greatly in appearance when made by different edges of the same weapon, or if they result from the same edge at different penetration depths (Novak 2000; Smith et al. 2009). One may be able to get at the range of possibility in appearance through multiple repetitions during experimental reconstruction, but the full range of variation is difficult or impossible to see; as such it is rare to be able to exactly match lesions to the particular weapon that caused them (Williamson et al. 2003).

3.2.2 Blunt force trauma

Blunt force trauma is the result of impact on the skeleton with a blunt object, and tends to cause fractures that differ depending on the skeletal element. In long bones, blunt force trauma often results in direct force injuries as described above, whereas in the cranial vault depressed fractures may be produced. There are many general proscriptions for the ways in which blunt force trauma affects bone, especially the depressed, radiating, and concentric fractures often resulting from trauma to the cranial vault (Berryman and Symes 1998). However, the behavior of some bones upon the application of blunt force is so variable that the lesions seldom have the same appearance from case to case, and thus are very hard to compare. The variability of rib fracture characteristics in response to blunt force trauma has led to significant difficulties in the interpretation of these injuries forensically and archaeologically (Daegling et al. 2008).

3.2.3 Sharp force trauma

Sharp force trauma results from attack with a bladed weapon, such as a knife, hatchet, sword, or bayonet; the resultant lesion is typically a straight incision with very sharp edges. The characteristics of the lesion produced will differ based on the weapon involved, the area of the weapon that contacts the body, and the way in which a given weapon is used (Lewis 2008). As with any weapon, the characteristics and appearance of the resultant lesion depend not only on the shape, mass, velocity, and direction of movement of the object used but also on properties of the bone such as its strength, density, shape, thickness, and individual health (Smith et al. 2009). In injuries resulting

from an attack with a bladed weapon, the weight of the weapon, sharpness of the blade, blade shape, and direction of force will determine the proportion of blunt force and sharp force that combine to produce the resultant lesion. For example, heavier and less sharp weapons such as an axe or hatchet will cause trauma with a higher blunt force component in addition to the sharp force component, producing a lesion that has more blunt characteristics than that resulting from a lighter sharper knife used in a slicing motion (Humphrey and Hutchinson 2001; Lewis 2008). This has been useful in differentiating between lesions produced not only by different types of bladed weapons but also by different classes of a single weapon, namely the sword; varying classes of sword that differ in weight, sharpness, and blade shape have been found to produce lesions that can be differentiated based on their appearance in bone (Lewis 2008). Injuries from smaller weapons, such as incised lesions made by knives, are often difficult to see in bone and therefore might easily be missed. This may cause further underestimation of the prevalence of trauma in a sample (Smith et al. 2009). Further, while the presence of a cut mark may constitute positive evidence of sharp force trauma, attack with a bladed weapon does not always result in such lesions. One clinical study found that as many as 20% of patients who reported being attacked with a sharp weapon presented with only a hematoma or a fracture rather than a cut mark in the bone (Shepherd et al. 1990). This suggests not only that such injuries may impact only the soft tissue but also that sharp force trauma may be difficult to recognize even when the skeleton is affected, as it may present as a non-specific fracture rather than a cut mark that can be specifically identified as resulting from an edged weapon.

3.2.4 Projectile trauma

Projectile trauma is related to the penetration of bone upon impact with a projectile such as an arrow or bullet. The type of projectile trauma relevant to the Smith's Knoll sample is ballistic, specifically musket wounds. Based on comparison with forensic and clinical data, several general characteristics of bullet wounds can aid in their recognition and interpretation (Willey and Scott 1996). The majority of the research on musket trauma has involved cranial lesions. When a bullet impacts the cranial vault, it generally produces a circular entrance wound with clear internal beveling. The bevel results from the lack of support from the diploë during penetration of the inner table, as the outer table has already been completely penetrated (Knight 1996). The shape of the lesion will differ depending on the angle of impact and the speed of the projectile, as well as the shape of the vault at the impact point. After traveling through the cranium the bullet may exit through the other side, producing an exit wound that exhibits clear external beveling. The direction of beveling therefore allows the differentiation of entrance from exit wounds within the vault (Smith et al. 2009). The wounding potential of a bullet is largely determined by its velocity, shape, size, and the maintenance of integrity of its flight path in addition to tissue density at the site of impact (Zych et al. 2008); since the musket balls used during the War of 1812 were large, circular, made of a heavy but soft material (lead), and were of a much lower velocity than modern bullets they tended to cause less damage than modern high-velocity projectiles (Lovell 1997, 2008). This means that the projectile may not always have had enough energy remaining to exit through the other side of the vault, leaving an impact scar on the inner table rather than a lesion

penetrating all the way through the skull (Bailey and Mitchell 2007). With penetrating wounds, displaced fragments of bone have the potential to cause significant secondary damage to the surrounding soft tissues (Knight 1996). Bullets may also glance off the bone without perforating it, or may penetrate only deeply enough to become embedded within the bone, however given the primary focus of the forensic literature on through-and-through cranial injuries from modern high-velocity projectiles, the possibility of seeing other manifestations of gunshot injuries has been understated (Willey and Scott 2006). This may affect their visibility in the skeletal sample, as other less obvious and less often documented lesions associated with gunshot wounds may be overlooked.

In elements other than the cranium, bullet wounds may have a different appearance. Directionality can be determined on elements with a flatter profile from the nature of the beveling present, as the lesion will be beveled on the side opposite to that from which the projectile impacts the bone (Smith et al. 2009). Musket wounds in the postcranial elements often result in comminuted fractures, and secondary injury caused by the resulting fragments of bone can be extensive (Knight 1996, Kaufman 2003). Gunshot trauma has been less often utilized in the reconstruction and interpretation of traumatic injury in the past. Despite the fact that bullets are a more recent invention and thus limited in the number of archaeological sites at which they can be found, gunshot wounds have been quite frequently observed in military and pioneer skeletons within North American contexts (e.g. Scott et al. 1989; Litt et al. 1993; Gill 1994; Willey and Scott 1996; Liston and Baker 1996), and can therefore be very useful indicators of interpersonal violence in the past.

3.3 Determining ultimate behavioral cause

Another categorization of trauma in which bioarchaeologists are interested is the differentiation between incidental and intentional trauma, allowing the elucidation of the ultimate behavioral cause of the injury. Incidental trauma encompasses injuries that occur accidentally; this is reflective of the hazards of everyday living and often indicates the results of human interaction with the physical environment (Larsen 1999; Lovell 2008). Accidental trauma commonly results from incidents such as falls. Intentional trauma, on the other hand, is the result of violent interactions between individuals. This reflects specific incidents of interpersonal interaction rather than general lifestyle conditions (Larsen 1999). These two types of trauma are differentiated based on the pattern of lesions within the skeleton as well as characteristics of the lesions themselves (Lovell 2008). For instance, sharp force and projectile injuries are generally assumed to represent what is referred to as intentional trauma, as these lesions are associated with attack with a weapon. Accidental weapon injuries, while mentioned in the forensic literature (Schmidt and Pollak 1996; Schmidt 2010), are often not considered as a potential etiology in bioarchaeological analyses. Antemortem and perimortem fractures present a more difficult problem, however, since the situations leading to these types of injury are much more non-specific. In the case of fracture, analysis of clinical and forensic data has elucidated the types of injuries that are more commonly respectively associated with either incidental or intentional trauma based on their location in the skeleton. Cranial trauma is commonly associated with interpersonal violence, as is maxillofacial injury (Ortner 2003). Lesions in the hands have a less secure but still significant association with

violent encounters as well, as do those in the ribs (Brickley 2006). Some fractures have also been associated with self-defense, such as the ulnar fracture commonly referred to as a "parry" fracture that often results from fending off a blow with the forearm. However, Judd (2008) urges caution with the use of this fracture category as the characteristics of a "true" parry fracture are found to be much more specific than most researchers in the past have used. The associations of these fracture types and locations with intentional violence are not unambiguous, as some accidental situations may cause cranial trauma or encourage defense with the forearm.

While the interpretation of patterns of skeletal injury that have been commonly associated with interpersonal violence clinically and archaeologically is warranted in many cases, some researchers have gone past a simple acknowledgement of the likely role played by violent interactions to infer actual intent based on the patterning of injuries. For instance, some sources go as far as to attribute a greater number of healed cranial fractures as intent to harm rather than kill and a greater number of fatal projectile injuries as intent to kill rather than harm (Larsen 1999). Other explanations for the patterning of these injuries may be ignored. This represents an over-extension of what can be reliably concluded based on the available evidence (Merbs 1989; Jurmain 1999); caution must always be employed in inferring behavior from evidence in human remains. Novak (2000) cautions that although cranial trauma is fairly securely associated with interpersonal violence and that in violent contexts traumatic injuries to the cranial vault significantly outnumber those to the postcranium, the vault is covered by much less soft tissue than most of the rest of the body and therefore an impact in this region is much

more likely to affect the skeleton. Based on the fact that injuries have a better chance of manifesting skeletally in the cranium, she cautions that a high incidence of cranial trauma may not be a valid basis for the conclusion that the head and face was the main target of attack as has been done in the past (Novak 2000). The cranial vault, like other flat elements such as the iliac crest and scapular blade, also has a relatively large and continuous expanse of bone exposed to potential injury; this may well factor into the increased visibility of skeletal injuries of these elements, in that they are more likely to sustain an impact and may also be more likely to produce a recognizable lesion. The likelihood of skeletal injury in a given element is also partially dependent on the strength of the bone. It has therefore been suggested that the common occurrence of facial fractures in violent contexts may not always reflect the "targeting" of this area but rather the fragility of the bones in this region of the skeleton (Shepherd et al. 1990). Bone strength will also impact the recognition of lesions, as many of the more fragile skeletal elements may be less likely to preserve in the ground and to be excavated in a condition that allows proper analysis. This will almost certainly lead to the underestimation of traumatic lesions in fragile skeletal elements such as the ribs and facial bones.

Even within the context of interpersonal violence, situations may arise in which the classification of trauma as intentional or incidental becomes ambiguous. For example, a phenomenon that is rarely discussed in the literature but does occur forensically is unintentional self-inflicted injuries in attackers, often involving bladed weapons (Schmidt and Pollak 2006; Schmidt 2010). Because this is an accidental injury that occurs within the context of a violent episode, classification of injuries of this type may be insecure.

Moreover, falls may easily occur during an altercation and although the resultant injuries would be related to a violent encounter they might leave skeletal lesions that are identical in appearance to those produced by a truly accidental fall. This demonstrates that differentiation between the broad behavioral categories of intentional and incidental trauma is difficult to accomplish, and in some cases the division between these types may be artificial.

The identification of violence-related injuries in the skeletal record is generally quite tentative; in many situations although the patterning of injuries is highly suggestive of interpersonal violence it cannot be definitively demonstrated to result from violent activities. Smith's Knoll is an unusual sample in that the context of the burial of the individuals it contains is relatively well known. In contrast to the majority of cemetery samples, which are the result of a slow accumulation of individuals over a long span of time, the Smith's Knoll sample consists of individuals who died and were buried following one specific violent incident. Therefore, whereas in most cases interpersonal violence must be inferred from skeletal and archaeological evidence, it is well documented that all of the individuals in the Smith's Knoll sample were exposed to violence and that their deaths were battle-related. Historic battle-related samples, including Smith's Knoll, offer unique opportunities to study skeletal evidence of violence because the injuries found within them can be more securely connected with interpersonal violence due to well-established context. While intent normally cannot be reliably inferred from skeletal evidence, the unique context of the Smith's Knoll sample may allow more secure speculation regarding this elusive factor. Given the fact that any

perimortem injuries would almost certainly be related to the battle in which these soldiers lost their lives, it can be assumed that these injuries were inflicted based upon the strategy set out for battle situations at the time. Even if there is no evidence of a traumatic lesion, it can still be inferred that the individual in question died from violence-related injuries. The frequency of traumatic lesions in the Smith's Knoll sample may therefore give some indication of just how under-represented traumatic lesions are in the skeleton.

In the context of a War of 1812 battle, the intent of all soldier participants would have been to fatally injure their opponents; therefore it is very likely that this murderous intent can be connected with each of the perimortem injuries seen in the individuals comprising this sample. Some of the injuries seen in the sample may also relate to phenomena such as overkill, given heightened emotions with the close contact and added uncertainty of a night battle. The identification of the behavioral circumstances behind traumatic lesions in the past is extremely difficult even with contextual evidence (Lovell 2008). This is one of the major reasons that the Smith's Knoll sample is so unique and useful for research around the bioarchaeology of violence, as not only the presence of interpersonal violent behaviors but also many more specific details regarding the event during which these individuals perished are known.

3.4 Sources of bias

There are several major sources of bias that affect bioarchaeological interpretations of skeletal trauma. While skeletal lesions are often presented as the best, most important, and often only direct source of evidence for violent confrontation

(Knüsel 2005; Knüsel et al. 2007), and some maintain that skeletal evidence is without the major interpretive biases associated with literary evidence (Walker 2001), skeletal evidence does have its own unique biases and limitations. As with many other pathological conditions, traumatic lesions dramatically under-represent the actual prevalence of injury within the sample (Jurmain 1999; Galloway 1999; Ortner 2003; Lovell 2008; Jordana et al. 2009; Murphy et al. 2010). As can be seen in the clinical literature regarding traumatic injury, most lesions that occur manifest only in soft tissue. For example, one study examining emergency room trauma victims found that only 26% of patients exhibited injuries that had associated bony lesions (Shepherd et al. 1990). This may vary by type of injury as well; Prieto (2007) suggests that stab wounds may be particularly under-represented in skeletal remains. Since only a small percentage of injuries impact the skeleton in the first place, the majority of lesions that may have been present at the time of death will be undetectable in the skeletal record. Having only the skeleton available for study rather than the entire body limits not only the visibility of injuries that an individual was likely to have experienced, but also the ability of the researcher to reconstruct the possible consequences and soft tissue injuries associated with the bony lesion itself (Wenham 1989). This means that much of the injury experience of the individual can only be guessed at. The skeletal sample and interpretations based upon it may also be limited by recovery biases affecting which elements are available for study in the first place; all excavation techniques introduce some bias into the sample that is generated, and the quality of this sample is important in determining the quality of analysis (White 1992). For the Smith's Knoll skeletal material,

the fragmented and commingled nature of the sample introduces further limitations (see Chapter 2), restricting the ways in which lesion prevalence can be calculated and expressed.

Much of the comparative data used to evaluate the types and prevalence of lesions found in archaeological samples comes from clinical and forensic research or from research using historical skeletal collections. However, the applicability of clinical data to archaeological skeletal material has been questioned. Many of the studies done on surviving victims use data collected from patients in emergency rooms, thereby relying on the self-reporting of injuries (Lovell 2008) as well as over-representing non-lethal injuries that are still severe enough to cause hospital admittance, and under-representing uniformly fatal wounds (Brink et al. 1998; Warren 2007). Some injuries are suggested to be more likely to be under-reported, such as rib, hand, and foot fractures (Jurmain 1999; Brickley 2006); the resultant bias may seriously skew fracture frequencies generated from this data. It has also been suggested that differences exist between data collected from different types of clinical samples, namely autopsy studies and research involving non-fatal injuries (Schmidt and Pollak 2006). It is unknown how both of these types of data may differ from archaeological samples and therefore how this may affect comparability. It seems likely that clinical studies utilizing data from living patients may be more relevant to the study of antemortem trauma whereas clinical data from autopsy samples may be more relevant to perimortem trauma, but this distinction is likely rarely if ever made. In addition to issues surrounding the data itself, there are potential issues that arise from the different theoretical bases and varying approaches taken in anthropological

versus medical research. For instance, definitions of commonly used terms such as perimortem may differ; medical examiners with full access to soft tissue injuries can often afford a much narrower classification of the perimortem individual as the vital reaction and initiation of healing occurs much sooner in soft tissue than in bone (Symes et al. 2002). Clinical reports must therefore be read cautiously with an awareness of possible differences that could affect comparability. Forensic data, even in cases where soft tissues are present, may have their own difficulties as well. Even when there is extensive survival of soft tissue evidence, lesions are still often ambiguous making interpretation difficult (Bennike 2008).

Not all types of evidence used to evaluate the ultimate behavioral cause of traumatic lesions are considered to have the same value for interpretation. The most unambiguous evidence of interpersonal violence is often held to be projectile points embedded in bone (Jurmain 1999). Skeletal evidence ranks relatively high on this scale, as it is considered to be direct evidence of trauma from the body of the affected individual (Larsen 1999). Archaeological evidence, such as projectiles in the grave fill or the presence of defensive fortifications, is classified as indirect corroborating evidence that is suggestive but not directly indicative of violent behaviors (Larsen et al. 1996). This is partly due to the fact that in the absence of direct evidence of the resultant lesions, most types of archaeological evidence cannot distinguish between the threat or the veneration of violent activities and the occurrence of these activities themselves (Knüsel 2005). Other types of contextual evidence, such as historical accounts, can be very useful. However these sources also have their own unique biases. Clinical evidence indicates that

witness accounts of violent injuries are questionably reliable for indicating the precise cause of a lesion and can at best provide an indication of the likely cause of injury (Shepherd et al. 1990). This suggests that first-hand accounts, while providing a very good indication of the general conditions that prevailed during the battle, may be less accurate when it comes to mentioning the specific types of injuries that were experienced by the authors' fellow soldiers. While historical accounts are extremely helpful in suggesting possible mechanisms of trauma and providing an idea of the type of soft tissue injuries that may have occurred without preserving in the skeleton (Scott et al. 1989), they can also be limiting. Behavioral interpretations may be limited to the possibilities presented in these primary sources, and the evidence made to fit the presumed events as described, without the researcher keeping an open mind to new possibilities not mentioned in the accounts. Due to the obvious limitations and biases of all types of skeletal and contextual evidence, the best solution is the incorporation of all available data in order to offset some of the potential sources of bias and hopefully therefore to arrive at the most accurate possible interpretation of events.

The aforementioned biases act in concert with the previously mentioned potential for traumatic lesions to negatively impact preservation, as well as the natural biases and limitations inherent in all archaeological skeletal samples as outlined by Wood et al. (1992). The degree to which a skeletal sample is actually representative of the population from which it originated is highly questionable (Komar and Grivas 2008). Although the Smith's Knoll sample is derived from a very specific subset of the population selected for health and a variety of other physical characteristics (Owsley et al. 1991), we can still not

reliably conclude that these individuals are representative of even that specific group. Therefore, we must keep in mind that the applicability of interpretations based on this sample to War of 1812 soldiers in general is not secure and any generalizations must be made with caution.

3.5 Bioarchaeological analyses of battle-related trauma in 19th century North American contexts

Several analyses have been completed on 19th century North American skeletal samples that are similar in many ways to the Smith's Knoll sample and may therefore serve as useful comparative material. Skeletal material from Snake Hill, another War of 1812 site in southern Ontario (Pfeiffer and Williamson 1991; Litt et al 1993), as well as from the battle of the Little Bighorn in Montana in 1876 (Scott et al. 1989; Snow and Fitzpatrick 1989; Willey and Scott 1996) has been evaluated by bioarchaeologists in an attempt to extract information on the traumatic injuries sustained by individuals involved in these conflicts. In both cases, historical documentary sources and first-hand accounts of the battle were compared with the available skeletal and archaeological evidence to more securely establish what battle conditions and soldiers' experiences were like. Therefore, these studies have similar analytical objectives and involve the use of skeletal material from individuals who also died in battle contexts during a roughly contemporaneous period to the individuals comprising the Smith's Knoll sample. This allows the Snake Hill and battle of the Little Bighorn samples to act as comparative material for the types of injuries that can be sustained as well as the interpretations that can be made based on these lesions. These studies represent what is available in the bioarchaeological literature

for skeletal analysis of battle-related material from this time period, and therefore archaeological comparison is mainly restricted to these sites despite significant differences in assemblage composition and formation processes.

Scott et al. (1989, 1998) examined skeletal remains from the battle of the Little Bighorn in 1876. The skeletal sample consisted of elements that remained buried with the marble markers indicating locations of burial on the battlefield after the majority of the remains had been removed and reburied in a mass grave in 1881. Therefore, the skeletal elements remaining had undergone considerable disturbance and had either been missed or rejected by those selectively collecting remains for reburial. Osteological analysis of these remains revealed several forms of perimortem trauma, including blunt force trauma predominantly represented by extensively fragmented cranial vaults and facial skeletons, sharp force trauma including both incised and chopping marks, and several gunshot wounds (Snow and Fitzpatrick 1989). The weapons utilized during this battle differed from those present at the battle of Stoney Creek; this is partially reflexive of the fact that the circumstances of the battle including the strategies, motivations, and identities of the participants were quite different. Native American weapons such as tomahawks played a major part, and in the time between the two battles new firearm technologies were developed. However despite these differences, the types and patterns of injuries sustained by soldiers during the battles are quite similar. Although firearm technology may have progressed, the bullets used were still large low-velocity projectiles that caused injuries similar in appearance to those sustained in 1813. The ways in which these samples differ

can be just as informative regarding battle conditions and soldier experience as the ways in which they are similar.

Skeletal trauma analysis has also been performed on soldiers from Snake Hill, another southern Ontario War of 1812 site (Pfeiffer and Williamson 1991; Litt et al. 1993). The Snake Hill sample is likely made up of American soldiers who were buried in a cemetery that is thought to have been associated with a military hospital. The sample consists of individual burials as well as three medical waste pits containing amputated limbs. Unlike Smith's Knoll, these individuals likely survived their battle injuries for at least a brief period and died later in the hospital, rather than perishing on the battlefield (Litt et al. 1993). Trauma was indicated in this sample by direct skeletal evidence as well as indirect archaeological evidence in the form of musket balls preserved within the burials in association with the skeleton. Osteological evidence included perimortem fractures and gunshot trauma, as well as evidence for immediate surgical care to treat the wounds incurred during battle. In addition to the analysis of trauma, the sample was also evaluated for basic osteobiographical information as well as isotope ratios to indicate diet and possible geographic origin (Pfeiffer and Williamson 1991). This provides more information about the special subset of the population from which both this sample and the Smith's Knoll sample are presumably derived, thereby allowing further contextualization of data from Smith's Knoll. Information from the analysis of the Snake Hill and battle of the Little Bighorn samples are particularly valuable because bioarchaeological information that can be used comparatively is relatively rare for North American populations from this early historic period (Owsley et al. 1991). Due to the

similarities that allow these samples to be compared, data regarding both the ways in which these samples are similar and how they differ can be used to inform our interpretations of the skeletal material from Smith's Knoll.

Chapter 4: The Battle of Stoney Creek in the War of 1812

The individuals in the Smith's Knoll sample were involved in the battle of Stoney Creek, an altercation that was part of the War of 1812 (see Chapter 2). In order to provide context for the circumstances surrounding the later life and death of these individuals, this chapter will provide background information on the War of 1812 more generally, as well as on the battle of Stoney Creek and how this battle relates to the events of the rest of the war. Accounts of the battle can provide an indication of the types of weapons that were used and the types of injuries that individuals may have sustained, allowing a more nuanced interpretation of the skeletal lesions evident in the sample. Historical context provides an excellent idea of the range of possibilities for injuries sustained during the battle and potential causes of death that may have led to these individuals' inclusion in the sample.

4.1 Causes leading to the outbreak of war, 1812

The war of 1812 was a conflict that erupted between Britain and the United States as a result of several sources of tension between them. After the War of Independence in which the United States gained independence from British colonial rule, there was significant American resentment over issues that remained unaddressed following the Peace of 1783 (Lucas 1906; Sutherland 2001). Combined with American indignation over the negative effects that the Napoleonic wars had on them as a neutral power, this

resentment led to an increasingly large faction of the United States Congress in favor of a war against Great Britain.

As a result of their ongoing conflict with France, Britain instituted several policies that incited the resentment of the United States. Predominant among these policies were the British Orders in Council, which restricted the trade of neutral powers with France and imposed a naval blockade of France and its allies. The naval supremacy of Britain at this time made these policies particularly effective, and the negative effect on American trade interests was enough to cause serious tension between the two nations (Lucas 1906). Britain also reserved the right to search neutral vessels on the Atlantic for British deserters and to seize these individuals; this policy of impressment was interpreted as an infringement upon American liberty, and furthermore the Americans maintained that the individuals seized were sometimes American citizens (Hannay 1905). As the Americans continued to expand further west, they encountered major difficulties with the Native American populations living in the territories they were attempting to settle. This situation also served to increase resentment towards Great Britain, as many Americans accused the British of inciting the Native Americans to fight and even of providing them with weapons (Sutherland 2001). The faction of representatives in Congress that were favorable to the declaration of war continued to grow steadily, and the tone of Congress became more warlike (Hannay 1905). The official reasons for the declaration of war, as stated in communications between President Madison and Congress at the beginning of June 1812, were the refusal of the British to revoke the Orders in Council, interference with American trade resulting from these and other British policies, the blockade of

American ports, the impressment of American seamen, and the Indian question (Lucas 1906).

In addition to the anger and resentment caused by the nature of interactions between the United States and Britain following the Peace of 1783, the war was partially the result of an American desire to take control of the continent. The major aim of the United States in declaring war was to conquer and annex Canada, thereby eliminating the British from North America (Hannay 1905; Lucas 1906). Canada was an attractive prize for the Americans, being full of rich agricultural land and with large expanses of territory that appeared to be sparsely settled and poorly defended (Sutherland 2001; Elliott 2009). The United States expected the conquest of Canada to be an easy victory, as many of the residents of Upper Canada had relatively recently emigrated from the United States (Hannay 1905); a large number of Loyalists, sympathetic to Great Britain, had left the United States during and immediately following the War of Independence and settled in Upper Canada. While it is true that many residents of Upper Canada had relatives still living in the United States and some may even have been sympathetic to the American position, the Loyalists living in Canada were largely still resentful of the way that they had been treated following the Revolution and were not likely to welcome an American invasion with open arms (Lucas 1906). The United States remained loudly confident that they could easily conquer the small British forces defending Canada and that victory would be "a mere matter of marching" (Sutherland 2001, i). Some indication of the fallacy of this attitude was provided by the Canadian reaction to the events surrounding a naval conflict in 1807. In response to the refusal of an American frigate to allow the

British their right of search for deserters on board, shots were exchanged and some American crew members were killed, wounded, and taken prisoner; this resulted in talk of an American invasion into Canada. In response, the Canadian militia was called out and this call for volunteers was met with an enthusiasm that unfortunately only briefly dispelled the common belief that Canadians would be sympathetic to and cooperate with the invading American force (Lucas 1906).

Support for declaring war was far from unanimous within the United States; the northern states, particularly New England, were most opposed to the idea of war. As these territories were located closest to Upper Canada, many in the northern states had relatives living across the border and therefore their moral support for the war was dubious. As well, those of the northeastern states with the most extensive commercial interests were opposed to an action that had the potential to eliminate the trade that had not been too seriously disrupted so far by the European war (Sutherland 2001). Being further removed from the conflicts with Native Americans in the west of the country, the northern states did not really have an interest in the Indian question or in war as a radical solution. As a result, many in the New England states were openly disapproving and therefore their support in the form of finances and volunteers was dramatically reduced (Fredriksen 1984).

At the outset of the war, neither side was fully prepared to enter into such a conflict. The British force consisted of well-trained career soldiers and professional officers (Elliott 2009), and Great Britain maintained naval supremacy on the Atlantic and the ability to utilize the blockade of American ports to impact them commercially. Their

troops were better organized, trained, and equipped. However, despite these potential advantages the resources of Great Britain were stretched thin by the conflict with Napoleonic France. In addition, the Canadian territory was inherently difficult to defend, given the very long frontier entirely exposed to American invasion (Lucas 1906). The United States had the advantage of a much larger population to draw recruits from as well as greater wealth and resources that could be devoted to the conflict. However, their military did not have adequate organization and the majority of their soldiers and even military leaders had limited experience and training (Elliott 2009). As well, the United States had more to lose from this war than the British because of its close proximity to home. The war laid open not only the Canadian border but also their own to attack by Native Americans and counterattack by the British forces; the Americans were also vulnerable to naval attack along the Atlantic seaboard (Lucas 1906). For the Americans, this was a war of offence rather than defense. This meant that traditional rationalizations of war for the protection of home and liberty were not available to Congress as a potential justification. However, for Canada this was a fight for liberty and for the existence of their colony as they then knew it (Lucas 1906).

4.2 The beginning of the Niagara Campaign, May 1813

Despite American expectations of a rapid victory when the war began, months went by and this situation failed to materialize. Although the United States attempted two invasions of Canada in 1812, neither was successful due to a combination of American inexperience and ineptitude and the aggressive actions taken by the British (Sutherland

2001). By the spring of 1813 the United States had intensified their efforts to move into Upper Canada, and on May 27th they launched a successful attack on Fort George in present day Niagara-on-the-Lake (see Figure 4.1).

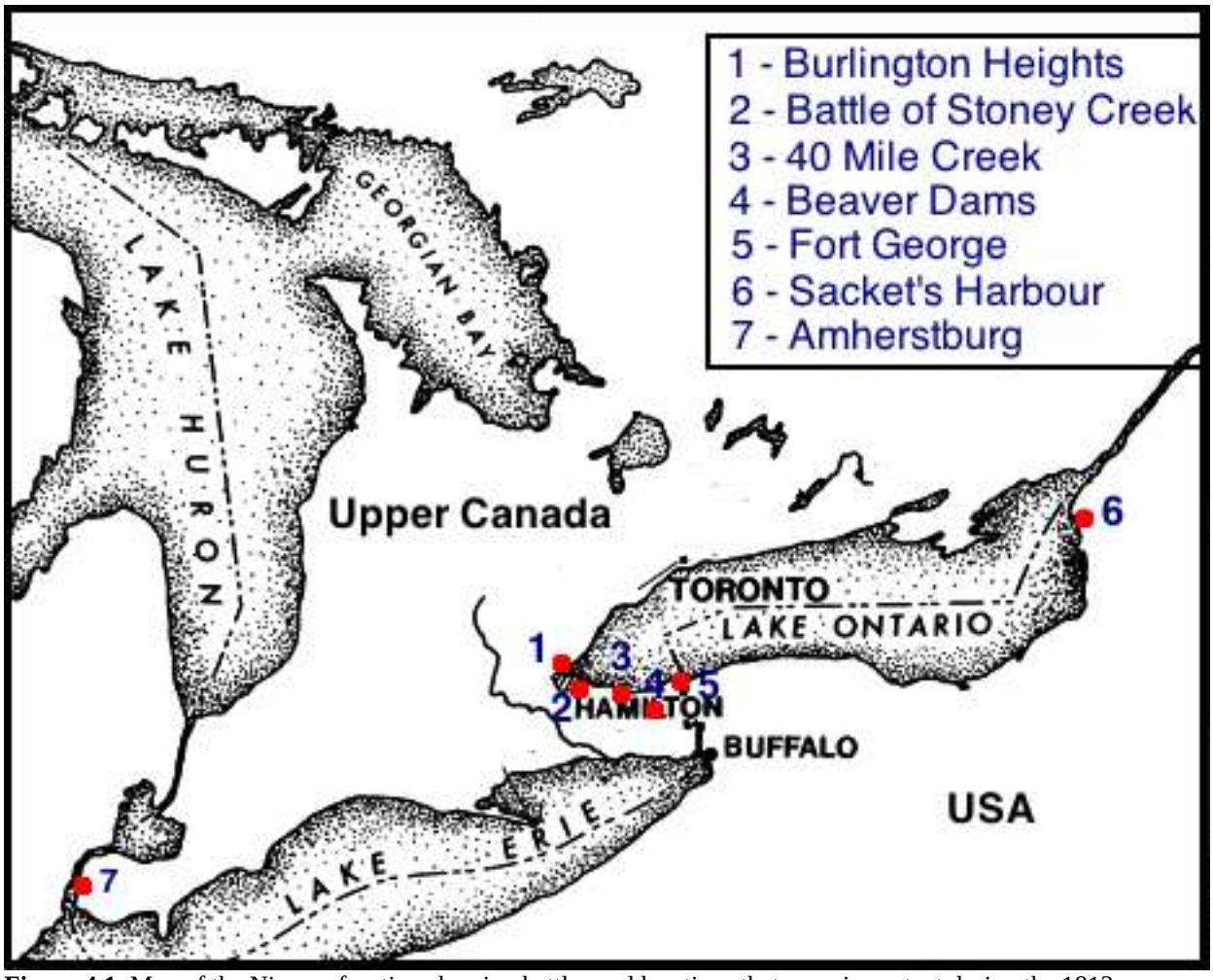

Figure 4.1. Map of the Niagara frontier, showing battles and locations that were important during the 1813 Niagara Campaign.

4.2.1 Fort George

An American force attacked Fort George, a British outpost, on May 27th, 1813. Naval forces under the American Commodore Chauncey fired on the fort, clearing the

way for American infantry to land and attack the fort from the rear. The British brigadier-general, Vincent, realized that he would not be able to hold out long against superior American numbers and decided that the only choice was to retreat inland. He gathered all of his forces and retreated back towards Queenston, stopping at Beaver Dams (see Figure 4.1) where the British had established a storehouse of provisions (Elliott 2009). Vincent paused here to gather supplies and meet with a few regiments of reinforcements; then the British force consisting of about 1,600 regulars or professional soldiers continued their retreat to 40 Mile Creek and finally to Burlington Heights (see Figure 4.1). At this point the militia, or ordinary citizens from the surrounding area recruited for the defense of Upper Canada, were dismissed and told that they were free to return to their homes; there is some indication that many of the militia had deserted prior to this point in order to protect their families and tend their fields. The British officers were therefore uncertain of the militia's service and Vincent thought it best that they return home (Hitsman 1965). Not all of the militia obeyed this order however, and a few militia members were likely present at the battle of Stoney Creek (Sutherland 2001)

The capture of Fort George was an important strategic victory for the United States, giving them a foothold in Canada and allowing them to take the offensive. The loss of Fort George left British positions all along the Niagara frontier exposed to the Americans (Lucas 1906; Hickey 1989). However, most accounts of this period in the war agree that the United States failed to follow up on their advantage, and that their failure to capitalize on the situation contributed to the ultimate failure of the 1813 campaign (Fredriksen 1989; Sutherland 2001). Although the British had suffered significant

casualties at Fort George, their force was still intact and was allowed to retreat all the way to Burlington Heights before being pursued, which would eventually cost the Americans greatly (Hitsman 1965; Hickey 1989). Decisions like this serve to illustrate the inefficiencies of the American military command, which had many officers with dubious experience and leadership ability, a lack of communication, and personal competition between officers that superseded the concerns of the army at times. Official American strategy, stating that offensive movements needed to be prompt and most importantly faster than the enemy, was ignored (Elliott 2009).

The American general, Dearborn, delayed in ordering an American force to pursue Vincent as he retreated northward. It was not until June third that he ordered for a force under Brigadier-General Winder to march to Burlington Heights to cut off the possibility of communication between Vincent and Prevost, who was occupying Amherstburg (see Figure 4.1). Another few detachments under Brigadier-General Chandler were dispatched the next day to join Winder's forces, and the combined American force camped on June fourth at 40 Mile Creek. Estimates of the size of this force differ in various accounts; it likely consisted of at least 3,000 men and included infantry, cavalry, and artillery units. At any rate, it was significantly larger than the British force of roughly 1,600 men.

4.2.2 Sacket's Harbor

At the same time as these land operations at Fort George and the retreat toward Burlington Heights were occurring, a British naval offensive was attempted on Sacket's

Harbor at the eastern edge of Lake Ontario (see Figure 4.1) that would affect the outcome of the Niagara Campaign. Throughout the War of 1812 in Upper Canada naval control of the lakes was extremely important for communication, a fact that was not fully appreciated by either side before the conflict began (Lucas 1906). With an expanse of land as large and undeveloped as Upper Canada was at that time, land transport was extremely slow and difficult. This meant that the only truly efficient way to transport supplies and reinforcements was over water, and naval control enabling access to the waterways therefore became vital (Hannay 1905; Lucas 1906). Despite Britain's naval supremacy on the seas, the war with France left them fewer ships to devote to the defense of their North American territory, and the United States' ships proved to be more efficient than anticipated. The two navies were therefore able to vie for control of the lake fairly evenly throughout 1812. By May of 1813, the United States had begun to construct a corvette that would vastly improve their naval capacity and push the quality of their navy above that of the British, tipping the scales in their favor. Commodore James Yeo, the commander of the British fleet, saw that in order to make a decisive strike at the American navy he would have to act while the two navies were still more even and the British may even still have a slight advantage (Elliott 2009). Sacket's Harbor provided that opportunity.

Sacket's Harbor was the location of the American fleet, and when Chauncey left the base to participate in the attack on Fort George it was left open to British designs (Elliott 2009). On May 29th, 1813 Yeo and a British naval force sailed to Sacket's Harbor to attack the relatively undefended remainder of the American fleet as well as the new

ship under construction. Due to unfavorable winds, the British decided to wait off the coast overnight. There was some skirmishing with ships coming into the harbor, which served to alert the Americans to the presence of the British and allow them to prepare for an attack. Despite American preparations the British entered the harbor the next morning and managed to land troops on one of the islands. Heated fighting occurred, and British casualties were heavy. The British decided to retreat despite having done little damage and having lost significantly more men than had the Americans (Hitsman 1965).

Although relatively little damage was done to the American fleet during this attack and it appeared to be a British defeat, this altercation did have important consequences for the Niagara campaign. When Chauncey learned of this attack on his naval base, he immediately returned to Sacket's Harbor to survey the damage that had been done. This aggressive action by the British made Chauncey extremely cautious and unwilling to leave his base unattended again; therefore for the rest of the Niagara campaign he did not venture out of the harbor and the lake was left to be traversed freely by the British navy (Elliott 2009). This naval supremacy allowed Yeo to supply Vincent's troops with reinforcements and supplies, and in the events following the battle of Stoney Creek the freedom of the British navy to roam unchecked had important consequences for the conduct of the American army.

4.3 The battle of Stoney Creek

The narrations of the events that occurred during the battle of Stoney Creek by secondary authors are based on several primary accounts of the battle written by both

British and American soldiers. In addition to official dispatches (Hannay 1905; Lucas 1906), secondary sources directly quote accounts written by many soldiers including Americans such as General John Chandler, William Duane, William Dunlop, Joseph Dwight, Jonathan Kearsley, James Mann, Patrick Macdonough, George McFeely, Mordecai Myers, John Patterson, Cromwell Pearce, Isaac Roach, and Lieutenant General Winfield Scott, and British soldiers such as Captain Ephraim Shaler and Joseph Lee Smith (e.g. Hitsman 1965; Turner 2000; Elliott 2009).

I was able to access several of the primary sources directly, namely those that have been reprinted with commentary by secondary authors. The primary sources that were accessible are the writings of Captain William Hamilton Merritt, Captain Ephraim Shaler, and Colonel James Burn. The journals of William Hamilton Merritt, a captain of the British volunteer dragoons, can be found in a volume edited by Sutherland (2001). The memoirs of Captain Ephraim Shaler of the 25th US Infantry are reprinted verbatim in an article by Fredriksen (1984); the letters of Colonel James Burn, an American officer who played an important part in the outcome of the battle, were reprinted in a later article by Fredriksen (1989). No other primary sources were readily available as many are published only in local archives or are not widely circulated, so for additional information I was reliant upon the secondary sources.

4.3.1 Events of the battle

By June fifth, 1813 the British force was encamped at Burlington Heights and had had the chance to strengthen their position. Burlington Heights was a relatively strong

defensive position for the British, and it afforded them access to the lake for communication and reinforcements, land routes to York and Kingston, and a line of communication with Prevost (Fryer 1986). However despite the advantages of this position, Vincent knew that he would be unable to hold it against the American army with the small number of troops available to him (Cruikshank 1913; Turner 2000). The British position at this point was rather desperate, and Vincent was trapped between trying to stand up to the onslaught of an American offensive and retreating around the lake with his troops already weary and no naval support (Elliott 2009).

As Vincent was regrouping at Burlington Heights, Chandler and Winder advanced with their brigades towards Vincent's position. They encountered a British advance guard and skirmished with them briefly, pursuing them back towards the British camp. It has been suggested that this pursuit led the Americans closer to Burlington Heights, and caused them to encamp much closer to the British position than they had planned to (Elliott 2009). The American encampment was set up at Stoney Creek, on the property of the Gage family. The position itself was quite strong, as it was bordered on one side by the slopes leading up to the escarpment and on another by a swamp; this meant that the camp could only be attacked from the front (Turner 2000). Despite the natural advantages of the chosen site however, the American generals did not properly secure and organize the camp to ensure that it was impenetrable. As a small party of British soldiers led by Harvey quickly discovered when they reconnoitered the American position in the evening of June fifth, that the camp was not organized in battle formation, rather each unit was left to camp where they pleased with no thought to quick formation in the case of an attack.

The line of the encampment was long and broken, the artillery was inadequately supported, and many of the troops were placed awkwardly in the rear and unable to assist with defense against a frontal attack (Hannay 1905; Fryer 1986). As well, the sentries placed were too few, and they were not sufficiently alert to properly protect the encampment. The advance guard stationed at the nearby Methodist church was composed of the company of riflemen who had participated in the skirmish earlier the same afternoon; they were exhausted and even their commander was worried that they would be unlikely to stay alert and awake (Elliott 2009). Several American soldiers readily recognized the disadvantages of such an encampment as well. As the first-hand account written by Captain Ephraim Shaler notes, "this was a great military blunder… being in an enemy's country and within a few miles of a large body of well disciplined troops… the whole brigade should have been encamped in regular military order" (in Fredriksen 1984, 416). The poor organization and protection of the American campsite left it vulnerable to attack; many accounts suggest that the Americans expected an easy victory the next day.

Harvey's party returned to Vincent at Burlington Heights and relayed what they had seen at the American encampment. Based on the weaknesses of the American defense they suggested that a night raid might be met with some success. Vincent's situation was desperate, and a night raid while daring and risky presented possibly the only chance for the British to snatch success from an almost hopeless situation (Marquis 1926). Vincent therefore agreed with this plan, and chose 704 regulars, roughly half of his force, to participate; Vincent accompanied the party but left Harvey in charge of the operation. The small force was composed of detachments from the 49th Regiment, the Eighth or King's

Regiment, and a few militiamen (Fryer 1986; Elliott 2009). They set out from Burlington Heights at around 11pm, with flints removed to prevent against accidental misfire and preserve absolute silence, and marched toward Stoney Creek (Dale 2001).

Although Chandler and Winder do not appear to have expected a British attack that night, there is some indication that it did not catch all detachments of the American army by surprise. The memoirs of Ephraim Shaler, the second lieutenant of the United States 25th Regiment, suggest that this regiment at least was alerted to the possibility of a British raid (Fredriksen 1984). The 25th was originally stationed in the road directly in front of the artillery as part of the advance guard along with one other detachment. However, before settling down for the night Smith, the commander of this regiment, insisted that an attack may occur and the 25th should move to higher ground, organize into battle formation, and sleep on their arms (Fredriksen 1984; Elliott 2009).

Accounts detailing how the British force got past the first few American sentries are contradictory. Many suggest that the British obtained the American countersign from a source, usually cited to be a paroled prisoner (Hitsman 1965; Caffrey 1977; Hickey 1989). Some maintain that the countersign was obtained from the first sentry who was taken as a prisoner, and that it was then used to fool the next sentry (Elliott 2009). Certainly the few sentries that the British encountered during their approach were quickly taken prisoner or quietly bayoneted. The advance guard, sleeping, as their commander had feared, in the Methodist church, was easily captured (Elliott 2009). Most accounts agree that one of the last sentries was alerted to the presence of the British as he heard the

dying groan of one of his colleagues who had been silently bayoneted; this man is said to have fired his musket in warning and thereby at least partially roused the rest of the army.

Whether or not the element of surprise was ruined by the sound of a sentry's shot, all semblance of surprise disappeared with the conduct of the British soldiers as they entered the American camp (Fryer 1986). Many sources suggest that the British soldiers were unsettled by the stress of the situation and the extreme enforced silence during their march, and they reacted to the culmination of this pressure by setting up a great yell along the line (Sutherland 2001). Shouting, they ran into the road in front of the main body of the American army and encountered campfires around which were only a few cooks; they killed some and the rest quickly fled (Fredriksen 1984). This was the road in which the 25th had originally been stationed, however since they had moved the British did not immediately encounter American soldiers as they had expected. Many of the British soldiers stopped by the light of the fires to fix their flints and load their muskets, which unfortunately only served to illuminate them as targets for the American soldiers who had recovered from their surprise enough to fire their muskets (Elliott 2009). The British sustained heavy fire while in the road, and some accounts suggest that most of the British dead lay here after the battle (Fredriksen 1984; Elliott 2009).

One element of the battle that all accounts agree on is the extreme confusion and disorder of this short conflict in the pitch dark. The British tried to advance several times and fell back, and just when the situation was critical for the British and it looked as though all were lost, Major Plenderleath of the 49th Regiment heard the artillery much closer than he expected and led a small party of his men towards it. The British captured

the artillery, which was inadequately protected by infantry units and whose gunners had not been provided with small arms for their own defense (Elliott 2009). The great importance of Plenderleath's charge is emphasized in many accounts, including the first-hand account of the battle written by Captain William Hamilton Merritt of the provincial cavalry. He writes "had not Colonel Plenderleth [sic] charged and captured their Guns, with 30 men, we should have been completely defeated" (in Sutherland 2001, 6).

In the confusion following the capture of the artillery, General Chandler had his horse shot out from under him, and in recovering from this shock he wandered into a company of men he assumed to be his and tried to direct their movements. Unfortunately this was actually the party of British soldiers that had just captured the artillery; they quickly took him prisoner (Elliott 2009). Winder was captured soon after in much the same fashion. The role of cavalry in this battle has been debated. Although they were certainly present and some accounts suggest that an American cavalry charge was attempted (for example Marquis 1926), others have shed doubt on this saying that a cavalry charge in the dark and the confusion would not have been practical and may have done more harm to the Americans themselves than to their enemy (Fredriksen 1989).

With both generals taken prisoner, the American army was left without the head of their command structure, a significant factor in the favorable outcome of the battle for the British (Fryer 1986). The British army was also largely without focus, as many British soldiers had fled into the wood in the confusion of the first few bayonet charges that had been so brutally repulsed by American musket fire; in fact Vincent narrowly escaped capture himself as he got lost during the battle and was not found until the next day. As

daylight neared Harvey decided that it would be best to retreat, so as to hide the small size of their force and if possible prevent or delay American pursuit and counterattack (Dale 2001). The Americans retreated from this battle with fewer losses, but left the British in control of the field (Hickey 1989). Coles (1965, 141) summarizes the outcome of the battle quite succinctly with the statement, "the British suffered severely, but the Americans broke first."

4.3.2 Events following the battle

Immediately following the battle the British forces retreated to Burlington Heights where stragglers from the battle continued to stream in, assuaging initial fears about the extent of British losses. The official figure for the number of British soldiers killed in the battle is 23, which is cited relatively consistently in accounts of the battle (Elliott 2009). Many more were wounded or taken prisoner.

The American army was still in a state of confusion, with both generals lost to the British as prisoners and a power vacuum at the top (Elliott 2009). Next in command was determined to be James Burn, a cavalry officer who had limited knowledge of infantry tactics and of the composition and situation of the army. As he wrote in a letter after the battle, "I commanded the advance and I did not even know the regiments that composed the Army" (in Fredriksen 1989, 305). Unsure of what to do, he called a council of officers and with the general consensus (although not without serious dissent) he decided that the American army should fall back to 40 Mile Creek to await reinforcements and further orders. The men were exhausted and short of ammunition, and this seemed to him to be

the best course of action (Fredriksen 1989). The Americans briefly returned to the field of battle to destroy their supplies, but most accounts agree that the American dead were left on the field (Hannay 1905; Fredriksen 1984; Elliott 2009). The number of American soldiers who were killed in this battle is not certain; official accounts suggest that only 17 soldiers died in the conflict but eyewitness accounts suggest that there were many more, some citing 61 dead from both sides (Elliott 2009). There are several reasons these numbers may have been manipulated in official accounts, including the attempt to protect the reputations of those in charge and to present the battle as more a victory and less an embarrassment for the American army.

The British returned to the battlefield to bury the dead from both sides. Some of the bodies were buried in the cemetery of the Methodist church, and others on the knoll on which the American artillery had been stationed (see Chapter 2). Most accounts do not discuss the nationality of the soldiers buried in either of the two mass graves; the only sources that make mention of this issue suggest that the dead from both sides were buried together without separation based on nationality (Elliott 2009).

4.3.3 Injuries sustained during the battle

Several pieces of information contained in accounts of the battle outline the types of weapons that were present at the battle and the types of injuries that resulted from their use. For example, the British advanced into the American camp with bayonets fixed, and there is also mention in the accounts of the use of swords (Elliott 2009). Muskets were definitely used during the battle, with the British using the Brown Bess flintlock musket

and the Americans the 1795 Springfield flintlock model. Conditions as described in the accounts were chaotic, with close hand-to-hand fighting and a lack of normal battle lines and typical strategy. Some of the accounts directly mention injuries sustained during the battle, such as falls from horses, bayonet injuries in the hip, musket injuries to the head, and limbs splintered and shattered by musket balls (Elliott 2009).

The memoirs of Captain Ephraim Shaler of the 25th Regiment contain specific information about the use of muskets by this detachment. This account states that rather than using the usual American ammunition arrangement of a musket ball topped by three buckshot, the 25th loaded their guns that night with 12 buckshot and no ball (Fredriksen 1984). This was said to be extremely effective against the British, especially at close-range, because the shot had a much wider spread than normal ammunition would. As Shaler states in his account, "such was the effect of our buckshot, at close quarters, that no troops, however well disciplined, could long stand before such a shower as was poured upon them from the gallant 25th," (in Fredriksen 1984, 418-9).

While it may seem that this would provide information only on injuries that could be observed in the skeletal remains of British soldiers, this is unfortunately not the case. All sources agree that conditions during the battle were marked by extreme confusion, and several accounts directly mention the possible occurrence of friendly fire (Shaler in Fredriksen 1984; Burn in Fredriksen 1989). It is said that the darkness of the night and confusion in the heat of battle meant that no one could tell who they were shooting at, and many out of fear may have stabbed or shot at anything that moved. As Colonel James Burn wrote in a letter following the battle, "it was so dark it was impossible to distinguish

friend from foe" (Fredriksen 1989, 305). This is corroborated by the account of Ephraim Shaler, who writes, "none could distinguish friend from foe; consequently all concert of action was lost, and confusion ensued: - our men often firing upon each other by mistake" (Fredriksen 1984, 419). Therefore buckshot injuries may also be found in the remains of American soldiers, and this although tempting is not a reliable way to infer the identity of any of the individuals in the sample.

Several of the accounts mention that some of the American cooks were struck down by British soldiers at the beginning of the battle (Fredriksen 1984; Fryer 1986; Elliott 2009). Since no discrimination was apparently made between the bodies as they were buried, this raises the possibility that the bodies of these cooks were buried along with soldiers killed during the battle. If this is true, there is the possibility that some of the elements we have recovered come from individuals who, although they did accompany the American army in the Niagara campaign, may not have actually been soldiers; this should be considered in the analysis.

4.3.4 Significance of the battle of Stoney Creek

The battle of Stoney Creek is often cited as a decisive battle, one of few in the war of 1812 (Turner 2000). Although small in scale, it was extremely important in that it turned the tide of the Niagara campaign and determined the direction of the remainder of the war. Although the American army had swept into the Niagara peninsula poised for victory and supported by vastly superior numbers, they were suddenly attacked and forced to retreat with their confidence depleted (Lucas 1906). The American defeat at

Stoney Creek effectively ended their advance into Upper Canada and began the process of their retreat back to Fort George and eventually out of Canada altogether. This defeat demonstrated the lack of strong leadership within the American army; although the Niagara campaign had a strong beginning with the victory at Fort George the Americans were unable to consolidate their gains and were eventually pushed out of the peninsula (Sutherland 2001). The outcome of the Battle of Stoney Creek tipped the odds no matter how slightly in favor of the British, allowing them to push forward with renewed confidence (Caffrey 1977).

4.4 The end of the Niagara campaign, June-July 1813

Following the American retreat to 40 Mile Creek, the British were assured that there would be no American counterattack, at least not immediately. The defeat at Stoney Creek was very demoralizing for the American army, and their retreat was not a jaunty one (Hannay 1905). When they reached 40 Mile Creek, events conspired to further lower their morale and push them to retreat all the way back to Fort George. Yeo, left free to roam with the British navy on Lake Ontario, brought some ships to harass the Americans at 40 Mile Creek; this luckily coincided with attacks by a small band of Native Americans on land. The threat to their line of communication that these attacks represented was worrisome to the American officers (Hitsman 1905). Orders arrived ordering the recall of the troops to Fort George, where British ships had been sighted off the coast and Dearborn feared an attack. In this situation, the defeat at Stoney Creek and the

circumstances following the American retreat combined to lower American morale and further strengthen the British advantage (Elliott 2009).

As the Americans retreated back from 40 Mile Creek to Fort George they were constantly harassed by Yeo, who also managed to capture several American boats carrying supplies. The American retreat gave the British the opportunity to go on the offensive, and they moved their encampment up to 40 Mile Creek. An advance guard under Fitzgibbon was posted near Beaver Dams, and through constant skirmishing with the Americans prevented them from becoming complacent (Hannay 1905). An attempt by the Americans under Boerstler to destroy Fitzgibbon's force went awry when Fitzgibbon learned of the attack and managed to turn it around with the help of several groups of Britain's Native allies, who surrounded and terrified Boerstler forcing him to surrender to the British at the first opportunity (Lucas 1906).

With the two major American reverses at Stoney Creek and then Beaver Dams, Dearborn decided to pull his forces from all other positions along the Niagara frontier save his one last outpost at Fort George (Fredriksen 1989). The reverses served to highlight Dearborn's incompetence, and he was withdrawn from command. Fort George, too, was eventually abandoned by the Americans; with the American retreats the British were back in their original position (Jacobs and Tucker 1969), quickly taking the opportunity to fill the void left by the retreat of the American troops. Stoney Creek was the high water mark of American penetration into Upper Canada, for the remainder of the war the United States army never again reached this far into enemy territory (Elliott 2009).

4.5 The end of the war, peace 1814

Although the war was not to end for more than a year after the effective conclusion of the American invasion of the Niagara peninsula in 1813, Upper Canada was never again to be the main theater of war the way it had been in the spring of 1813. The tide of war swept back and forth between the British and the Americans in that final year, with victories and defeats on both sides. However, neither side was clearly able to gain the upper hand and score a decisive victory against the other. Eventually, peace negotiations began in Europe and a peace agreement was finally concluded; the Treaty of Ghent was signed August first, 1814 (Lucas 1906). The treaty settled several questions that remained to be answered between the British and the Americans, including the definition of the border between the United States and the Canadas. Strangely, by this point in the war peace had been restored in Europe and so the original reasons for its declaration were no longer relevant (Lucas 1906), no mention was made whatsoever of the Orders in Council in the treaty agreement. The treaty essentially restored many of the same conditions as the prewar state (Sutherland 2001).

The war of 1812 is often looked upon as a relatively insignificant conflict, of which neither the British nor the Americans really have any reason to be proud (Lucas 1906). However, the war does provide an illustration of the extreme difficulty of conquering a large territory, even if it appears to be inadequately defended, as well as the importance of water communication in such a situation. As well, while the war may not have been of vital importance to Britain or to the United States, it can be considered the "national war of Canada" (Lucas 1906, 259), an event that served to pull together the

different factions living in British North America in the early nineteenth century and effectively marked the beginning of what would become Canadian nationalism.

Chapter 5: Methods

The current reanalysis of the Smith's Knoll material began with a complete re-inventory of the entire collection. Previous analyses had labeled most of the fragments and organized them by element. However, there were no records available with information about each fragment. The archaeological reports indicate that there were 770 identified elements in the collection (Griffin-Short 2000).

5.1 Cataloguing

The collection was catalogued with the goal of creating a database containing detailed information about each of the Smith's Knoll fragments. As the collection will be reburied when the current analysis has been completed, it is important to preserve as much information as possible so that future researchers may have the data necessary to study the collection without access to the fragments themselves. Creating a detailed inventory of the bones that are present in a collection is essential not just to preserve information that may not be available in the future, but also to demonstrate the meaningfulness of the results; a reported absence or low frequency of a particular type of lesion is meaningless unless it can be demonstrated that the elements upon which this condition would appear were available for analysis in the first place (Grauer 2008). Information about each fragment was originally recorded in Microsoft Excel spreadsheets specific to each element; these spreadsheets were then combined and the information inputted into a database created using Filemaker Pro 2011 software.

The information to be collected from each fragment was partially determined by the requirements of the analyses to be performed. It was important to balance the need to record as much information as possible and the time constraints set for the analyses themselves. To begin, each fragment was identified by element and the data for each recorded in the appropriate spreadsheet. Every identifiable fragment was given a unique number beginning with SK for Smith's Knoll, which had not been done in previous analyses. Some fragments had been previously labeled with letters; if present this label was recorded as well. These letters assigned during the previous analysis identified the trench in which the element was found (Griffin-Short 2000). Some elements were also labeled with numbers on small pieces of tape. These numbers were recorded if present although it was not clear what they correspond to. More specific details about the identity of the bone were recorded if applicable, for example information on the side of the bone and the number for elements like metacarpals, metatarsals, and ribs. For the phalanges, we recorded whether the fragment was proximal, intermediate, or distal. For the vertebrae, type (cervical, thoracic, or lumbar) was recorded as well.

Completeness was recorded using the zonation method adapted by Knüsel and Outram (2004) for use on human bone from a method originally developed for zooarchaeological remains (Dobney and Rielly 1988). This method is designed for use on fragmentary human remains, for which other systems of recording completeness that are centered on the expectation of largely complete and isolated human skeletons (for example Buikstra and Ubelaker 1994) may not be appropriate (Outram et al. 2005; Knüsel et al. 2007). In this method, each element is divided into zones based on common

postmortem breakage points, providing a more detailed breakdown of the entire bone including the diaphyses (Knüsel and Outram 2004). This allows for the percent completeness to be easily calculated for each element by dividing the number of zones present by the total number of zones for that element (information regarding the number of zones per element is provided in Appendix I). A zone was recorded as present if a fragment had any part of the zone, so this method may tend to slightly overestimate completeness. However each zone is relatively small, minimizing overestimation. For elements for which zones are not provided by Knüsel and Outram (2004), such as the patella, percent completeness was estimated directly and recorded in 25% ranges.

In order to better quantify fragmentation, the size of each fragment was also recorded based on the categories provided by Knüsel and Outram (2004). In order to determine the size class of a fragment more quickly, circles were printed with diameter ranges of 10mm. The smallest range into which the fragment completely fit was recorded as its size.

Information on age and sex were recorded whenever possible using the age categories set out in Buikstra and Ubelaker (1994). Determination of the age of fragments usually relied on evidence of the stage of epiphyseal fusion, with fully fused fragments classified as adult and unfused or fusing fragments classified as young adult or adolescent based on the timing of fusion of the particular element. Information on sex was only recorded for fragments of the pelvis and a few fragments of the mandible.

Information was then recorded on modifications to the bone that may have occurred during life, around the time of death, or following death. The presence of

traumatic lesions was recorded by noting the presence or absence of antemortem trauma, perimortem trauma divided into the categories of musket injuries, sharp force injuries, and fractures, or postmortem trauma. The presence or absence of perimortem disturbance fractures was also recorded; this term refers to fractures that have some characteristics indicating the bone was likely fresher when the damage occurred, for example hinge fragments or splits from the breakage, but it is clear that the damage definitely occurred postmortem. More specific notes were recorded if any of these categories of trauma or postmortem disturbance fracture were present on a fragment. Postmortem breakage was recorded as present or absent, as was reconstruction during previous analyses. If reconstruction was present, a detailed description was provided. The degree of weathering was also recorded, which was important due to the relatively poor preservation of many of the fragments in the collection. The weathering stages used were graded from 0 to 5, following those outlined in McKinley (2004). In terms of recording pathological lesions, the presence or absence of new bone formation and pathological lesions more generally were recorded; if present, detailed notes were made.

An "other" column provided for the recording of anything else of interest on each fragment, including for example individual variation or mold. As equipment was available for further analysis of pathological lesions and potential traumatic lesions found on the bones, we also recorded whether further analysis was to be completed for each fragment and if so what type and whether it had been completed. Further analysis was available in the form of X-ray, microCT, and examination with a digital microscope. Lastly, the observer's initials were recorded.

In addition to the information recorded in the spreadsheets, detailed pictorial documentation was completed for each fragment. A drawing was completed for almost all elements, consisting of a photocopy of a standard outline of each element on which was marked exactly which areas of the element were present as well as any potential traumatic or pathological lesions, postmortem disturbance fractures, or reconstruction. For the hand and foot bones and the ribs, standard outlines were difficult to come by and there were many very small fragments for which a diagram would not be particularly useful; therefore only the fragments that had possible lesions or features of note were drawn freehand. Each diagram was scanned and stored as a PDF document associated with the database. All fragments were also photographed, and the photographs and diagrams were attached to the appropriate line in the database. At least two photographs were taken of each fragment, documenting each side. More were taken if deemed necessary, especially for fragments that had potential lesions or interesting features. All photographs were taken with a photo scale and a small piece of paper identifying the fragment's unique SK number.

After as many fragments as possible had been identified by element, there were still many fragments that could not be identified precisely. Following Knüsel and Outram's (2004) suggestion that some useful information may still be gleaned from unidentifiable fragments, we recorded some information for these fragments as well in a separate spreadsheet. Many of these fragments had been previously labeled with trench letters, so where present this labeling information was recorded. Each fragment was placed into one of several general categories: large long bone, small long bone, vertebral

column and sacrum, cranial or mandibular fragment, flat bone, small irregular bone, metacarpal/metatarsal, phalanx, trabecular bone, cortical bone, or other. The 'other' category was used when the piece of bone could potentially be placed in more than two of the other categories. A column for notes was also included in the spreadsheet, but this was only used in a small number of cases. For each of these categories, the number of fragments of each size class present was recorded using the same size classes as had been applied to the identifiable fragments. During recording, the edges of each fragment were examined to check whether it displayed the sharp edges characteristic of perimortem breakage. It became evident during our experimental work that perimortem breakage often results in very small fragments with sharp edges; so as to avoid missing any possible evidence of perimortem injury we examined even small unidentifiable fragments for evidence of perimortem fracture characteristics and perimortem sharp force trauma characteristics. A few fragments with evidence for sharp force trauma were found, but no fragments had evidence of perimortem fracture. It is likely that many more such fragments would have been overlooked during excavation; it is also possible that significant weathering along the edges of additional fragments may have acted to disguise their relation to any perimortem traumatic event.

5.2 Analysis of Traumatic Lesions

After cataloguing was complete, all of the elements marked as having potential perimortem lesions were examined macroscopically. In addition, some of the elements marked as having potential sharp force or musket trauma were examined microscopically

using a digital microscope. Although other options for further analysis existed, including X-ray and micro-CT analyses, these were performed on antemortem trauma, potential pathological lesions, or for determination of age at death rather than for the analysis of potential perimortem lesions.

My analysis concentrated almost entirely on the postcranial trauma in the Smith's Knoll collection. To date much of the bioarchaeological work done on perimortem trauma has focused on cranial bones; this area had been closely investigated in the previous analyses undertaken on the Smith's Knoll material (Liston 2000). The major focus of this investigation was the less frequently studied postcranial skeleton.

5.2.1 Macroscopic analysis

During the cataloguing process, each fragment was classified as having perimortem musket trauma, sharp force trauma, and fractures present (P), possibly present (P?), or absent (A). After cataloguing had been completed, the database was searched to return all fragments that had been classified as having or possibly having any sort of perimortem lesion. Each of these bones was then reanalyzed, and a final decision made regarding whether or not the lesion observed was likely to have occurred perimortem. For each category, lesions were classified as having perimortem trauma present (P), absent (A), or indeterminate (I). The indeterminate category was utilized when the cortex surrounding a lesion was completely missing, thereby removing the researcher's ability to observe potential perimortem characteristics. In these cases weathering, erosion, and other post-depositional processes have removed any evidence that may have led to a

classification of perimortem trauma, and with this evidence gone the timing of the lesion can never be definitively known.

In order to classify lesions as likely having occurred perimortem or postmortem, they were examined visually for characteristics associated with breakage of fresh and dry bone (see Chapter 3). Features such as sharp edges, smooth fracture surfaces, hinged edges, and radiating fractures were taken as indications of perimortem breakage. Features such as rough fracture surfaces, squared or stepped edges, and breakage at right angles to the cortical surface of the bone were taken as indicators of postmortem timing (Lovell 1997, 2008; Ortner 2003). A significant color difference between the fractured or cut surface and the rest of the cortex, indicating that the timing of exposure to the burial environment differed significantly, was also taken as evidence that damage most likely occurred postmortem (Haglund et al. 2002; Ubelaker 2002; Wheatley 2008). A relatively conservative approach was taken, so that if there was significant doubt regarding the potential for a lesion to have occurred around the time of death, perimortem trauma was marked as absent. Often, this decision was assisted by observations made while visualizing the lesion under the digital microscope (see Section 5.2.2). For potential sharp force lesions observed in the ribs, comparisons were made with experimental lesions made in porcine ribs with a replica socket bayonet to indicate the typical appearance of perimortem damage associated with this weapon (see Section 5.3.1 and 5.3.3).

5.2.2 Microscopic analysis

During the cataloguing process, a column labeled "Further Analysis" was included on the recording spreadsheet for each element. One of the available options for further analysis was observation of a fragment under the VHX-1000E digital microscope, which was obtained on loan from Keyence Corporation. After cataloguing had been completed, all of the fragments that had been marked for examination with the microscope were listed using the database and set aside for analysis.

The digital microscope was used with two different lenses to magnify from five to 250 times. Another lens capable of magnifying up to 2500 times was provided, but was found to be of limited utility for objects with large differences in depth across the surface, such as bone. This instrument allows for the production of depth composition and three-dimensional images. Depth composition images allow a detailed, in-focus two-dimensional view of three-dimensional surfaces, as the microscope lens focuses at every level and the picture composed is entirely in focus. Three-dimensional images reproduce an image of the surface of the bone, which can then be manipulated, rotated, and measured in various ways using the microscope software.

Each fragment marked for analysis with the microscope was set aside as described above. The diagrams created during cataloguing were consulted in order to confirm the location of lesions that were considered likely perimortem along with any notes made during initial observation of the fragment. Each potentially significant lesion was visualized under the microscope at several magnifications, beginning at a lower magnification and then viewed with increasing levels of detail; both depth composition

and three-dimensional images were saved. For all of the smaller elements or small fragments of larger elements, the higher magnification lens beginning at 20 times magnification was used. For larger elements, the lower magnification lens beginning at five times and extending up to 20 times magnification needed to be used. This visualization often assisted in the decision made on the likely timing of the injuries examined (see Section 5.2.1).

Experimentally generated lesions from the musket injury and both sharp force trauma experiments were also visualized and photographed using the digital microscope (see Section 5.3). The procedure for visualizing and saving images of these lesions followed the same procedure as that described above for the Smith's Knoll skeletal elements. The ribs and replica leg bones could be viewed with the higher magnification lens, whereas most of the scapulae from the replica buttocks were too large to be viewed with this lens and could only be visualized under lower magnification. Images of these lesions were saved to act as a comparison with potential perimortem lesions seen in the Smith's Knoll skeletal material, either for determining lesion timing, likely causative implement, or potential range of fire or type of ammunition.

5.2.3 Quantitative Analysis

Once a decision had been made and each lesion had been definitively classified as likely perimortem (P) or postmortem (A), calculations to determine prevalence were performed. Crude prevalence is reported as a percentage and simply reflects the frequency of a given condition within a skeletal sample (Lovell 2008). Prevalence can be

expressed in several different ways, depending on the units in which one is interested in looking at the frequency of a condition, for example by individual, or by element. Given the disarticulated, commingled nature of the Smith's Knoll sample (see Chapter 2), it was not possible for skeletal elements to be associated with one another into groupings that represent individuals. As each element therefore had to be considered on its own, prevalence was calculated by element, producing what are often referred to as "element count" rates (Lovell 2008). Prevalence was calculated by dividing the number of elements containing a particular type of perimortem traumatic lesion by the total number of observable elements in the collection, then multiplying this frequency by 100 to produce a percentage.

The calculation of prevalence for each category of traumatic lesion was made more complicated by the fragmentary nature of the Smith's Knoll skeletal material. Classic element count method calculations make the assumption that all elements involved in the calculation are complete and therefore have all aspects available for the observation of potential lesions (Lovell 2008). However, with skeletal material that has undergone significant postmortem damage as the Smith's Knoll collection has, this may not be true (Judd 2002). Therefore, while calculating prevalence different levels of preservation and completeness of elements had to be accounted for. This was facilitated by the use of the zonation method (Knüsel and Outram 2004; see Section 5.1). Percent completeness was calculated for each element by dividing the number of zones present by the total number of possible zones. Different values for prevalence by element could then be calculated based on subsets of each element set that had a different minimum percent

completeness. Prevalence was calculated for each type of perimortem trauma in each element for only complete fragments (all zones present), as well as for all fragments regardless of completeness (categorized as the total element count). Frequencies were then calculated for fragments that were at least 75% complete, at least 50% complete, at least 25% complete, and at least 10% complete for elements that had four or more possible zones. However some of the elements on which lesions were most commonly found (for example the ribs) have only three zones, making these completeness cutoffs meaningless. For elements with only three zones, prevalence was instead calculated for fragments that were at least 67% complete. For all prevalence calculations, the number of eligible fragments in each category that displayed lesions were divided by the total number of eligible fragments available in the collection.

In addition to perimortem (P) and postmortem (A) classifications, some lesions were placed into the indeterminate (I) category meaning that the timing of the injury could not be reliably deduced based on the evidence that remained after taphonomy had taken its toll. As these lesions represent injuries that may be perimortem in nature, separate prevalence rates were calculated with these lesions included. The difference between the prevalence with and without indeterminate lesions may provide some indication of the impact of surface weathering in masking and obscuring perimortem lesions.

Once various prevalence figures had been calculated for each element, they were compared statistically to determine whether significant differences existed between them. Chi-square tests were performed to determine if the differences between the frequencies

calculated based on differing levels of completeness were statistically significant. Evaluating differences in the prevalence of lesions based on completeness gives some idea of the role of fragmentation and postmortem breakage in masking the presence of perimortem traumatic lesions.

In addition to evaluating the prevalence of perimortem lesions by element, an attempt was also made to evaluate the frequency of these lesions at the level of the individual. In order to facilitate this, calculations of the minimum number of individuals (MNI) were performed for each relevant element. The MNI was determined for both the right and left fragments of each element, and was taken as the higher of the two values. The number of pieces of each element displaying perimortem lesions could then be expressed as a percentage of injured individuals out of the minimum number of individuals that must be present within the sample for each element in turn.

5.2.4 Statistical Analysis

Once prevalence values had been calculated using each method, the results were compared using chi-square and Fisher's exact tests to determine whether the differences between these values are statistically significant. Chi-square values are calculated using the formula $X^2 = \sum (f_o - f_e)^2 / f_e$, and significance is then determined based on comparison of the chi-square value with critical values corresponding to different p values at a given number of degrees of freedom. Using GraphPad software, chi square values were calculated for the number of fragments with and without perimortem lesions for each method compared against the total element count method, which served as the expected

values. When a given method had a small sample size, as was the case for the element count method using only complete elements and for the individual count method, the Yates' correction was applied in this calculation. These calculations yielded chi-square values and significance values for each prevalence method. GraphPad software was also used to apply the Fisher's exact test, which yields a more accurate significance figure than does chi-square analysis. Based on both of these tests, results of a method are considered to be statistically significantly different than would be expected using the total element count method if the significance value is less than or equal to 0.05. Significance values less than or equal to 0.01 indicate especially significant results.

5.3 Experimental Analyses

5.3.1 Preliminary visit to Fort George

In order to contextualize the lesions seen in the Smith's Knoll skeletal material and to attempt to correlate them with the instruments that may possibly have caused the injuries, comparative lesions definitively caused by weapons used during the War of 1812 were necessary. In the absence of controlled clinical or forensic studies that can be used to provide comparative images or samples for injuries caused by modern instruments, these lesions needed to be experimentally created. Replica weapons from the War of 1812 can be difficult to come by, but a range of these weapons is held by Fort George in nearby Niagara-on-the-Lake, a War of 1812 fort that has been restored as a historical site. Replica weapons including bayonets, several different models of sword, and muskets

were available at this location. Dr. Megan Brickley and I made a preliminary trip to Fort George to meet their staff and get a clear idea of the facilities and equipment that may be available for future experimental studies. Materials for a preliminary experimental study involving replicating bayonet wounds to the ribs were brought along to test the available weapons at the Fort. The necessary materials to test different types of edged weapons and the lesions they produce were also taken to the Fort in order to better contextualize some of the trauma seen in the long bones of the collection.

Several triangular nicks and splits thought to be related to bayonet injuries, and noted as such during the previous analysis (Liston 2000), were observed on rib fragments in the collection. To more securely establish whether the bayonet could in fact have caused the lesions observed in the sample, comparative lesions definitively caused by a bayonet similar to those in use during the War of 1812 were required. Porcine ribs were chosen to replicate human ribs in this experiment, as they are readily available and as pig bones are generally considered an acceptable proxy for human bones (Wieberg and Wescott 2008). A rack of pork back ribs with all of the meat covering the bones was chosen, so as to replicate as closely as possible the living torso. The rack of ribs was placed on the grass to prevent any damage to the weapons from impacting a hard surface. A staff member from Fort George, a larger man better able to approximate the strength with which a soldier during the War of 1812 could have thrust the bayonet, inflicted sharp force wounds on the ribs with a replica bayonet of the period. The bayonet was thrust into the ribs several times, ensuring that the ribs were impacted at different points so as to get the maximum possible number of comparative lesions. It was evident when a lesion was

created, as the impact was audible and the bayonet often became lodged in or between the ribs and was quite difficult to extract.

In order to replicate some of the cut marks seen in the long bones of the sample a defleshed bovine femur was included, on which to create experimental lesions. The femur was struck with several edged implements that may have been used during the Battle of Stoney Creek, including a tomahawk, a sabre, and a bayonet. This was done in order to give a better idea of the classes of weapons that may be responsible for the marks seen on the Smith's Knoll material.

All weapons used in the experiment were replicas that are used by Fort George staff in educational demonstrations, often given to groups of school-aged children. As such, the edges of the weapons are quite dull for the safety of demonstration participants. Despite the fact that none of the weapons had been sharpened, they still managed to create well-defined sharp force lesions rather easily; although lesions made by sharpened weapons would likely be more comparable to those sustained in battle conditions, the lesions created by the unsharpened replica weapons provide a sufficient comparison for the purposes of this analysis.

Upon returning to the lab, the rib bones and femur were processed for further examination. The bones were boiled in water in a large pot for several hours. They were then placed in warm water in plastic containers with a small amount of detergent, and incubated at around 45 degrees until the soft tissue had completely lifted from the bones and most of the grease had been removed. The amount of time needed in the incubator

differed depending on the element, with the ribs needing significantly less time than the two halves of the femur, which due to its size needed to be incubated separately.

5.3.2 Musket injuries to the iliac crest

Figure 5.1. Preparation of the replica buttocks to be used in the musket experiment, as described in Section 5.3.2. Porcine scapulae are covered with center loin chops attached with rubber bands, with five to six on each cafeteria tray.

Traumatic lesions related to musket injuries were observed on the iliac crest of three innominates in the Smith's Knoll sample (SK1147, SK1161, and SK1178); these lesions appear to have occurred as a result of musket ammunition traveling from the posterior to the anterior aspect. In order to further investigate the details of the circumstances resulting in these injuries, it was necessary to reconstruct the buttocks of a young male soldier in a standing position. Porcine scapulae were chosen to represent the human iliac crest, as they are similarly flat and while slightly thinner were deemed to be the closest faunal proxy. The spines were removed from the scapulae with a hacksaw and a Dremel tool so that they would lie flat. The scapulae were then covered with center loin pork chops about one to one and a half inches (3.81 cm) thick to simulate muscle (see Figure 5.1); five to six scapulae and chop packages were arranged on each cafeteria tray and

Figure 5.2. Sample tray from musket experiment, showing pork chop and scapula packages (as shown in Figure 5.1) covered with pork belly. Nine trays like this one were prepared for use in the experiment.

covered with a large piece of belly pork about one and a half inches (3.81 cm) thick to simulate the subcutaneous fat and skin (see Figure 5.2). The pork chops were attached directly to the scapulae using rubber bands, and the pork belly attached to the underlying pork chip and scapula packages using larger rubber bands wrapped around the trays. Each tray was then wrapped in thin cotton fabric covered by thicker wool fabric to simulate the coat and shirt of the uniforms that soldiers would have worn during the War of 1812. Although no material was added to replicate the pants, it was thought that two layers would sufficiently represent the thickness of fabric covering a typical soldier in 1812 (Ron Dale, personal communication, 2011). Nine trays were prepared for use in the experiment.

Figure 5.3. Shooting of the trays during the musket experiment. Ron Dale of Parks Canada is depicted firing a replica Brown Bess musket at the first group of three trays containing replica buttocks. Three sets of three trays were shot in this manner, from three distances as described in Section 5.3.2.

Shots were fired at an outdoor shooting range using a replica Brown Bess flintlock musket, the model used by the British army during the war of 1812 (see Figure 5.3). The ammunition and powder used was necessarily of modern make, and we were unable to access ammunition that would exactly replicate that used during the Battle of Stoney Creek. During the experiment, the replica musket was loaded with one .69 caliber musket ball and three .33 caliber buckshot. In 1813, the British army typically used only a .69 caliber musket ball with no buckshot, and the American army typically used a .65 caliber musket ball topped with three .33 caliber buckshot (Ron Dale, personal communication, 2011).

Therefore with limited resources we had access to a mix of typical British and American ammunition. Because modern powder is much more powerful than that used in 1813, less powder (about 70 grains rather than 120) was included in each cartridge to attempt to approximate the same effect.

To estimate the likely degree of spread of the buckshot, shots were taken first at paper targets at distances of 10 yards (9.14 m), 15 yards (13.72 m), 20 yards (18.29 m), and 50 yards (45.72 m). Accuracy at 50 yards was very low, so it was determined that for the best experimental results the trays of replica buttocks should be shot at a closer range. The trays were set up three at a time on wooden stands with the woolen fabric layer facing the shooter as straight on as possible. Each group of three was shot at a different distance, with shots being taken at distances of 10 yards or 9.14 m (trays 4, 5, and 6), 15 yards or 13.72 m (trays 3, 7, and 8), and 20 yards or 18.29 m (trays 1, 2, and 9). Each tray was shot as many times as necessary to have clear impacts from at least one musket ball and one buckshot. The trays were then dissected in the lab, tissue measurements were taken at all points of impact, and the scapulae with lesions were processed to remove the remaining soft tissue and grease.

Scapulae from each tray were placed in clear, lidded plastic containers labeled with their tray number. To each container were added 10 to 10.5g of either Tergazyme detergent or Amaze detergent to de-flesh and degrease the bones (after Mairs et al. 2004), and the container was then filled with water. The scapulae were incubated in the detergent at 47 degrees Centigrade for about three weeks, with the water being changed as necessary every few days. They were then rinsed and allowed to dry at room temperature.

Detailed photographs and measurements of the diameter and spread of the lesions were taken using a digital microscope at low magnification (five to 20X magnification) in addition to documentation with a digital camera. Diameter was measured for all lesions in which the bone remained intact around the lesion, as those in which the surrounding bone had split into multiple pieces would not provide accurate measurements. In instances where more than one lesion was present on a single scapula, the spread of the lesions was measured as the distance from the midpoint of one lesion to the midpoint of the other. All such measurements were compared to determine any potential trends within the material based on range of fire.

5.3.3 Bayonet and/or sword injuries to the lower leg

The injury that appears to have the most clearly perimortem characteristics is a cut mark that was observed on the distal diaphysis of a fibula in the sample (SK129). It was unclear without comparative lesions what type of edged instrument was likely to have caused this mark; based on historical accounts the potential classes of sharp force weapon present at the battle would have been swords and bayonets. These are the two classes of weapon that were chosen for testing. Although it is possible that tomahawks may also have been present at the battle, this class of weapons was excluded as a possibility based on the results of the preliminary investigation (see Section 5.3.1); the lesions resulting from the tomahawk were found not to resemble any of the lesions seen in the Smith's Knoll material (see Chapter 6). Two potential scenarios that each may have resulted in the lesion observed in the collection were devised: first that a sword had sliced through the

tibia and impacted the anteromedial aspect of the distal fibula at the end of its stroke, and second that a bayonet had penetrated the space between the tibia and fibula and impacted the fibula on the anteromedial surface that way.

In order to replicate the human lower leg, suitable proxies needed to be found for both the tibia and the fibula. Upon examination of McMaster's zooarchaeological collections, it was determined that deer tibiae would most closely approximate human tibiae, as they are very similar in size and shape. The human fibula is very unique in size and shape, and no easily accessible faunal elements were found to correspond exactly. The closest resemblance was found to be with lamb tibiae, which approximate human fibulae in diameter and cortical thickness although not in shape. Each lower leg replica was therefore constructed from a deer tibia and a lamb tibia held together with elastic bands. In order to replicate the interosseous space, we placed foam earplugs and small pieces of blue sticky tack at the proximal and distal ends of the lamb tibiae and secured the properly spaced bones together with large elastic bands (see Figure 5.4). Four replica legs were created.

Figure 5.4. Replica leg number one. This photograph depicts the deer tibia (top) attached to the lamb tibia (bottom), representing the human tibia and fibula respectively. The bones are attached with rubber bands, and proper spacing is achieved with the use of foam ear plugs as shown at right.

This experimental work, like the original experimental work involving sharp force trauma to the ribs, was undertaken at the Fort George historical park using their replica War of 1812 weaponry. Each replica leg in turn was affixed to a support made of hay.

Hay was chosen to provide sufficient support for the replica limbs to remain mostly immobilized but not too rigid under the force of each blow, as well as to avoid any damage to the blade that may result from impact with a harder surface. Two of the legs (samples one and two) were then struck with a sword, and the remaining two (samples three and four) were stabbed with a bayonet. As with the previous experimental work, a male staff member from Fort George handled the weapons so as to better approximate the amount of force behind the injuries. The sword samples were struck such that the sword passed through the tibia before impacting the fibula, as in the first scenario described above; this involved orienting the legs on the hay with the deer tibia superior to the lamb tibia. The bayonet samples were struck such that the bayonet was thrust into the interosseous space and impacted both the tibia and fibula. Given the difficulty of aiming the bayonet thrusts and the inability of the elastic bands to secure the bones well enough to completely prevent them from moving under the force of the thrust, this scenario did not consistently work out as planned. In order to garner enough force to make clear marks on the bone, the bayonet was thrust repeatedly at the legs without precise aim in an attempt to create any lesions possible on the fibulae that could later be examined. Samples three and four were therefore struck as many times as was necessary to create clear lesions. As well, the replica tibiae and fibulae were tied together with string provided by the Fort George staff to give greater stability and prevent the elements from moving apart. As with the previous experimental work done using Fort George replica weapons, the instruments were unsharpened as they are typically used for educational demonstrations. Therefore while the experiment yielded clear lesions on the bones, there

may be differences between these experimental lesions and those that would have been sustained during battle with weapons sharpened for use.

While at Fort George, the original bayonet experimental work was repeated with a different cut of ribs, as the back ribs originally used were quite different in size and shape from human ribs. A rack of pork side ribs was affixed to the hay support. The bayonet was thrust into the ribs several times, attempting to impact as many ribs as possible to create clear lesions in the bones.

The legs and ribs were then processed individually before analysis. For the legs, the rubber bands, earplugs, and sticky tack were first removed from the bones. Each leg was then placed in a large pot and simmered in water for five to six hours. The loose soft tissue was removed from the bones, and they were placed in square plastic lidded containers with 10 to 10.5 grams of Tergazyme detergent and enough water to almost fill the container to the top (as described in Sections 5.3.1 and 5.3.2). The bones from each sample were incubated in the water and detergent at 47 degrees Centigrade for about two weeks, with the water being changed as necessary every few days. Processing was considered to be complete when all soft tissue had been removed from the bones and all of the bone marrow had been removed from the shafts of the deer tibiae. The bones were then rinsed and allowed to dry completely at room temperature. The ribs were processed in the same way, with any bones that did not show clear bayonet impacts being discarded before incubation.

Detailed photographs of the resultant lesions were taken using a digital microscope at magnifications of 20, 30, and 50 times. Photographs were also taken of the

possible perimortem lesion on SK129 with the digital microscope in order to compare the appearances of lesions created by various weapons with the archaeological bone injury. In addition to these comparative lesions, the description of the diagnostic characteristics of sword injuries in opposition to those resulting from other types of edged instruments provided by Lewis (2008) was used to evaluate the potential causes of the lesion observed on SK129.

Chapter 6: Results

The results of the quantitative and qualitative analyses of the potential perimortem sharp force, musket, and fracture trauma are presented and discussed below according to two methods of organization. The results are laid out first by element in which the lesions are found, and subsequently by the type of traumatic lesion present. This organization allows the conceptualization of the traumatic lesions in the collection as associated by affected element and by lesion type, the two most relevant groupings given how trauma to the skeleton is to be discussed. In the subsequent section, each different type of trauma (sharp force, musket, and fracture) is considered and discussed separately. The results of the experimental analyses are then presented.

6.1 Analysis of traumatic lesions by element

In this section, the quantitative results are first presented and then the relevant lesions and their specific characteristics are qualitatively described. The descriptions of the lesions observed in the collection are organized by element, following the suggestion by White (1992) that the postcranial elements represent discrete units in the adult skeleton and can therefore be analyzed systematically. All types of trauma are presented together.

6.1.1 Quantitative analysis

Prevalence rates for each element based on varying completeness thresholds are summarized for all types of trauma in Table 6.1 (for a more detailed breakdown of the

numbers of fragments included in each category, see Appendix I). The same set of prevalence rates calculated inclusive of lesions classified as indeterminate are presented in Table 6.2, and represented graphically in Figure 6.1. The results of statistical analyses evaluating the significance of these results are also presented. In calculating the prevalence of perimortem traumatic lesions, the individual count prevalence figures were generally found to represent the highest values. The highest prevalence value was found to be 15% for the innominate, followed by the fibula (8.33%), patella (7.69%), scapula (5%), femur (4.55%), and ulna (4.35%). The ribs, carpals, and vertebrae, for which calculating prevalence by individual was not possible, yielded total element count prevalence values of 3.02%, 2.22%, and 1.64% respectively.

Table 6.1. Prevalence of Perimortem Traumatic Lesions in the Smith's Knoll Skeletal Collection

Element	Total ECP	Complete Frags	Frags ≥ 75%	Frags ≥ 67%	Frags ≥ 50%	Frags ≥ 25%	Frags ≥ 10%	Total ICP
Carpals	2.22	-	-	-	-	-	-	-
Femora	1.01	0.00	0.00	0.00	0.00	1.64	1.30	4.55
Fibulae	1.22	0.00	0.00	0.00	5.56	1.79	1.22	8.33
Innominates	2.33	0.00	11.11	7.14	14.29	5.45	3.06	15.00
Patellae	3.85	-	6.25	-	4.35	4.17	-	7.69
Ribs	3.02	7.41	-	8.51	-	-	-	-
Scapulae	2.38	0.00	25.00	11.11	13.33	6.90	2.38	5.00
Ulnae	0.23	0.00	1.32	1.32	0.71	0.23	-	4.35
Vertebrae	1.64	0.00	4.00	4.00	2.86	1.82	1.64	-

ECP = Element count prevalence; ICP = Individual count prevalence; Frags = Fragments

Prevalence (%) as an element count and an individual count, listed by element, for all possible perimortem traumatic lesions in the Smith's Knoll collection. Individual count prevalence values are calculated based on the MNI determined for each element individually. Total element counts are calculated by dividing the total number of fragments of each element with lesions by the total number of fragments of each element in the collection.

Table 6.2. Prevalence of Traumatic Lesions in the Smith's Knoll Skeletal Collection with the Inclusion of both Perimortem and Indeterminate Lesions

Element	Total ECP	Complete Frags	Frags ≥ 75%	Frags ≥ 67%	Frags ≥ 50%	Frags ≥ 25%	Frags ≥ 10%	Total ICP
C/T	6.67	-	-	-	-	-	-	-
Clavicles	2.38	5.00	-	2.94	2.94	2.38	2.38	5.56
Femora	2.02	0.00	0.00	0.00	0.00	3.28	2.60	9.09
Fibulae	1.22	0.00	0.00	0.00	5.56	1.79	1.22	8.33
Innominates	2.33	0.00	11.11	7.14	14.29	5.45	3.06	15.00
Patellae	3.85	-	6.25	6.25	4.35	4.17	4.17	7.69
Phalanges	0.71	0.00	-	0.44	0.44	0.71	0.71	-
Ribs	3.02	7.41	-	8.51	8.51	3.02	3.02	-
Scapulae	2.38	0.00	25.00	11.11	13.33	6.90	2.38	5.00
Ulnae	0.23	0.00	1.32	1.32	0.71	0.23	0.23	4.35
Vertebrae	1.64	0.00	4.00	4.00	2.86	1.82	1.64	-

ECP = Element count prevalence; ICP = Individual count prevalence; Frags = Fragments; C/T = Carpals and Tarsals

Prevalence (%) as an element count and an individual count, listed by element, for all possible perimortem and indeterminate traumatic lesions in the Smith's Knoll collection. Total element counts are calculated by dividing the total number of fragments of each element with lesions (present or indeterminate) by the total number of fragments of each element in the collection.

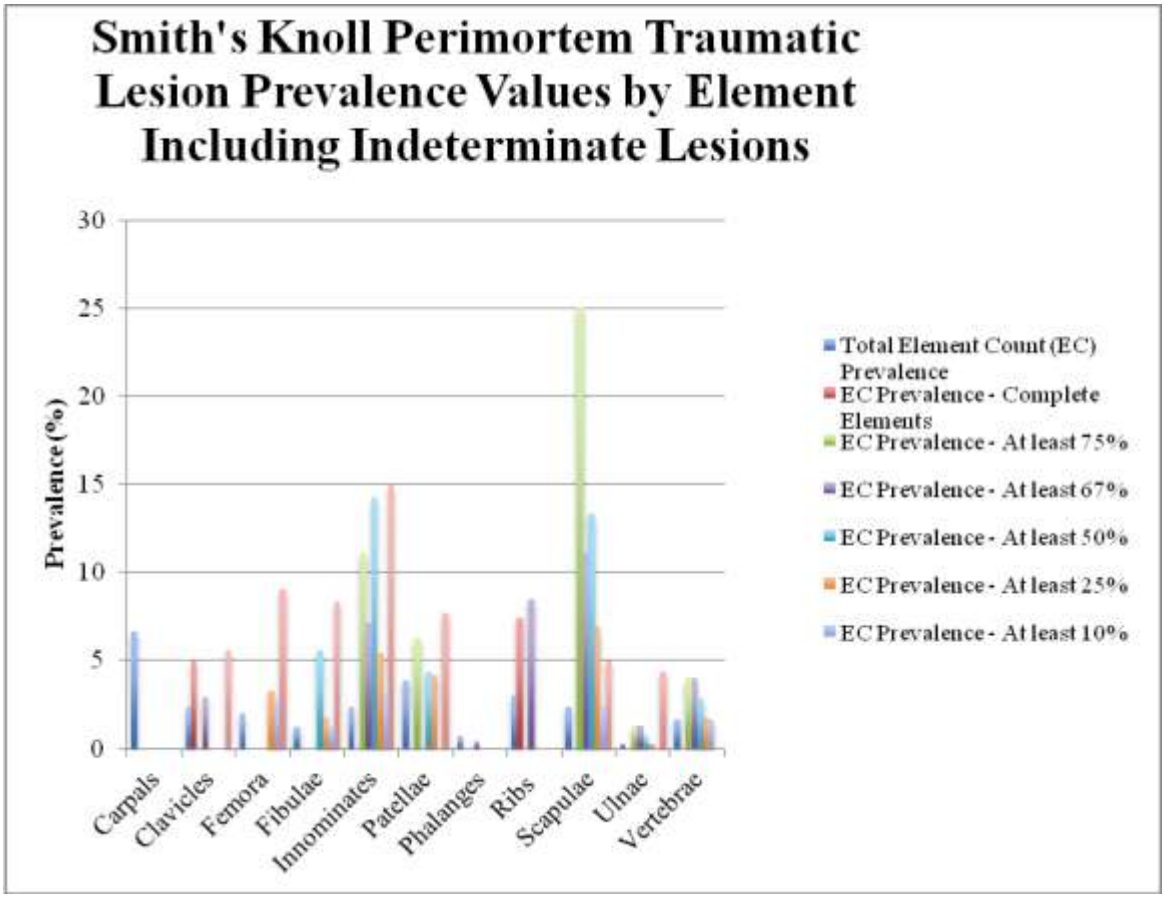

Figure 6.1. Prevalence values obtained using different element count methods as well as the individual count method, for lesions classified as either present or indeterminate. A cluster of colored bars representing the various methods used is presented for each element, the absence of a method bar for a particular element indicates either that this method was not applicable to that element or that it yielded a prevalence value of zero; these can be differentiated by observing the values present in Table 2. This graph shows the potentially large effect of taking completeness into account in the calculation of perimortem traumatic lesion prevalence within the Smith's Knoll collection.

6.1.1.1 Statistical Analysis

The results of the chi-square analyses performed to evaluate the statistical significance of the differences in prevalence values calculated using the various element count prevalence methods compared against total element count prevalence are presented in Table 6.3.

Table 6.3. Chi-Square Values for Prevalence Calculation Methods Accounting for Completeness

Prevalence Calculation Method	X^2	Significance (p value)	Fisher's Exact Significance
Element Count (EC): Complete	0.022†	0.8821	1.000
EC: At least 76%	0.424	0.5149	0.4567
EC: At least 67%	5.255	0.0219*	0.0308*
EC: At least 50%	6.529	0.0106*	0.0155*
EC: At least 25%	0.299	0.5846	0.6751
EC: At least 10%	0.027	0.8706	0.8899
EC: Including P and I Lesions	0.628	0.4279	0.5092
Individual Count	17.149†	0.0001*	0.0027*

EC = Element count; P = Present; I = Indeterminate

Chi-square values comparing prevalence values calculated through various methods to account for percent completeness against total element count prevalence as an expected value. Significant values are starred. Values marked with the symbol † represent categories for which the count was less than 5, and so these values were calculated using Yates' correction for small sample size. The degrees of freedom were equal to one for all calculations.

The result obtained using a given method can only be considered to be statistically significant if the significance value is less than or equal to 0.05 (see Section 5.2.4). Significant differences therefore exist between total element count prevalence and the results of two of the alternate element count methods, those that restricted completeness to fragments with at least 67% present and to fragments with at least 50% present. Significant differences also exist between total element count prevalence and individual count prevalence values. The significance values for the element count method using fragments with at least 50% present and the individual count method are approaching or less than 0.01 respectively, indicating that these statistical results are especially significant.

6.1.2 Qualitative analysis

This section contains detailed descriptions of the lesions present within the collection, organized by the skeletal element in which they are found. Lesions classified as both perimortem present and indeterminate are considered here. In the sections devoted to elements for which a minimum number of individuals could be calculated, this value is provided. Most of the lesions observed in the collection are pictured here; for additional images see Appendix II.

6.1.2.1 Carpals and Tarsals

One potential perimortem lesion was found in a fragment of carpal (SK1807); this left scaphoid has a sharp slice mark across its dorsal surface (see Figures 6.2 and 6.3). The cut surface is very flat, and the edges very sharp and cleanly sliced, indicating that the injury likely occurred around the time of death. One further lesion is present in a tarsal fragment that was classified as indeterminate. This left navicular (SK1827) has a triangular penetrating injury from which all of the surrounding cortex has been removed, precluding the ability to definitively classify its timing (see Figure 6.4). Each carpal and tarsal is represented by a single zone and percent completeness was not assessed for the wrist and ankle bones, meaning that the ways in which prevalence can be expressed are limited. An MNI figure was also not calculated for the carpals or tarsals, further restricting prevalence expressions.

Figure 6.2. Dorsal view of left scaphoid SK1807, showing potential perimortem slice mark. This photograph demonstrates this lesion's very flat sliced surface.

Figure 6.3. (Above) Digital microscope image of the flat dorsal cut surface of SK1807. Magnification is X20.

Figure 6.4. (Left) Triangular penetrating mark on left navicular SK1827, classified as indeterminate.

6.1.2.2 Femora

One potential perimortem lesion was found in the distal epiphysis of a femur (SK0320). There are two large and very sharp slice marks on the anterior surface of the distal end of the diaphysis and the epiphysis of a left femur (see Figure 6.5). Unfortunately, the cut surfaces were glued together during the previous analysis and could only be directly examined at their edges. However the very flat surface as well as the sharp and cleanly sliced edges of this lesion suggests that it can be classified as perimortem. A further potential lesion is present on the diaphysis of another left femur (SK0122) in the form of a large cut mark. Due to the absence of cortical surface surrounding the lesion, it was classified as indeterminate (see Figure 6.6). As SK0320 is 45% complete and SK0122 is only 36% complete, these lesions only contribute to the prevalence of sharp force trauma if all fragments greater than 25% complete are included in the calculation. If the completeness requirement is any higher, the prevalence of lesions in this element appears to be zero. Prevalence can also be represented by individual in this element; the minimum number of individuals for the femur was calculated to be 22 based

on fragments from the left side, therefore a possible perimortem lesion is present in one of 22 potential individuals. If indeterminate lesions are included, this increases to two of 22 potential individuals.

Figure 6.5. Digital microscope image of sharp slice marks in the distal epiphysis of left femur SK0320. Magnification is times five.

Figure 6.6. Digital microscope image of cut mark on the diaphysis of left femur SK0122, classified as indeterminate. Magnification is X30.

6.1.2.3 Fibulae

One potential perimortem lesion was found on the anteromedial surface of the distal diaphysis of a right fibula fragment (SK0129). This lesion is a cut mark with a particularly sharp and straight bottom edge, a slightly hinged or lipped upper edge, and a small associated radiating fracture (See Figures 6.7, 6.8, 6.9). Experimental lesions were created on replica lower legs to attempt to garner more information on the likely origin of this lesion (see Section 6.3.2). As SK0129 is 50% complete, this lesion only contributes to the prevalence of sharp force trauma if all fragments greater than or equal to 50% complete are included in the calculation. Prevalence can be represented by individual for

the fibula; the minimum number of individuals was calculated to be 12 based on fragments from the left side, therefore a possible perimortem lesion is present in one of 12 potential individuals.

Figure 6.7. (Above) Potential perimortem cut mark in the distal end of right fibula SK0129. The associated radiating fracture (arrow) can be seen to the right of the cut mark.

Figure 6.8. (Left) Digital microscope image of cut mark on SK0129. Plastic deformation is evident.Magnification is X30.

Figure 6.9. (Below) Digital microscope image of cut mark on SK0129. Magnification is X50.

6.1.2.4 Patellae

One potential perimortem lesion was found on the superomedial corner of a right patella (SK1361). The corner of this element displays a sharp slice mark (see Figure 6.10) very similar in appearance to that found on SK1807 (a left scaphoid). The perimortem nature of this lesion, as with the slice marks found in a carpal and a femur in the collection, is suggested by the flat surface and sharply sliced edges of the injury. Percent

completeness was assessed directly for the patella rather than based on zones, and was given as a 25% range (see Section 5.1). As SK1361 is in the highest completeness range, it is reflected in the prevalence rate regardless of the completeness threshold. The minimum number of individuals was calculated to be 13 based on fragments of the right patella, therefore a possible perimortem lesion is present in one of 13 potential individuals.

Figure 6.10. Potential perimortem slice mark seen on right patella SK1361. This photograph illustrates the very flat surface and sharp edges of the lesion, which suggest that it occurred around the time of death.

6.1.2.5 Ulnae

One potential perimortem lesion was found on the anteromedial midshaft diaphysis of a right ulna (SK0147). This cut mark displays sharp edges along which there is some plastic deformation, indicating likely perimortem timing. The lesion's appearance has definitely been altered by weathering of the cortex indicated by removal of the surrounding cortical surface, and now appears as a large open cut mark with radiating fractures and hinging at the edges (see Figure 6.11). The fragment SK0147 is 88% complete, meaning that unless only complete elements are included it is represented in the

calculated prevalence. The minimum number of individuals was calculated to be 23 based on fragments of the right ulna, therefore a possible perimortem lesion is present in one of 23 potential individuals.

Figure 6.11. Potential perimortem damage to the anteromedial midshaft diaphysis of right ulna SK0147. This lesion has sharp edges and plastic deformation, suggesting perimortem timing. This photograph shows the weathering of the cortex, postmortem damage that has altered the lesion's appearance.

6.1.2.6 Vertebrae

One potential perimortem lesion was found on the body of a thoracic vertebra (SK2078); the small triangular cut is located on the left inferior margin of the anterior body (see Figure 6.12, 6.13). The sharp edges and cleanly cut trabecular bone displayed by this lesion are suggestive of perimortem timing. This specimen is 75% complete, so the presence of this lesion is reflected in the prevalence if fragments 75% complete or more are included in the calculation. No MNI count was determined for the vertebrae given the large number per individual and the difficulty of identifying the vertebral number for most fragments. Therefore the prevalence of lesions in the vertebrae cannot be represented by individual.

Figure 6.12. Potentially perimortem cut mark (arrow) on the left inferior margin of the anterior body of thoracic vertebra SK2078.

Figure 6.13. Three dimensional rendering of the cut mark observed on SK2078, created using the digital microscope. Magnification is X30.

6.1.2.7 Innominates

Potential perimortem lesions were found on the iliac crest of three innominates within the sample (SK1147, SK1161, SK1178). The iliac crest of right innominate SK1178 displays a possible musket ball injury, represented by a horseshoe-shaped defect that measures 2.09 cm in diameter (see Figure 6.14). There is beveling on the anterior surface, indicating that the trajectory of the musket ball would have been posterior to anterior. Left innominate SK1161, on the other hand, displays two small circular depressed lesions on the posterior aspect of the iliac crest, which measure 0.86 cm and 0.97 cm respectively in diameter (see Figures 6.15, 6.16). The lesions are quite close together, the distance between their centers being 1.50 cm, and are possibly the result of buck shot impacts. On the iliac crest of right innominate SK1147 there are two different types of lesions (see Figures 6.17, 6.18). At the edge of the iliac crest is a keyhole defect similar to that seen on SK1178, measuring 3.28 cm in diameter and with beveling also indicating a posterior to anterior trajectory. Associated with this lesion is a small circular

and very slightly depressed lesion, measuring 0.68 cm in diameter, that is possibly the result of buck shot impact. All of these lesions display characteristics that suggest perimortem timing, including for each some combination of beveling, plastic deformation, radiating fractures, and typical musket lesion shape. While SK1147 is 88% complete, SK1161 and SK1178 are only 56% and 50% complete respectively. All three lesions will therefore only be included in the prevalence calculation if the completeness threshold is 50% or lower.

Figure 6.14. (Above) Exit side of keyhole defect observed on right innominate SK1178, associated with perimortem musket trauma.

Figure 6.15. (Above, right) Two small circular defects observed on left innominate SK1161, possibly associated with perimortem buckshot trauma.

Figure 6.16. (Right) Digital microscope image of one of the circular defects pictured in Figure 6.15, on SK1161. Magnification is X30. This demonstrates the appearance of the small depressed defects thought to represent buckshot impact.

Figure 6.17. Exit side of keyhole defect observed on right innominate SK1147, thought to be associated with perimortem musket trauma.

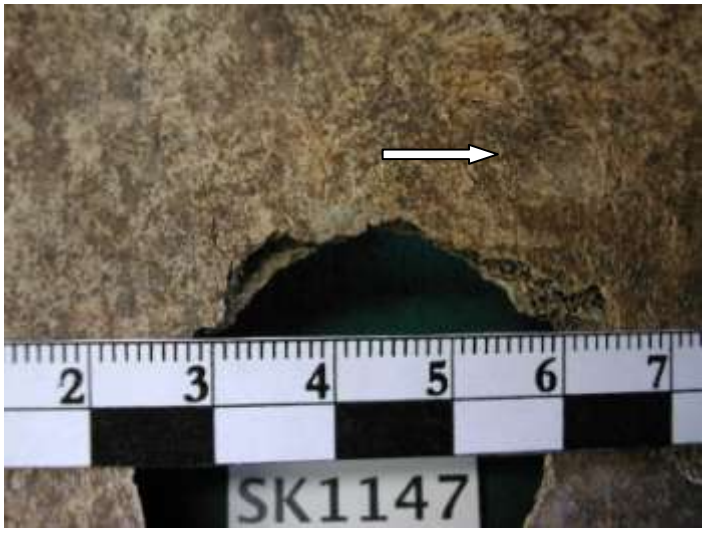

Figure 6.18. Entrance side of keyhole defect observed on SK1147, and the associated small circular defect (arrow) likely caused by perimortem buckshot impact. This specimen indicates both types of musket trauma observed in the collection, a combination of the types of lesions seen separately on SK1161 and SK1178.

The minimum number of individuals was calculated to be 20 based on fragments of the right innominate. Since there are one right and two left elements with lesions, the possibility of two of these fragments belonging to the same individual must be considered. However, it was determined that these elements are likely to have come from three discrete individuals based on features of the pelvis that can be used to indicate age. Right innominate SK1147 was definitively aged as adolescent (16-20 years of age) based on epiphyseal fusion of the iliac crest and the anterior inferior iliac spine. Left innominate SK1161, on the other hand, was tentatively aged as young adult (21-34 years of age). The other right innominate, SK1178, was aged only as adult (21-44 years) but differs

significantly in the appearance of its auricular surface, which is correlated with age. These three elements likely belonged to individuals of differing age categories; therefore possible perimortem lesions are present in three of 20 potential individuals.

6.1.2.8 Scapulae

Two potential perimortem lesions were found in two scapulae within the sample (SK1917, SK1990). The right scapula SK1917 displays a possible musket ball injury on its posterior aspect between the glenoid fossa and the base of the acromion process (see Figures 6.19, 6.20). This lesion has the appearance of a round depressed fracture with hinged fragments at the edges. The blade of the left scapula SK1990 is fractured; the sharp fracture lines and deformation at the fracture edges indicate that the lesion is possibly perimortem (see Figures 6.21, 6.22). Although this fracture may be due to sharp force, blunt force, or musket impact, it has been generally classed as a fracture as the origin of the lesion cannot be determined based on bony characteristics. SK1990 is 78% complete while SK1917 is only 56% complete, meaning that both lesions are only included in the prevalence calculations if the completeness threshold is set at 50%. The minimum number of individuals was calculated to be 20 based on fragments of the left scapula. Since there is one right and one left element displaying lesions, again the possibility of these elements belonging to the same individual must be considered. The elements are quite similar in size and appearance. While SK1990 likely originated from an adolescent (16-20 years of age), as the border of the scapular blade is completely unfused (Schaefer et al. 2009), this area of the bone is not present for comparison in SK1917. The possibility that these two elements represent the same individual cannot be

excluded, and they must be considered together when the prevalence by individual is calculated for the scapula. Therefore a possible perimortem lesion is present in one of 20 potential individuals.

Figure 6.19. (Above) Digital microscope image of round defect observed on right scapula SK1917, associated with perimortem musket trauma. Magnification is times five.

Figure 6.20. (Right) Potential perimortem damage observed on SK1917, showing depressed fragments at the edge.

Figure 6.21. (Above) Close-up image of potential perimortem fracture of SK1990, showing deformation. Photograph taken with the digital microscope. Magnification is X20.

Figure 6.22. (Left) Potential perimortem fracture observed on left scapula SK1990. The fractured portions of the scapular blade demonstrate deformation. Also, the border of this scapula is unfused, indicating that this individual was likely an adolescent (16-20 years of age).

6.1.2.9 Ribs

Fifteen potential perimortem lesions were found in the ribs within the sample (SK0322, SK0324, SK0327, SK0329, SK0335, SK0336, SK0338, SK0339, SK0340, SK0345, SK0370, SK0371, SK0708, SK0792, SK0802). Fourteen of these lesions are triangular nicks in the cranial and caudal borders of the ribs possibly resulting from perimortem sharp force trauma, likely inflicted by a bayonet (see Figures 6.23-6.28). They are very similar in appearance to the experimental lesions created in porcine ribs using a replica socket bayonet from the War of 1812 (see Section 5.3.1 and 5.3.3). The final lesion is a long (2.8 cm) sharp split in a rib fragment (SK0322) that possibly corresponds to a perimortem fracture (see Figures 6.29, 6.30). While this may also have resulted from the impact of a bayonet as suggested previously (Liston 2000), it is also possible that perimortem fractures like this can result from musket trauma or other impacts to the torso unrelated to sharp force trauma. Therefore, it is classed simply as a fracture.

Figure 6.23. Potential perimortem cut marks along cranial border of rib fragment SK0324. The typical triangular shape of lesions likely associated with the socket bayonet is evident in this photograph.

Figure 6.24. (Above, left) Digital microscope image of a potential perimortem cut mark on rib fragment SK0327, from the anterior side, showing characteristics of the sharply sliced triangular mark. Magnification is X50.

Figure 6.25. (Above, right) Another digital microscope image of the potential perimortem cut mark on SK0327 pictured in Figure 3.24, from the posterior side. Magnification is X100.

Figure 6.26. (Right) Digital microscope image of a potential perimortem cut mark on rib fragment SK0335, showing characteristics of the triangular mark. Magnification is X50.

Figure 6.27. Potential perimortem cut mark on the caudal edge of rib fragment SK0336. This mark displays sharp edges indicating likely perimortem timing.

Figure 6.28. Digital microscope image of the potential perimortem cut mark on rib fragment SK0338, demonstrating the characteristics of this triangular mark. Magnification is X30.

Figure 6.29. Potential perimortem fracture (2.8 cm in length) along caudal border of rib fragment SK0322. Image displays the sharp fracture margin and plastic deformation that suggest perimortem timing for this lesion.

Figure 6.30. Digital microscope image of the potential perimortem fracture line on rib fragment SK0322, also pictured in Figure 6.29. This clearly shows the sharp fracture margin. Magnification is X20.

The rib fragments that display potential perimortem lesions are of differing levels of completeness. Two of the fragments have part of all three zones present, 10 have only 67% of zones present, and three have only 33% of zones present. As there are some fragments classed as complete that display lesions, the prevalence will not be zero no matter what the completeness threshold is. However, the number of lesions reflected in the prevalence will change quite a bit depending on the requirements set for completeness.

As is the case for the carpals, phalanges, and vertebrae, no MNI count was determined for the ribs. There are a large number of ribs present in each individual, and with the exception of the first and occasionally second and 12th ribs, most of the rib fragments could not be identified by number. Due to the size and shape of the ribs, they also frequently break into relatively small pieces, impeding precise identification. Therefore the prevalence of lesions in the ribs cannot be represented by individual.

6.1.2.10 Clavicles

No lesions were found in the fragments of clavicle in the Smith's Knoll skeletal material that could be classified as having possible perimortem trauma present. However, lesions were found on the superior surface of a fragment of right clavicle (SK1101) that were classified as indeterminate. This fragment displays three relatively sharp looking cut marks, however it is impossible to definitively establish the timing of these lesions because the surrounding cortex has been completely removed (see Figures 6.31, 6.32, 6.33). As SK1101 is a complete clavicle, the presence of these lesions is accounted for in the indeterminate-inclusive prevalence rate regardless of the completeness threshold. The MNI was calculated to be 18 based on pieces of the right clavicle, therefore an indeterminate lesion is present in one of 18 potential individuals.

Figure 6.31. (Above) Cut marks on superior surface of right clavicle SK1101 classified as indeterminate based on the lack of surrounding cortex.

Figure 6.32. (Right, top) Digital microscope image of one of the indeterminate cut marks on clavicle SK1101. Magnification is X100.

Figure 6.33. (Right, bottom) Digital microscope image of another indeterminate lesion on clavicle SK1101. Magnification is X50.

6.1.2.11 Phalanges

No lesions found in the phalanges within the collection could be classified as having possible perimortem trauma present. However, two hand phalanx fragments (SK0978, SK1053) display lesions that were classified as indeterminate. Both of these pieces show shallow potential cut marks on their palmar surfaces, and in both cases so much of the surrounding cortical surface has been removed that it is impossible to determine whether the lesions may have occurred perimortem (see Figures 6.34, 6.35). While SK0978 is 67% complete, SK1053 is only 33% complete. This means that both lesions will be excluded from the indeterminate-inclusive prevalence rate if only complete bones are taken into account, and one of these will also be excluded if only bones with two or more zones present are included. Due to the very large number of phalanges present in each individual and given the fact that the finger or toe number to which a given phalanx fragment may belong was indeterminable for almost all of the fragments, it was impossible to calculate an MNI count based on the phalanges. The prevalence of lesions in the phalanges could not be calculated by individual, and is restricted to an element count.

Figure 6.34. Cut marks on the palmar surface of hand phalanx SK0978 (arrows), classified as indeterminate due to the lack of surrounding cortex. The cut marks are faint; three of them extend across the palmar surface from above left to below right.

Figure 6.35. Digital microscope image of cut marks on the palmar surface of SK0978. Magnification is X50.

6.1.2.12 Unidentified fragments

Five fragments that could not be identified by element were found to have small portions of their edges that were sharply sliced and appeared to display evidence of possible perimortem sharp force trauma. Three of these fragments were classified as cortical bone, one as trabecular bone, and one as 'other' since it contained both trabecular and cortical bone but displayed no identifying features. These fragments had edges that were sharp and straight, resembling potential perimortem slice marks. However, they were all very small and no information could be gathered from them other than the fact that evidence for perimortem trauma is present in even very small fragments within the collection. The injuries from which these fragments originally derived have likely been largely destroyed by postmortem damage and breakage, rendering them otherwise invisible in the record.

6.2 Analysis of Traumatic Lesions by Lesion Type

Prevalence rates for lesions related to each type of trauma are presented in Table 6.4 (for more detailed breakdowns of the number of fragments included in each count, see

Appendix I). The differences in element count prevalence rates by element are presented in Figure 6.36, and the differences in individual count prevalence rates by element are presented in Figure 6.37.

Table 6.4. Prevalence of Perimortem Sharp Force, Fracture, and Musket Trauma Lesions in the Smith's Knoll Skeletal Collection, Using the Element Count Method

Element	Sharp Force Trauma	Fracture	Musket
Carpals	2.22	-	-
Femora	1.01	-	-
Fibulae	1.2	-	-
Innominates	-	-	2.33
Patellae	3.85	-	-
Ribs	2.82	0.20	-
Scapulae	-	1.19	1.19
Ulnae	1.64	-	-
Vertebrae	0.23	-	-
Total	0.74	0.07	0.15

Prevalence (%) as an element count, listed by type of trauma, for all possible perimortem traumatic lesions in the Smith's Knoll collection. Total element counts are calculated by dividing the total number of fragments with lesions of the appropriate type by the total number of fragments in the collection (2,701).

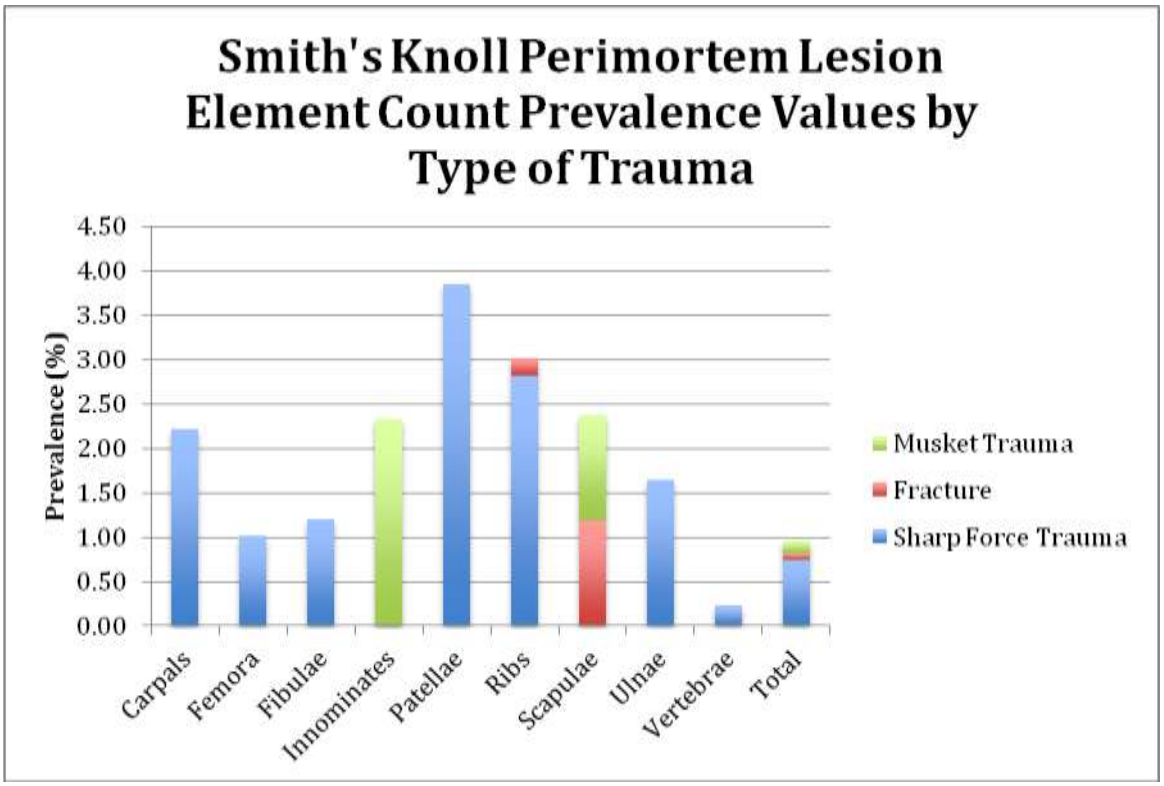

Figure 6.36. Element count prevalence values calculated for each element, broken down by type of traumatic lesion.

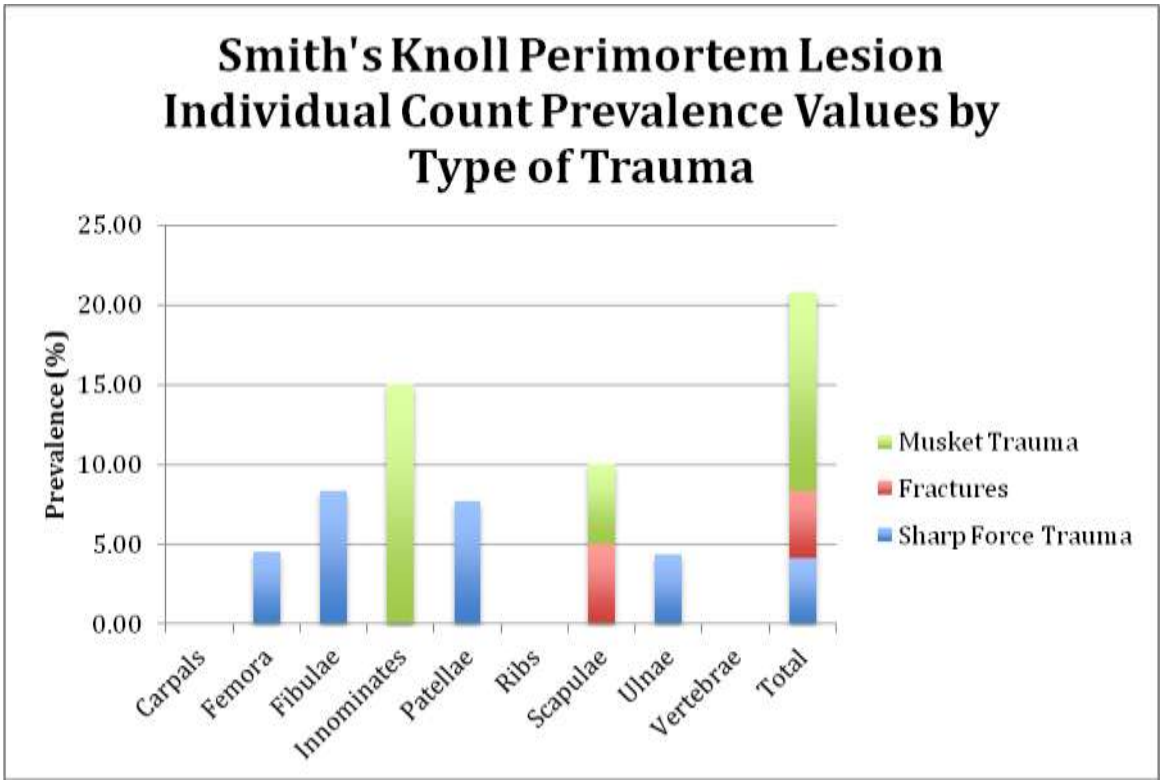

Figure 6.37. Individual count prevalence values calculated for each element, broken down by type of traumatic lesion.

6.2.1 Sharp force trauma

Sharp force trauma lesions are mainly observed in the collection in the form of cut and slice marks on the bones. All of the lesions designated as potentially perimortem (described more fully in Section 6.1.2) are located on the extremities and in the torso. Three can be found on the long bones (one femur, one fibula, and one ulna) and 14 on the ribs, although three small irregular bones (one patella, one carpal, and one vertebra) also display these lesions. The distribution of all types of trauma on the skeleton, including sharp force lesions, is illustrated in Figure 6.38.

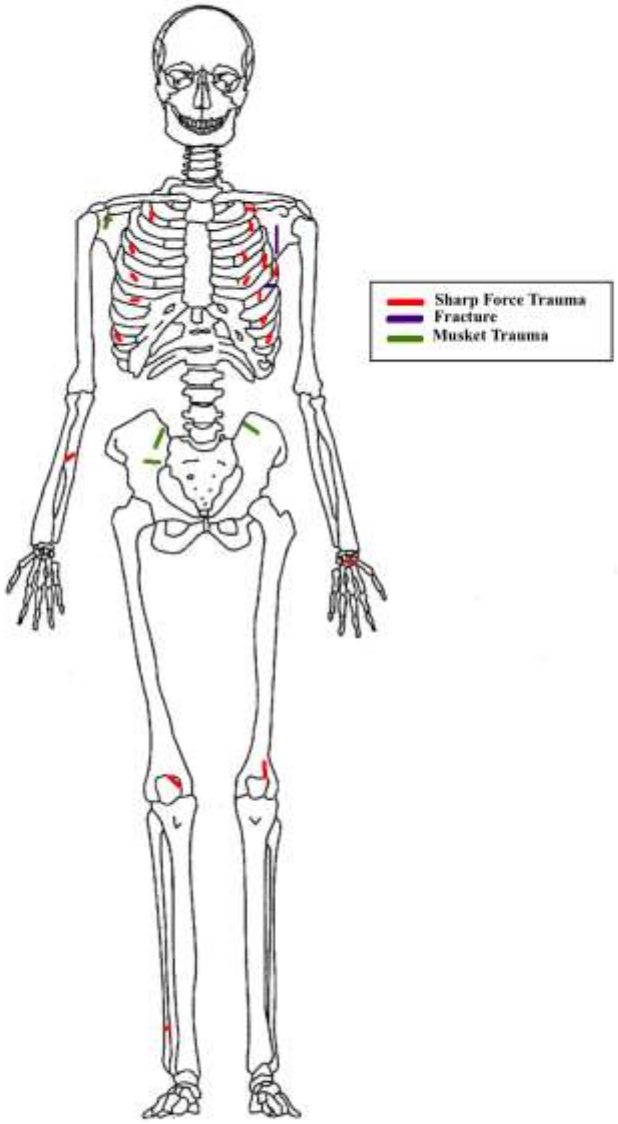

Figure 6.38. Distribution of perimortem traumatic lesions on the postcranial skeleton. The location of lesions associated with sharp force trauma, fractures, and musket trauma are represented as detailed in the legend. Only one lesion (of the right innominate) is visible solely from the posterior, so it is placed in the equivalent location on the anterior of the element. Lesions in the ribs are shown on the correct side where possible, however the precise locations of the lesions as shown are not accurate and they are not placed on the correct rib number due to the impossibility of determining rib number for most fragments.

6.2.2 Fractures

Only two lesions observed in the collection have been classified as potential perimortem fractures, one in a scapula and one in a rib fragment (see Section 6.1.2), both components of the torso. The category of perimortem fracture trauma is much broader in potential cause than either of the other categories utilized during this analysis. Fractures are the bony response to force beyond that which can be dealt with through plastic deformation alone (Ortner 2003), and they can result from a multitude of different causes. Unlike the categories of sharp force and musket trauma, the involvement of a specific instrument is not implied. Perimortem fracture lines are often associated with both sharp force and musket trauma, in the form of radiating fractures from lesions that have a clear cause or in the form of nonspecific breakage resulting from the force of impact of a sharp weapon or musket ball in the body. Radiating fractures were observed in the collection, associated with sharp force traumatic lesions on the fibula and the two possible buckshot injuries on the iliac crest. However, as they were seen in association with another type of lesion they were not considered separately from the main injury, in order to avoid having single lesions counted twice. The two lesions that have been classed nonspecifically as "perimortem fracture" may in actuality be related to the impact of a musket ball or the force of the thrust of a bayonet or slash of a sword, in addition to other possibilities. However, in the absence of soft tissue evidence that would assist in establishing more clearly the events surrounding the death of each individual within the collection, the root cause of lesions that do not display clear characteristics associated with a specific type of weapon is virtually impossible to determine. Additionally, due to the ambiguity in the length of the perimortem interval, it is also possible that these fractures occurred during

the process of the removal of the remains from the battlefield and burial of the deceased individuals.

Section 6.2.3 Musket trauma

Four of the perimortem lesions observed in the postcranial material of the Smith's Knoll collection could be definitively attributed to musket injuries. Three of these lesions are present on the iliac crest, and one in a scapula (see Section 6.1.2). While only four injuries have characteristics that allow them to be readily associated with musket trauma, such as beveled edges and lesions of a round shape that corresponds with musket ammunition, other injuries with less specific attributes may also have occurred secondary to impact from a musket ball. In fully articulated individuals it is often possible to link multiple lesions that may be found in the same individual to a common cause or to determine how lesions and their causative impacts may have interacted. However, the disarticulated, commingled, and fragmented nature of the Smith's Knoll sample precludes our ability to do this and necessitates that each lesion be considered separately from all others.

The distribution of lesions associated with musket trauma in the skeleton displays an interesting pattern. In addition to the four postcranial lesions, there are four cranial wounds that have characteristic attributes of musket ball injuries, including a circular lesion shape and significant beveling. Definitive musket-related lesions are therefore present in the flat bones of the cranial vault, scapula, and innominate.

Of the three lesions on the iliac crest, only one was noted during the previous analysis (SK1178; Liston 2000); the other two are previously undocumented (SK1147, SK1161). A component of each of these injuries that had previously gone unnoticed is a small circular depressed fracture that is likely related to the impact of buckshot ammunition (see Figure 6.16). During the War of 1812 the British and American armies used different models of flintlock musket loaded with different types of ammunition. While the British musket was typically loaded with .69 caliber lead shot, the Americans typically used a .75 caliber lead ball topped by three .33 caliber lead buckshot pellets (Elliott 2009). Variations in this practice did exist, as one American regiment present at the battle of Stoney Creek reports using 12 buckshot and no ball (Fredriksen 1984). The 25th Regiment, whose captain reported this practice, was very active during the battle and therefore buckshot ammunition would have been not only present and used in the battle, but would likely have been a significant factor in the wounds sustained by the British army during the battle. This cannot be used to infer that the remains are likely British, however, as numerous contemporary sources mention the occurrence of friendly fire (e.g. Lucas 1906; Fredriksen 1989; Turner 2000). Given the darkness of the night and the chaotic nature of the battle, it is likely that individuals belonging to both armies sustained injuries caused by American ammunition.

6.3 Experimental Analysis of Traumatic Skeletal Lesions

6.3.1 Preliminary visit to Fort George

The sharp force lesions created with the socket bayonet on the rack of back ribs during the preliminary visit to Fort George (see Section 5.3.1) were quite similar in appearance to the lesions seen on the ribs within the sample, consisting mainly of triangular nicks along the cranial and caudal edges. Despite this similarity of lesion type, however, the back ribs were not particularly close in shape to human ribs, being much flatter and broader. While this did not decrease the value of the comparative lesions and they still proved very helpful in providing an idea of the appearance of perimortem lesions created by a bayonet, it was decided that it would be useful to perform further experimental work on ribs that more closely approximated the shape of human elements (see Section 6.3.3).

Figure 6.39. Tomahawk utilized during Fort George experimental work. This is a replica of the tomahawks that would have been used by Native Americans at the time of the battle, although it is an unsharpened educational tool.

The experimental sharp force lesions created on the bovine femur were also quite useful in indicating which classes of weapon are likely to have contributed to the lesions seen in the Smith's Knoll skeletal material. Lesions were inflicted using a tomahawk (see Figure 6.39), a curved cavalry sabre (see Figure 6.40), and a socket bayonet (see Figure 6.41). Despite the fact that an unsharpened educational model was used, the

Figure 6.40. Curved cavalry sabre utilized during Fort George experimental work. This is a replica of the model of sword most commonly used during the War of 1812. The scabbard is shown at top. This sword is also an unsharpened educational tool.

Figure 6.41. Socket bayonet utilized during Fort George experimental work. This is a replica of the instrument that would have attached to the top of soldiers' muskets during the War of 1812. It is also an unsharpened educational tool.

tomahawk cut cleanly through the femur on the first stroke. As any tomahawk used during the battle would likely have been razor sharp, and no damage of this kind was seen in the collection, we concluded that it is very unlikely for any of the lesions observed in the skeletal material to have resulted from a blow of the tomahawk. This corresponds well with accounts of the battle as the number of Native American warriors or militia members who may have utilized such a weapon would have been very limited at Stoney Creek (Elliott 2009).

The other two classes of weapon, swords and bayonets, created lesions that corresponded much more closely with the damage seen in the Smith's Knoll material. The cuts and slices that resulted from impact with these two weapons bore a close resemblance with the cut marks on some of the Smith's Knoll long bones. As this was a preliminary study using an element with questionable usefulness as a proxy for human bone and the lesions made by the different types of weapon were not clearly labeled and

differentiated, further and more specific experimental work needed to be completed (see Section 6.3.2). This experimental work, taking place quite early on in the cataloguing process, served to provide a good idea of likely appearance of perimortem lesions that may be encountered, and allowed us to eliminate one potential class of sharp force weapon as having had a significant impact on the lesions created.

6.3.2 Musket injuries to the iliac crest

Measurement of the diameters of the buckshot and musket-ball induced (see Figures 6.42 and 6.43) lesions to the replica buttocks that had been shot at all three distances (10, 15, and 20 yards, or 9.14, 13.72, and 18.29 m) was completed using the digital microscope. The results of these measurements for buckshot injuries, along with measurements of the spread of lesions if two were present on the same bone, is presented in Table 6.5. Along with the values for the diameter of the experimentally produced lesions, this table contains the diameters of the relevant lesions in the Smith's Knoll material for which these experimental injuries are meant to provide a comparison (SK1147, SK1161).

Figure 6.42. (Left) Replica Brown Bess musket used during experimental work.

Figure 6.43. (Right) Replica War of 1812 period ammunition. From left to right, .69 musket ball, .65 musket ball, and .69 musket ball with three .33 buck shot (arrow - used during experiment).

Table 6.5. Measurements of the Diameter and Spread of Experimental and Archaeological Buckshot Injuries

Specimen	Diameter of First Lesion (cm)	Diameter of Second Lesion (if applicable, cm)	Distance Between Lesions (cm)
Tray 1 (20yards/18.29m)	0.7	0.86	4.01
Tray 3 (15yards/13.72m)	0.94	1.01	4.34
Tray 4 (10yards/9.14m)	0.83	-	-
Tray 5 (10yards/9.14m)	0.98	-	-
SK1147	0.68	-	-
SK1161	0.86	0.97	1.50

Measurements of buckshot injuries in scapulae from all three distances, compared with lesions found in archaeological specimens. The diameters of all lesions present were measured, as well as the distance between the centers if two lesions were present on the same bone, using the digital microscope.

Measurements of lesion diameter were also made for the musket ball injuries seen in the experimental and archaeological specimens. The results of these measurements are presented in Table 6.6. From the nine trays that were assembled and shot, scapulae from only six trays displayed lesions that could be reliably measured. While trays six, seven, and nine were impacted by both types of ammunition, the scapulae were broken into multiple pieces. These pieces could be fitted together for photography of the lesions, but due to breakage along the edges and the inability to completely refit the pieces accurate measurement of the lesion diameter was deemed impossible. Measurable lesions associated with both buckshot and musket-ball injuries were present in at least one specimen shot at each of the three distances.

Table 6.6. Measurements of the Diameter of Experimental and Archaeological Musket-Ball Injuries

Specimen	Diameter of Lesion (cm)
Tray 2 (20yards/18.29m)	2.49
Tray 8 (15yards/13.72m)	1.91
Tray 4 (10yards/9.14m)	2.05
SK1147	3.28
SK1178	2.09

Measurements of musket ball injuries in scapulae from all three distances, compared with lesions found in archaeological specimens. The diameters of all lesions present were measured using the digital microscope.

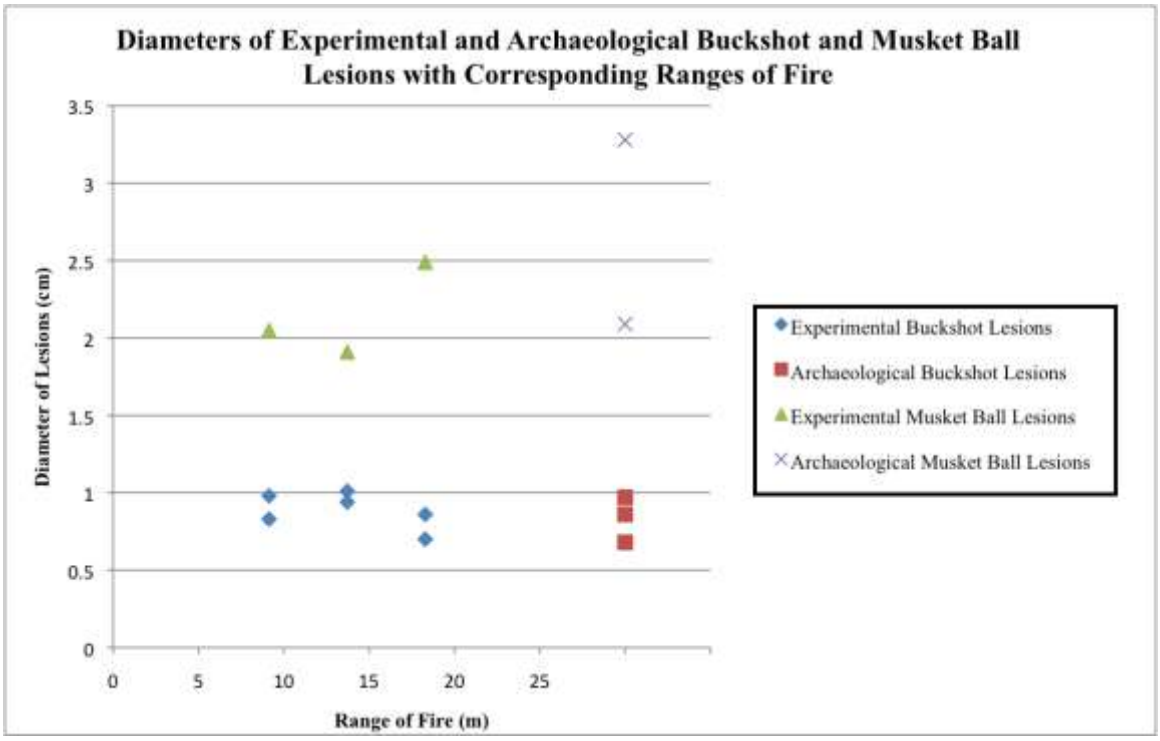

Figure 6.44. Scatter plot showing the relationship between the diameter of experimental buckshot and musket ball lesions and the range of fire (9.14, 13.72, or 18.29 m). The archaeological lesions, for which range of fire is unknown, are displayed beside the experimental lesions for comparison. They are in a vertical line, the only important measure being the diameter of the lesion as these archaeological lesions could have come from any of the experimental distances used or a distance that was not tested.

No clear correspondence was found between the diameter of the lesion or spread of the buckshot and the distance from which the experimental specimen was shot, which is illustrated in Figure 6.44. While there looks to be a general trend in the diameter of lesions as correlated with the range of fire, there is clearly quite a bit of variability and the

Figure 6.45. Experimental musket ball lesion in replica buttock from Tray four, exit view.

sample size is much too small to garner any useful conclusions. Qualitatively, the appearance of the lesions created in the experimental specimens and the lesions observed in the archaeological elements are similar in some ways and different in others. In the archaeological innominates, the musket ball injuries present as through-and-through wounds associated with beveling along the edge of a horseshoe-shaped defect. The musket ball lesions in the experimental specimens are quite similar in appearance when the impact was toward the edge of the scapula, especially when the effects of weathering are taken into account. Other experimental musket ball lesions present as circular defects with beveling (see Figure 6.45). The archaeological buckshot lesions are small, depressed fractures with a characteristic circular shape and very low penetration. In the experimental specimens, however, all projectiles went clean through the soft tissue, bone, and cafeteria trays (see Figure 6.46), except one buckshot that became embedded in the bone. This buckshot was found in a tray that had been shot at the closest distance, further emphasizing the variability exhibited in the behavior of the musket ammunition. More generally, in the experimental specimens significant variability was observed in the effects of the ammunition on the bone at each distance. At a given distance some bones exhibit clear lesions while others were simply shattered by the impact. Based on the values obtained and qualitative appearance of the lesions that were created during this experiment, it

appears that the effects of the musket ball and buckshot ammunition used during the War of 1812 on bone are not consistent.

Figure 6.46. Buckshot lesions in experimental and archaeological specimens (as labeled). Magnification is times five. All experimental specimens are shown in exit view as this most clearly shows the characteristics of the lesions. However, the archaeological lesion does not penetrate through the bone, and so only the entrance view could be shown.

The inconsistency of the relationship between lesion diameter and range of fire as determined by these experimental results means that the range of fire cannot be reliably determined from the diameter of the experimental lesions. However, it is clear from the experimental results that the diameters of the archaeological buckshot and musket ball lesions correspond very well with those of the experimental lesions. This indicates that

these lesions are likely correctly interpreted as resulting form the impact of musket ammunition. The musket ball lesion on SK1147 has the largest diameter (3.28 cm), a figure that is above the range of the experimental lesion diameters. This lesion may have an increased diameter size due to the significant amount of weathering that was present on this element, which may have enlarged the edges of the lesion and artificially increased its size. The diameter of this particular lesion was difficult to measure; more of the iliac crest is missing from this specimen and the weathered and preserved portions of the edge of the lesion are difficult to differentiate, so more assumptions needed to be made regarding which areas of the lesion would support the most reliable measurement of diameter.

For specimens with more than one buckshot lesion per element, the spread of the lesions was also measured from the center of one lesion to the center of the next. While no relationship is evident between the spread of the lesions and the range of fire (see Table 6.5), there were only two experimental specimens for which this measurement was even possible. Before beginning the experiment, paper targets were shot with the same ammunition to assess musket accuracy and get a preliminary idea of the possible spread of the buckshot. These targets were shot from 10, 15, 20, and 50 yards (9.14, 13.72, 18.29, and 45.72 m respectively), and based qualitatively on the appearance of the lesions on the paper targets there was no correspondence between the spread of the lesions and the range of fire, corroborating the quantitative results from the bony elements. It was expected that closer ranges of fire would result in a smaller buckshot spread, as with less distance to travel after exiting the barrel of the musket there would be less time for the

pellets to travel apart from one another. However, while this expectation held at 10 yards with the buckshot impacting close together on the paper target, shots at successive distances were much more variable with some being further apart and some even closer together. This further demonstrates the variability in spread and the unpredictability of the projectile trajectory from the flintlock musket.

6.3.3 Bayonet and/or sword injuries to the lower leg

After processing the replica lower legs, it became evident that some of the experimental lesions created were clearer than others. Leg number one was impacted with a sword, and although a lesion was observed in the field there were no clear perimortem lesions on the diaphysis of the replica fibula. It is possible that the lesion observed in the field failed to impact any deeper than the periosteum, and was therefore lost when the periosteum was removed during processing. Leg number two was also impacted with a sword, and again no very clear-cut mark was present on the diaphysis of the replica fibula. There was a perimortem defect near the distal end of the shaft, however it appears to be more of a depressed fracture with some sharp characteristics than a sharp cut mark (see Figure 6.47). The lack of sharp force

Figure 6.47. Digital microscope image of the experimental lesion produced on replica leg two using a sword. This photograph was taken using the HDR function, and the magnification is X50.

characteristics may be a result of the fact that this is an unsharpened educational model replica sword, rather than a sharpened sword ready for use in a battle context. With neither of the sword-impacted replica legs yielding a clear comparative sword lesion, I had to rely mainly on the description of the characteristic features of sword lesions provided by Lewis (2008) for comparative purposes. Despite the lack of useful lesions, the impact of the sword on both of these replica legs easily sliced through the tibia to impact the fibula, even though the sword used had not been sharpened. This served to demonstrate that the original sword scenario (see Section 5.3.3) was indeed possible, and should still be considered as a potential cause of the lesion observed in fibula SK0129.

The two bayonet-impacted legs yielded a much clearer comparative bayonet lesion. Leg number three was impacted with a socket bayonet, and clear lesions were produced on both the replica tibia and the replica fibula (see Figure 6.48). These were photographed under various magnifications using the digital microscope, and provided excellent comparative features. Leg number four was also impacted with the socket bayonet, and while two cut marks are present they are fairly shallow. The detergent used in processing the bone impacted this specimen poorly, and following processing the outer cortical surface began to peel quite badly. The flaking and

Figure 6.48. Digital microscope image of the experimental lesion produced on the replica fibula of leg three using a socket bayonet. Magnification is X50.

peeling of the cortical surface makes the lesions on the bones of this replica leg very difficult to observe. As a result, comparison mainly relied upon the lesions present on leg number three to represent perimortem bayonet wounds of the fibula.

The corresponding lesion in the Smith's Knoll material is a sharp, likely perimortem cut mark on the distal anteromedial surface of the diaphysis of the fibula SK0129. Based on comparison with the experimental lesions on leg number three, this archaeological injury differs quite significantly in appearance from this lesion produced by a bayonet. SK0129 displays a lesion that has a very sharp and straight lower edge, with an upper edge that is slightly hinged and lipped away from the sharp kerf floor (see Figures 6.7-6.9). There is a small radiating fracture associated with the lesion. These features are not present in the experimental bayonet lesions, and therefore this injury is not likely to have been caused by the impact of a bayonet. Associating the lesion definitively with possible causation by a sword is difficult and ultimately proved impossible, due to the lack of clear experimental lesions in the two replica legs that were impacted with the cavalry sword. However, the cut mark found in SK0129 corresponds quite well with the description of a characteristic sword lesion given by Lewis (2008) based on his own experimental work. The mark presents as a deep cut with a straight kerf, and cross-sectionally it displays one obtuse angled wall and one acute angled wall with traces of damage, rather than the consistent v-shape associated with a knife-like weapon; these traits are associated with damage caused by a sword rather than another class of edged weapon (Lewis 2008). Sword marks, as described in the literature, generally display features associated with both the sharp cutting blade and some aspects of blunt

force trauma such as lateral pushing back and radiating fractures, both of which can be observed in SK0129.

Based on the available evidence, it therefore appears likely that the lesion observed on SK0129 is due to a sword cut rather than the stabbing impact from a socket bayonet. This suggests that the first scenario, in which a sword cut through the tibia and impacted the fibula at the end of its stroke, is more likely to have resulted in this lesion than the second scenario involving the bayonet. However, in the absence of a clear comparative experimental lesion made by sword impact, this association can only be made based on the descriptive evidence provided by Lewis (2008) regarding his own experimental results. All that can be securely concluded based on the experimentally produced lesions is that the injury observed on SK0129 does not resemble the lesions created with the thrust of the bayonet.

6.4 Summary of the results

The qualitative and quantitative analyses of perimortem traumatic injury performed on the material of the Smith's Knoll collection indicate that lesions attributable to fracture, sharp force trauma, and musket trauma are present in the assemblage. Lesions are present in all areas of the body, with sharp force trauma predominately in the torso and extremities and musket trauma predominately in the flat bones of the cranium, innominate, and scapula. The majority of lesions observed in the collection are caused by sharp force trauma. Quantitatively, it can be seen that the fragmentary nature of the sample has likely affected the prevalence of injuries visible therein, as the comparison of

different prevalence calculation methods demonstrates that taking completeness into account significantly impacts the values obtained. The types of injuries present in the skeletal elements of the sample are consistent with the types of weapons in use during the battle; further consideration of various aspects of these lesions can provide valuable information regarding the circumstances surrounding the death of the individuals composing the collection.

Chapter 7: Discussion

The presence, appearance, and frequency of perimortem traumatic lesions observed within the Smith's Knoll assemblage are closely related to the perimortem injuries sustained by individual soldiers whose remains contributed to the formation of the collection. The link between observed skeletal injuries and soldier experience can be elucidated through a close examination of the patterning of lesions in the sample compared with historical information regarding the events of the battle, lesions created experimentally, lesions observed in other skeletal samples from similar contexts, and other bioarchaeological studies of violence in the past. The presence of comparative and corroborating material in such abundance is a unique feature of the Smith's Knoll collection, and allows for increasingly nuanced interpretations that can make valuable contributions to bioarchaeological conceptions of warfare and its expression in the skeletal record. The perimortem traumatic lesions observed in this sample, when considered in the context of historical accounts of the battle as well as of bioarchaeological and medical studies of material from other military sites from the same period, therefore have the potential to provide significant information regarding violence and warfare in the past.

7.1 Analysis of perimortem traumatic lesions

Several features of the perimortem traumatic lesions observed in the Smith's Knoll assemblage have the potential to provide information regarding the expression of

violent activities in the skeletal record. The types, patterns of distribution, severities, and prevalence values of lesions present reflect the weapons used to inflict injury, conditions during the battle, and other aspects of soldier experience. As well, the types of lesions not observed within the sample can be quite informative regarding aspects of battle conditions as well as potential postmortem alterations to the collection that could affect features of the lesions observed skeletally. The results of the experimental analyses are also discussed in the context of the lesions observed in the collection, and brief mention is made of the significance of the statistical results.

7.1.1 Types of lesions present in the sample

The types of lesions that are displayed in the skeletal elements of the Smith's Knoll sample reflect the conditions that prevailed during the battle of Stoney Creek. Sharp force trauma, musket trauma, and perimortem fractures are all observed in the collection, and the lesions are consistent with the weapons that were used by the British and American armies during the War of 1812. The type and characteristics of perimortem lesions present in the sample provide information on the types of weapons that inflicted injury in soldiers during the battle and how these instruments were actually used, data which can then be compared and combined with other sources of evidence to build a more accurate conception of the battle.

Perimortem sharp force lesions are seen in elements of the extremities and torso of the Smith's Knoll assemblage. There would have been several classes of weapon capable of producing such lesions present at the Battle of Stoney Creek, including bayonets,

swords, and potentially tomahawks (see Figures 6.39, 6.40, 6.41). The lesions observed in the collection are consistent with injuries associated with either the socket bayonet or the sword; however the appearance of tomahawk lesions is quite different than the lesions that are present at Smith's Knoll, as is demonstrated by the results of our experimental work (see Section 6.3.1) The bayonet and sword are therefore likely to have been the two classes of edged weapon most relevant in causing injuries sustained during the battle of Stoney Creek. These two classes of weapon have significant differences in form and function that would certainly affect the lesions they produce in the soft and hard tissues of the human body, lesions with the potential to reveal much about the experience of soldiers during the battle.

Some of the lesions observed in the collection exhibit characteristics that make them more likely to have been caused by the socket bayonet rather than another class of edged weapon. For example, the sharp force lesions present in the ribs are largely in the form of triangular nicks consistent with the profile of the bayonet. Similarly, the triangular lesion in the anterior body of a thoracic vertebra (SK2078) corresponds well with the shape of the bayonet. These lesions of the torso have quite a different morphology than the cut marks on the long bones of the limbs. It is significant to note that the only sharp force lesions that can be relatively securely linked with the bayonet are present in the torso. Although standard military training instructed soldiers to aim lower down into the abdomen in order to reduce the risk of having one's bayonet caught between the ribs, there are many documented cases of bayonet injuries to the torso (Kaufman 2003).

Figure 7.1. 'India' pattern musket with socket bayonet, c. 1800. This demonstrates the triangular shape of the bayonet, which attaches to the end of the musket. Image taken from Kaufman (2003, 178).

The socket bayonets used by both the American and British armies during the War of 1812, a standard weapon during the first half of the 19th century (Kaufman 2003), were triangular at the tip and were designed to be used with a thrusting or stabbing rather than a cutting motion (see Figure 7.1). The sides of the triangular blade were very straight, and upon going into battle soldiers would have kept their bayonets sharpened to a fine point. During the War of 1812, the characteristics of the weapons that were available largely dictated the strategies that were utilized. The main infantry weapon was the flintlock smoothbore musket, and due to the inaccuracies of this instrument most battles therefore consisted of movements of massed infantry formations, as this was the situation in which the musket proved most effective (Kaufman 2003). The bayonet was designed for use as a purely defensive implement to protect infantrymen at close range, conveniently attaching to their musket to avoid the necessity of carrying an additional weapon. However they were occasionally used offensively, mainly in the form of a bayonet charge after several rounds of musket fire. In such a case, the moral effect of a mass of infantry rushing forward with bayonets pointed was typically sufficient to cause the enemy to retreat, avoiding hand-to-hand combat (Kaufman 2003). Hand-to-hand fighting was therefore not particularly common and in a typical battle soldiers would not have much occasion to utilize their bayonet.

Under exceptional circumstances however, such as the British night advance during the battle of Stoney Creek (see Chapter 4), the bayonet was occasionally used as the major weapon in an offensive.

The extent of close-range fighting that occurred at Stoney Creek was quite unusual. Therefore, the relative frequency of sharp force trauma and particularly lesions attributable to the bayonet may be higher in the Stoney Creek material than at other sites of the same period. Lesions associated with this edged instrument are not generally noted in the bioarchaeological literature (Scott et al. 1989; Owsley et al. 1991). In many collections the absence of bayonet-related lesions of the ribs as observed at Smith's Knoll might be related to issues of preservation, as the ribs are often highly fragmented and poorly preserved. It may also be related to biases imposed by the nature of the investigation, as small elements such as the ribs may not have been analyzed in detail in previous investigations. This is not the case for Snake Hill or the Battle of the Little Bighorn, however, in which several perimortem fractures, incised marks, and projectile injuries of the ribs were noted (see Section 7.2.2 and Section 7.2.3).

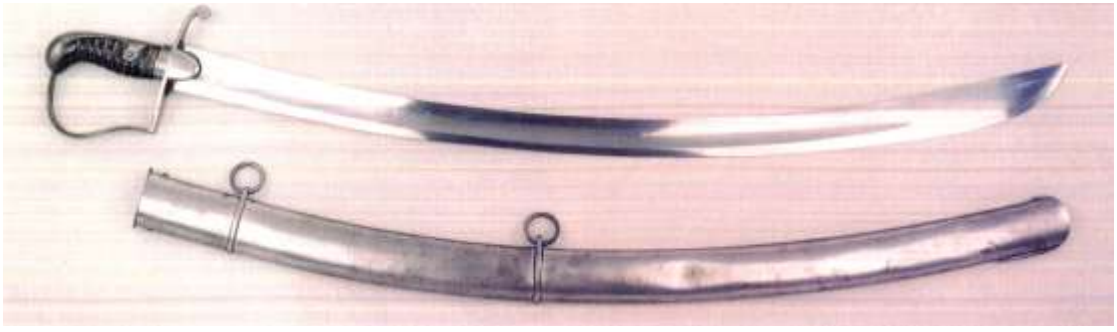

Figure 7.2. British light cavalry sword and scabbard. This model was introduced in the British army in 1796. It was one of the most effective and commonly used models available at the time. Image taken from Kaufman (2003, 192).

Soldiers in the British and American armies also used several types of swords during the War of 1812. Probably the most common of these was the British cavalry sword, a long curved sabre used with a cutting motion to slash at the enemy (see Figure 7.2). Although a variety of swords designed for cutting, thrusting, or both were in use at the time, the curved cavalry sabre is generally considered to have been the most useful and efficient (Kaufman 2003). Some of the cut marks in the long bones have different characteristics than the triangular nicks found in the bones of the torso, and therefore it is likely that they were caused by swords rather than the bayonet. One lesion in particular, found on the distal fibula (SK0129), has characteristics that align more closely with sword lesions than those associated with the bayonet; this was determined based on experimental lesions as well as the sword lesion characteristics outlined by Lewis (2008) (see Section 6.3.3). Lesions that have large, sharply sliced surfaces such as those observed on the scaphoid, femur, and patella (see Figures 6.2, 6.5, 6.10) are also more consistent with injuries inflicted by a sword rather than a bayonet. These injuries appear to be caused by the slicing motion of a large blade.

Projectile trauma is present in the crania, the innominates, and one scapula of the Smith's Knoll collection, and these lesions are consistent with the types of ammunition used by both armies during the War of 1812. Lesions corresponding with both major types of ammunition, musket balls and buckshot (see Figures 6.42 and 6.43), can be observed in these skeletal elements. While lesions attributable to the impact of musket balls are quite commonly described in the bioarchaeological and medical literature for this time (e.g. Scott et al. 1989; Litt et al. 1993; Gill 1994; Willey and Scott 1996;

Kaufman 2003), the presence of lesions resulting from the impact of buckshot has rarely been noted. One example of a lesion with buckshot embedded in the bone has been described in the tibia of an individual from the Terry Collection, a documented historic assemblage (de la Cova 2010). However, no lesions relating to buckshot have been described in archaeological material or surgical collections from the historic period (Scott et al. 1989; Owsley et al. 1991; Willey and Scott 1996; Kaufman 2003). This may be a result of the rarity of use of this type of ammunition, as the British army did not use it and many collections available are not from North American conflicts (Kaufman 2003). Later in the 19th century firearms with rifled barrels began to replace the smoothbore flintlock, and therefore by the time of battles such as the Little Bighorn buckshot was likely no longer in use; certainly no mention is made of the use of buckshot ammunition in analyses of material from this battle (Scott et al. 1989; Snow and Fitzpatrick 1989). No potential buckshot-related lesions were observed at the Snake Hill site, although these remains are also attributed to soldiers from the War of 1812. The lack of buckshot lesions in this sample likely relates to the fact that these soldiers have been relatively securely established as members of the American army, and the battles in which they took part prior to their death are significantly less likely to have involved friendly fire than the battle of Stoney Creek (Litt et al. 1993). Still, it is not clear whether lesions that can be attributed to buckshot injury are not present in these other historical samples or whether they have simply not been observed. The lesion noted by de la Cova (2010) contained buckshot ammunition that remained embedded in the bone, greatly aiding in the attribution of cause in this case. With the absence of ammunition directly associated with

the lesion as would certainly be the case in disturbed archaeological remains, these lesions are likely much more difficult to detect. Due to the absence of additional War of 1812 skeletal samples available for analysis, it appears that for the time being the presence of buckshot-associated lesions is a unique feature of the Smith's Knoll archaeological skeletal sample.

There are two lesions observed in the Smith's Knoll collection that have been attributed simply to perimortem fracture. This nonspecific designation is related to the absence of characteristics associated with sharp force or projectile trauma, although this does not rule out the contribution of either of these forms of trauma in the creation of the lesions (see Section 6.2.3). In the previous analysis, the perimortem split in a rib (SK0322) was classified definitively as bayonet trauma (Liston 2000). However, there are many other impacts to the torso that could result in such a lesion, including but not limited to a fall, a blunt force impact, or a musket ball. Musket balls are notorious for the unpredictability of their course within the body, and once it entered the torso a projectile could deflect and impact many elements in its course. Many such projectiles entering the torso can result in fractures to the ribs (Kaufman 2003). Due to the shape and arrangement of the bones in the torso, it has also been documented that impacts in one area of the rib cage can cause fractures to other areas without a direct impact to the area of the bone displaying the lesion (Daegling et al. 2008), meaning that a fracture in this area especially could be associated with musket or sharp force trauma without displaying characteristic signs of either. Alternatively, it has already been established that sharp force trauma to the torso occurred during the battle (see Section 6.2.1) and this could also

have contributed to the presence of perimortem fractures in this area. In short, the cause of either lesion classified as a perimortem fracture cannot be more specifically determined.

Perimortem fractures can be difficult to distinguish from damage that occurred after the time of death, as collagen and moisture content do not change instantaneously with death but are lost along a continuum, meaning that fracture characteristics go through gradual changes and may appear perimortem for months after the death of an individual (Wieberg and Wescott 2008). Breakage, fragmentation, and fracture are very common in the elements of the collection; there are many examples of fractures that display mixed characteristics, simultaneously showing evidence of deformation or hinging as well as rough fracture surfaces and stepped fracture margins. These mixed lesions likely occurred while the bone was still relatively fresh, representing an earlier stage in the continuum than those that display breakage with a significant color difference at the edges and definitively dry fracture characteristics. The presence of mixed characteristics makes a definitive decision on the timing of a lesion much more difficult to make.

The situation is made more complicated by the fact that the timing of a lesion in relation to the death of an individual is not the only factor that can affect the proportion of fresh and dry fracture characteristics displayed. Microenvironmental changes between different areas of the burial environment may contribute to varying moisture retention in various elements based on their burial position; this is especially relevant to the Smith's Knoll sample as the elements contained therein were buried in a mass grave. Mass graves

contain the remains of multiple individuals in haphazard positions that are buried in contact with one another, and the presence of additional corpses in the vicinity of a set of remains can act to prolong the retention of moisture (Moraitis et al. 2009). This feature of the mass grave would vary in its effect on remains based on their proximity to the center of the grave, with those at the middle being surrounded by the most other remains and therefore experiencing the most moisture retention. Unfortunately, the remains were significantly disturbed and moved from their original burial positions by taphonomic processes including churning of the soil during farming practices and the direct exhumation and reburial of the remains by human agents. Also, during the original excavation and previous analysis elements were sorted and labeled based generally on which trench they were found in, but were not given individual identifying numbers or mapped precisely (Griffin-Short 2000). As a result, the original and successive position of the various elements in relation to one another cannot be discerned and thus potential differences in the rate of moisture and collagen loss cannot be determined.

7.1.2 Distribution of lesions present in the sample

In addition to the types of lesions present in the sample, the distribution of different types of lesions throughout the skeleton can be very telling with regard to the types of weapons relevant to events during the battle, how these weapons were used, and how this would have affected the experience of individuals taking part in the conflict. While the lesions attributed to sharp force trauma are displayed in the torso and

extremities of the individuals in the collection, the musket trauma is present in flat bones throughout the body. Perimortem fractures in this sample are restricted to the torso.

Sharp force traumatic lesions with characteristics allowing them to be associated with the socket bayonet are located mainly in the ribs, with one lesion present on the body of a thoracic vertebra. The presence of so many thoracic bayonet lesions runs counter to the typical strategy soldiers were to follow when using the bayonet. The weapon is designed for thrusting into softer areas of the body such as the abdomen, and areas such as the thorax should be avoided due to the complexity of the skeleton in the rib cage and the difficulty of removing the sharp point of the bayonet once it has become lodged in bone. This advice must have been difficult to follow, however, in the chaos of close-range fighting in a real battle situation. Conditions during the battle of Stoney Creek, happening as it did in the complete darkness, were increasingly confusing and aim therefore further impaired. Bayonet wounds to the skeleton, similar to buckshot injuries, are not mentioned in the reports of osteological analyses at the roughly contemporaneous sites of the battle of the Little Bighorn and Snake Hill (Scott et al. 1989, Litt et al. 1993). While there is mention of one soldier suffering a superficial bayonet wound to the chest in the surgical material discussed by Kaufman (2003), none of the skeletal lesions preserved in this collection are related to injury with a bayonet. Again, the apparent paucity of bayonet lesions in contemporary samples may relate to the significant differences in battle conditions between Stoney Creek and other battles during the War of 1812; most conflicts did not involve close-range fighting, and the bayonet was likely rarely used. As well, the bayonet had originally been introduced mainly to protect infantry soldiers in the event of

a cavalry charge, and as the use of heavy cavalry units during battle was phased out during the nineteenth century later battles may not have seen as much involvement of the bayonet (Kaufman 2003). This weapon would likely still have been in use in some capacity however, as mention is made of bayonet wounds in the surgical literature relating to injuries sustained during the First World War (Wallace 1916). Without closer examination of the skeletal material from these collections, the possibility that this type of trauma is present but that its association with the bayonet has not been recognized cannot be completely disregarded.

Additional lesions associated with sharp force trauma are present in the extremities of the sample. There are potential perimortem cut marks on a distal fibula, distal femur, and ulna, as well as potential perimortem slice marks on a patella and a carpal. Indeterminate lesions are also present in a tarsal, a clavicle, an additional femur, and two hand phalanges. Based on experimentally created comparative lesions and the description of sword lesion characteristics presented by Lewis (2008) the mark on the distal fibula can be fairly securely associated with an injury caused by a sword rather than a bayonet or tomahawk (see Section 6.3.3). The lesion present on the diaphysis of an ulna is more difficult to classify definitively due to the significant postmortem damage and weathering present around the mark, however it is quite large and the associated deformation is suggestive of a larger instrument with a significant blunt force component, which would be consistent with the use of a sword. The lesion present on the distal femur is very large and consists of two parallel cuts to the anterior surface of the bone, slicing deeply into the diaphysis and epiphysis. This damage can be definitively attributed to a

slicing rather than stabbing motion, as can the sliced lesions observed on a carpal and patella within the sample. Therefore, it is likely that the postcranial lesions in the long bones and small irregular bones of the upper and lower extremities can be attributed to damage inflicted with a slicing instrument rather than a stabbing instrument, and are likely related to damage created using a sword.

The positioning of these potential sword injuries is quite unusual for wounds sustained in a battle context during the War of 1812. However, it is likely that the occurrence of otherwise unusually placed lesions may once again be related to the unique battle conditions present at Stoney Creek. It is possible that these lesions represent defensive wounds, especially the two lesions present in the wrist and the forearm. Defensive lesions are commonly observed in the upper extremity, so the conceptualization of these two injuries as relating to defensive behavior is not unreasonable. While much less common, it is possible for defensive wounds to be present in the lower extremities as well, especially if there is a possibility that the victim were lying on his back or had fallen down at some point during the altercation (Prieto 2007). Lesions present in the lower extremity have been attributed to defensive actions in other bioarchaeological analyses, for example a cut mark seen on the tarsals and metatarsal of the plantar surface of an individual's foot at Fort William Henry was interpreted as an injury sustained during attempted self-defense (Liston and Baker 1996). It is possible that the lesions found on the distal femur, distal fibula, and patella may have occurred when an individual on the ground raised his leg in an attempt to defend himself from attack. It is also possible that the individual being struck was in an elevated position where his

lower leg was exposed to attack from the ground, such as being seated on horseback. However, this situation is thought to be less likely since although cavalry was present at the battle of Stoney Creek, a cavalry charge would have been ineffective in the dark and therefore the cavalry did not play a significant role (Elliott 2009). While neither of these scenarios would likely arise during a typical War of 1812 conflict, the uniquely chaotic and close-range battle conditions at Stoney Creek make either possible.

Musket trauma within the Smith's Knoll sample is present in the cranium, innominate, and scapula. The sole presence of projectile injuries in the flat bones of the skeleton presents an interesting pattern. This could reflect the fact that non-cylindrical bones like the scapula, iliac crest, and cranial vault present a large continuous surface for potential impact by a projectile. It has been suggested that since the cranial vault is covered by less soft tissue than much of the rest of the human body, an impact on the cranium is more likely to affect the skeleton than an impact in many other areas of the body (Novak 2000). However, this is perhaps not the only explanation for the apparent ease of expression of lesions in the cranium. Another feature of the cranial vault that may make it amenable to lesion formation is the relatively flat expanse of bone that provides sufficient surface area to make an impact likely, and a surface whose reaction to impact is much less complex than a cylindrical element and more likely to show a discrete lesion rather than simply shattering. This type of surface is also more likely to show such a lesion than elements like the ribs, which are quite thin and readily break into multiple pieces with impacts as a result of both perimortem traumatic and post-depositional forces. If this is the case and these features of the cranium are part of the reason that the results of

Figure 7.3. Musket ball injury to the lateral edge of a patella from Ballingall's surgical collection. This damage would be very difficult to detect in archaeological material. Image taken from Kaufman (2003, 119).

Figure 7.4. Distal femur from Ballingall's surgical collection, displaying musket ball injury. This type of damage would be readily recognizable in the archaeological record if preserved. Image taken from Kaufman (2003, 103).

so many violent encounters are displayed in the skull, the same could then be said of other flat bones, such as the scapula and the innominate.

Flat surfaces with at most a gentle curve, such as those of the cranium, scapula, and innominate, may more obviously display a clearly recognizable projectile lesion with characteristic features such as beveling. It is possible that musket lesions are more difficult to recognize in cylindrical or more irregularly shaped elements. This would certainly be true for some lesions that lack the more specific characteristics linked to musket injuries such as beveling and round lesion shape and would likely not be recognized as musket trauma out of context (see Figure 7.3). However, musket injuries to the long bones are in many cases quite recognizable (see Figure 7.4). Musket injuries in several postcranial elements besides the scapula and innominate have been noted in skeletal analyses of other contemporary sites such as the battle of the Little Bighorn and Snake Hill, including lesions observed in the long bones, ribs, and vertebrae (Snow and Fitzpatrick 1989; Owsley et al. 1991; Kaufman 2003). At Smith's Knoll, the lack of

musket trauma in elements other than the cranial vault, innominate, and scapula may relate to issues of preservation, or the masking of lesions by taphonomic processes. Contemporary accounts of the battle mention many instances of soldiers taking musket balls to the extremities, and in most cases the impact is described as having "shattered" the limb (Elliott 2009); these small pieces would then probably be more easily taphonomically altered and therefore less easily recognized as lesion components.

Traumatic lesions characterized as perimortem fractures are restricted within the Smith's Knoll sample to the bones of the torso. One such lesion is present in the blade of a scapula, and another in a rib fragment. While rib fractures are commonly encountered archaeologically when there is sufficient preservation of the ribs for these lesions to be observed, fractures of the scapula are uncommonly observed archaeologically. Lesions of the scapula are said to result from the application of direct force (Lovell 2008), and a fracture with displacement as observed in the Smith's Knoll material likely requires impact of quite a large magnitude. Historically, scapular fractures have been observed as a result of musket injury (Kaufman 2003). In the case of sharp force trauma, however, the scapula is generally held to be more likely to perforate whereas elements like the ribs react by fracturing (Rogers 2004). Despite this general trend, the alternative possibility of a significant impact to the torso caused by a bayonet thrust cannot be ruled out as a possible cause. Therefore while the potential cause of this perimortem fracture in the scapula cannot be more precisely determined, what is certain is that it represents a considerable direct impact to the torso of the individual concerned, providing more

information about the potential experiences of soldiers involved in the Stoney Creek conflict.

7.1.3 Prevalence of lesions present in the sample

Quantitative analysis of the lesions present within the Smith's Knoll skeletal material is particularly useful in illustrating the paucity of skeletal evidence for what must have been the very numerous soft tissue injuries leading to the deaths of the individuals that make up the sample. As is evident in Tables 6.1 and 6.2, the frequencies of all types of trauma observed in each class of element in the sample are quite low overall, ranging from 0.23% to 3.85%. When the number of fragments included in each prevalence calculation is restricted based on completeness, these frequencies drop to even lower figures. When only complete elements are included, which actually complies with the assumptions inherent in a prevalence calculation in the first place, the prevalence figures using the element count method for all elements except the ribs (7.41%) drop to zero. The large differences in prevalence calculated based on differing completeness requirements illustrate the large effect of postmortem damage within the sample on the quantitative representation of perimortem traumatic lesions. This postmortem damage is mainly in the form of fragmentation and breakage, which has resulted in a larger number of smaller fragments that have lower percent completeness values.

The prevalence values for each element are affected to a slightly different degree by changing the requirement for percent completeness of fragments to be included in each calculation based on the element count method. The completeness requirement which

results in the highest possible prevalence value is different for every element, varying based on the degree of postmortem breakage in each class of element, the completeness categories that can be investigated based on the number of zones an element is divided into (information on the number of zones per element is provided in Appendix I), and the percent completeness of the fragment(s) on which the perimortem lesions are actually present. If the majority of lesions are present on relatively complete fragments, then prevalence values are likely to be higher for the methods that have higher completeness requirements. This is the case for elements such as the scapula, vertebrae, patella, and innominate. If the fragments that display lesions are relatively incomplete, however, then prevalence values will be lower at higher completeness requirements and will not begin to increase until the completeness requirement is decreased quite substantially. This is found to be the case for elements such as the femur and the fibula, for which the prevalence is calculated to be zero until the completeness requirement has dropped to 50% for the fibula or even as low as 25% for the femur. The degree of difference in elemental prevalence rates based on differing requirements for completeness can therefore be seen to depend quite heavily not only on the fragmentation and postmortem breakage within the sample but also on the completeness of the particular fragments on which perimortem lesions are found.

It is evident based on the reported prevalence figures (see Table 6.4, Figure 6.2, and Figure 6.3) that there are more lesions associated with sharp force trauma in the collection than there are lesions associated with any other type of trauma. However, while this is reflected in the total prevalence for the collection using the element count method,

it is not evident in the total prevalence using the individual count method. Due to the fact that the sharp force lesions are scattered throughout the skeleton, when the elements containing these lesions are considered together the minimum number of individuals that they represent only amounts to one. These lesions may all be present on elements belonging to different individuals, but due to the fragmentary and disarticulated nature of the collection this cannot be definitively demonstrated, and so the minimum estimate must be relied upon. Lesions related to perimortem musket trauma, on the other hand, are fewer in total number (n=4). Despite their smaller numbers they are present on three elements that can be demonstrated to have likely belonged to three different individuals, bringing the minimum number of individuals that they represent up to three. This difference in the distribution of the various types of traumatic lesions in the skeleton therefore affects the prevalence figures calculated using the individual count method, but not those calculated using the element count method.

For the majority of elements, the highest prevalence value out of all of the methods used is that calculated utilizing the individual count method. The single exception is the scapula, likely due to the fact that the two scapulae displaying perimortem injuries cannot be definitively demonstrated to originate from two separate individuals. The minimum number of individuals calculated for the entire sample (n=24) likely underestimates the actual number of individuals contained within the sample, and the minimum number of individuals calculated based on each element (see Section 6.1.2) is for many elements quite a bit lower even than this figure. This causes the prevalence value as calculated based on the minimum number of individuals for each particular

element to in most cases be slightly higher than it would be if based on the minimum number of individuals for the sample as a whole. The preservation and relatively good representation of small elements of the extremities suggests that the individuals within the sample were likely buried in their entirety, and this is consistent with the historical accounts of the burial of the remains following the battle (Knüsel et al. 2007; Elliott 2009). However, there has been extensive disturbance of the remains since their original burial, and these taphonomic processes have significant potential to introduce biases in the elemental representativeness of the sample that may be more difficult to discern. Therefore, following the procedure utilized by White (1992) it was thought safest to calculate the individual count prevalence values based on the minimum number of individuals determined for each element rather than that determined for the sample as a whole (see Tables 6.1 and 6.2).

Although the individual count prevalence values provide the highest estimates of the number of perimortem lesions within the Smith's Knoll sample for the majority of elements, these figures still almost certainly under-represent the prevalence of violent injuries sustained by individuals during the battle of Stoney Creek. This under-representation likely results from limitations both of skeletal evidence more generally and of the Smith's Knoll sample in particular. Based on evidence from clinical studies, it has been well established that only a fraction of injuries that affect the soft tissue impact and leave a recognizable lesion in the skeleton (Shepherd et al. 1990). Poor correspondence between soft and hard tissue lesions also means that very serious, lethal injuries to the soft tissue may not be associated with any skeletal damage at all, and conversely skeletal

lesions that are quite serious and extensive in appearance may actually cause relatively minor harm to the individual (Knüsel 2005). In addition to this more general limitation of skeletal evidence, several features of the Smith's Knoll sample itself may contribute to an increased under-representation of perimortem traumatic lesions. The complex post-depositional taphonomic history of the sample's remains and the high degree of resulting postmortem breakage, fragmentation, and other types of damage has the potential to mask or remove evidence of traumatic lesions that may have been present on the remains at the time of original burial.

Quantitative analysis of the perimortem traumatic lesions in the sample was not performed during either of the previous analyses (McVeigh 1998; Liston 2000). However, the number of lesions identified as well as the number of fragments that could be identified and catalogued differs from the previous to the current analysis. It is therefore likely that, had quantitative analysis been performed previously, the prevalence values calculated during the current analysis would differ from previous figures. It is possible that the lesions present in the material have changed since the skeletal elements were last examined due to further postmortem damage that may have occurred during storage, handling, and analysis. Due to the fact that not every fragment observed during the previous analysis was labeled with a trench letter or number, it is impossible to determine the occurrence of extent of this potential damage. While damage of this sort may have occurred, it is more likely that the differences in the number of lesions observed result from the varying perspectives and approaches used by the researchers performing the analysis.

7.1.3.1 Statistical analysis of prevalence values

While differences are observed between the prevalence values calculated using each of the element count methods, only two of these methods yielded results that are actually statistically significantly different than the total element count prevalence values. The three methods producing statistically significantly different results were those that restricted fragment completeness to 67% and 50% for inclusion, as well as the individual count method (see Section 6.1.1.1). The first two are somewhat unexpected, as it suggests that the essential assumptions of prevalence calculations may not be violated by not accounting for completeness. However, it is more likely that the lack of significant difference in values calculated using the total number of fragments and restricting fragment inclusion to those that are complete or at least 75% complete is the result of the percent completeness values for the specific elements in which lesions are observed. The majority of lesions appear to be displayed in elements that are around 67% complete, meaning that significant differences in the calculated prevalence rates do not appear until the completeness requirement is dropped to this value. Elements that are at least 75% complete or fully complete show very low counts of traumatic lesions, and the number of fragments eligible to be included in these categories is correspondingly lower as well. The number of relatively complete bones is therefore so small that it is very difficult to observe lesions that would likely have been present in the more highly fragmented elements, especially given the correlation of perimortem lesions and poor preservation with increased breakage. It therefore appears that completeness is a factor in the observation of traumatic lesion prevalence.

The pattern that can be seen in the level of statistical significance achieved for different element count methods appears to be highly affected by the large number of lesions found in the ribs relative to those observed in other elements; the ribs are divided into three zones under the zonation method, making 67% a relevant figure and 75% not a useful measure for this element. This may be why the imposition of a 75% completion requirement does not appear to affect the calculated prevalence of trauma in the assemblage. The prevalence values calculated using the individual count method were also found to statistically significantly differ from the total element count prevalence values, however this is not unexpected due to the large discrepancies in how values associated with each of these two methods were calculated. Also, while some of the element count methods appear to be affected by the large number of lesions present in the ribs, the inability to calculate a MNI figure for the ribs results in individual count values unaffected by rib lesions.

7.1.4 Severity of lesions present in the sample

Several of the lesions observed within the sample are quite extensive, far beyond what is absolutely necessary to end the life of an individual. One of the clearest examples of this is the lesion present in the distal femur of one of the individuals in the collection (SK0320; see Section 6.1.2.2). This element displays two parallel slice marks that are quite long, although the extension of these marks into and beyond the end of the fragment precludes the exact measurement of their length, and extend deep into the trabecular bone. A large slice mark is also found on a patella within the sample (SK1361; see

Section 6.1.2.4). As these two lesions are present in a left femur and a right patella they cannot have resulted from a single blow, meaning that these two lesions necessarily represent unrelated injuries. The presence of traumatic lesions beyond what is necessary to cause the death of an individual raises the possibility that the phenomenon of overkill occurred during the battle. Overkill is often associated with homicide, and has been observed to occur in the heat of battle, especially during close contact (Rogers 2004). A relatively common feature of some contemporary remains is the presence of multiple blows of a sabre to the cranium, and Kaufman (2003) suggests that in the heat of battle it was not unusual for men to sustain many blows delivered by a sword. In a close combat situation in which one necessarily has to kill or be killed, it makes sense that a soldier would use what may appear to be excessive force, in order to ensure that their opponent has actually been defeated and no longer has the potential to fight back. Perhaps what is considered "excessive" in terms of the violence with which an individual is attacked must be re-conceptualized for a battle situation, especially one occurring in total darkness and confusion like Stoney Creek. Whether one soldier would have known that the death of the other had already occurred and continued to strike cannot be known, therefore the correspondence of the potential occurrence of overkill at Stoney Creek and Duhig and Martinsen's (2007) concept of the paramortem interval and the continuation of personhood past the moment of death although very possible cannot be securely established.

While the presence of these rather extensive injuries within the Smith's Knoll skeletal material hints at the presence of overkill, it is difficult to conclude definitively

that this phenomenon occurred at Stoney Creek without the ability to evaluate patterns within the individuals comprising the sample. The evaluation of overkill in many cases relies upon the ability to identify multiple injuries in a single individual (Rogers 2004). Due to the fragmented, commingled, and disarticulated nature of the Smith's Knoll sample, associating separate elements into individuals is impossible. The evaluation of overkill is also often dependent on the analysis of wounds generally considered to be automatically fatal, including in many cases cranial trauma. However, the Smith's Knoll cranial material is fragmented enough to mainly preclude the evaluation of cranial blunt force trauma within the assemblage. As cranial lesions are difficult to assess and the number of cranial and postcranial lesions cannot be assessed by individual for the skeletal material in this collection, phenomena such as overkill and injury recidivism may be hinted at, but their presence within the sample cannot be definitively demonstrated.

7.1.5 Lesions absent from the sample

Perimortem traumatic lesions can be observed in all classes of element present at Stoney Creek, including long bones, cranial bones, small irregular bones, and elements of both the axial and appendicular skeleton. However, the distribution of different types of lesions within the skeleton reveals patterns that are informative not only due to the types of lesions that are present, but also the types of lesions that are not observed within the sample. One example of lesions that may be expected based on their description in other roughly contemporary military skeletal assemblages is musket trauma to the long bones.

While lesions that can be definitively associated with projectile trauma can be observed in various areas of the skeleton including the cranium, pelvis, and shoulder, there is a conspicuous lack of projectile trauma in the long bones of the sample. The long bones do present narrower targets with much less surface area present for the impact of a projectile than flatter elements like the innominate or scapula; this may lead one to reasonably conclude that musket trauma would manifest far less frequently in these areas of the skeleton. However, projectile injuries are observed in the long bones of several skeletal assemblages from roughly contemporaneous military conflicts, including both archaeological (Snow and Fitzpatrick 1989; Owsley et al. 1991; Willey and Scott 1996) and surgical (Kaufman 2003) collections. This would lead one to expect that Smith's Knoll would yield evidence of similar lesions; the absence of these lesions in the collection is therefore conspicuous.

The somewhat surprising absence of long bone projectile injuries in this collection likely relates to either the military tactics used during the battle of Stoney Creek, the burial context of the individuals comprising the sample, or more probably a combination of the two. Typical military strategy during the War of 1812 dictated the use of blocks of infantry and massed infantry formations. The flintlock smoothbore musket in use at this time could be very effective when fired into a line of men, as would have been the case in many of the collections in which long bone projectile injuries are observed (Kaufman 2003). At Stoney Creek, however, no typical masses of infantry were formed in the darkness and chaos of the battle; the flintlock muskets used during this conflict have a relatively low accuracy when fired at a target as small as one individual soldier, and

therefore bullets may have been less likely to impact the extremities during this battle than in those for which typical strategies were used. Additionally, it is clear from the appearance of sample projectile injuries in the long bones that the impact of the musket ball often caused significant fragmentation around the wound site (Kaufman 2003; Figure 7.5). This is corroborated by historical accounts of the battle, which refer to musket balls "shattering" and "splintering" limbs (Elliott 2009). Given the high degree of weathering and erosion seen in the Smith's Knoll remains, it is likely that if small fragments resulting from such an injury were recovered during excavation in the first place, postmortem modification of the edges of these pieces of bone may have masked or removed perimortem edge characteristics and thereby rendered these lesions invisible. The fact that the remains were buried in a mass grave may also impact the visibility of these injuries within the sample. When individuals are found in discrete burials in which minimal disturbance and movement have occurred, small fragments are likely to be present in association with the limb from which they originated; therefore the opportunity is available to observe such lesions in

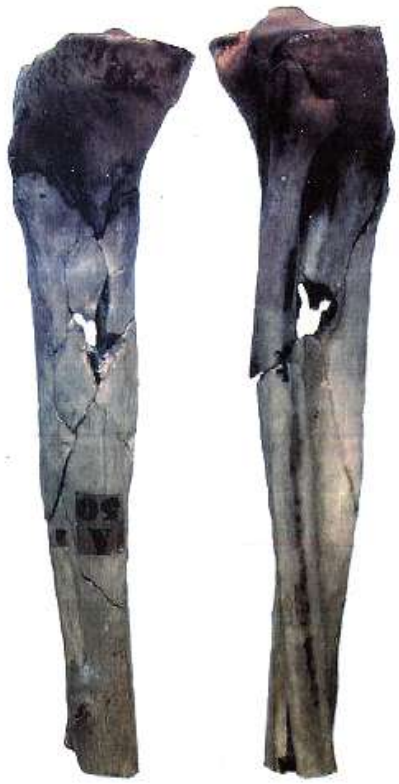

Figure 7.5. Musket ball injury to a proximal tibia, from Ballingall's surgical collection. The fracturing caused by the impact of the musket ball would cause extensive fragmentation of the tibia in the ground, and so it is likely that these fragments would not be recognized archaeologically if not found in an individual burial context. Image taken from Kaufman (2003, 126).

situ, where they would likely be much more visible. The considerable amount of disturbance and movement experienced by the elements of the Smith's Knoll sample, in contrast, likely caused the separation of fragmented components of any lesions that may have been present, hugely decreasing their visibility.

7.1.6 Experimental analyses

The experimental lesions created on replica ribs and lower legs during the two excursions made to Fort George functioned mainly to provide comparative lesions, indicating the potential cause and likely range of appearance of lesions observed within the Smith's Knoll sample. Marks created on both the back and side ribs provided excellent comparative lesions allowing many of the sharp force injuries seen in the archaeological rib fragments to be associated with likely causation by the socket bayonet. Lesions created in the replica lower legs allowed the evaluation of the cut mark observed on the distal fibula in fragment SK0129, and provided evidence linking the injury to likely causation by a sword stroke.

The injuries inflicted on the replica buttocks using musket ammunition were designed to assist in providing some indication of the range of fire and possibly the type of ammunition associated with the lesions observed on the three innominate fragments of the collection (SK1147, SK1161, SK1178; see Section 6.3.2). The lesions produced experimentally are generally consistent in size with the lesions observed in the archaeological bone, indicating that these lesions could have been caused by musket ammunition and confirming that lesions previously suspected to be associated with either

musket balls or buckshot likely were. However, the lack of a consistent relationship between range of fire and lesion diameter or the distance between buckshot lesions meant that this experiment does not allow any reliable conclusions to be made regarding the bioarchaeological lesions observed in our sample. The fact that all of the projectiles easily passed through all of the soft tissue and bone does suggest that the putative buckshot lesions found in the two archaeological innominate specimens, consisting only of slight depressions, must have involved projectiles whose velocity had decreased considerably before impact. However, this would not necessarily have involved a greater range of fire, but could also have resulted from passage through or deflection off of another surface either inside or outside of the body before impacting the iliac crest. The range of fire and effectiveness of the flintlock musket were also quite variable, and may have been affected by many factors including the quality of the black powder used, whether the barrel of the musket were worn or badly made, the potential impact of fouling as powder collected in the barrel with continued use, as well as the weather due to the vulnerability of the flintlock mechanism to windy or wet conditions (Kaufman 2003). These many sources of variability complicate attempts to predict the range of fire based on the appearance of the lesion even further.

The results of this experiment serve to further demonstrate the unpredictable nature of weaponry during the War of 1812, in terms of accuracy, consistency of flight path, and projectile velocity. Given the large degree of variation, the type of information required would likely only be useful in terms of average measurements from a large number of samples. Therefore, in order to observe any useful trends in lesion diameter or

spread, sample size would have to be much greater; given the time and budget constraints on this experiment a larger sample size was not feasible at this time. The current inability to make reliable conclusions regarding range of fire from an experiment such as this limits what can be known about this aspect of the conditions of battle to the information contained in the historical accounts.

7.2 Consideration of the Smith's Knoll sample in historical context

The skeletal lesions observed on the Smith's Knoll remains can be better understood in the context of the period during which the related injuries were sustained. Insight into the circumstances surrounding the origins of these lesions can be gained through comparison of the lesions displayed in the collection with those observed in other roughly contemporaneous skeletal samples as well as in documented surgical collections. The perimortem injuries can also be considered in light of the injuries that have been described in historical accounts of the battle and of the War of 1812 more generally.

7.2.1 Battle of the Little Bighorn, Montana, USA, 1876

The analysis of the partial remains of 34 individuals from the battle of the Little Bighorn (Scott et al. 1989, 1998) revealed evidence for several forms of perimortem trauma, including blunt force trauma in the form of extensively fragmented cranial vaults and facial skeletons, sharp force trauma in the form of incised and chop marks, and projectile trauma (Snow and Fitzpatrick 1989). Despite the differences in weapon type and participant identity between this battle and the battle of Stoney Creek (see Section

3.5), the types and patterns of injuries sustained by soldiers during the battles are quite similar.

The skeletal sample examined by Scott et al. (1989, 1998) is described as having undergone considerable disturbance, including exposure at the surface, exhumation, and reburial. This is similar to the post-depositional history of the Smith's Knoll material, although no specific postmortem damage is discussed, and it is likely that much of the alteration to the bones of the Little Bighorn sample consisted of weathering of the cortical surface and increased fragmentation. Assemblage formation processes have a significant effect on the elemental composition of the resulting skeletal sample; in the case of the battle of the Little Bighorn, removal of many elements for placement in the mass grave resulted in the under-representation of larger bones at all but two of the markers excavated (Scott et al. 1989). This type of selective reburial is not known to have occurred at Smith's Knoll, and the assemblage from the battle of Stoney Creek in contrast has fairly good representation of all sizes of postcranial elements. Despite the relatively high degree of disturbance and disarticulation undergone by the Little Bighorn sample, the association of grave markers with the skeletal material as well as the presence of at least one or two relatively undisturbed graves allowed the attribution of various skeletal elements to individuals. The presence of recognizable individuals at the site enabled much more to be said regarding the prevalence and pattern by individual of traumatic lesions within the Little Bighorn sample than was possible for Smith's Knoll.

Scott et al. (1989) observed substantial amounts of perimortem trauma on the remains, in the form of blunt force, sharp force, and projectile trauma. Given the

qualitatively high amounts of trauma present on the skeletal elements, much of this perimortem damage is attributed to mutilation of the remains (Scott et al. 1989). Contemporary settler and Native American accounts indicate that this type of mutilation, most commonly crushing of the skull or scalping, was common at the time of the battle (Scott et al. 1989). Similar use of excessive force resulting in brutal lesions beyond what would have been necessary to kill an individual is suggested by some of the injuries observed in the Smith's Knoll sample. This sign of perimortem or possibly 'paramortem' violence indicates emotional expression that at the Little Bighorn is attributed to vengefulness of the participants (Scott et al. 1989) but if present at Smith's Knoll may have resulted from heightened fear in the confusion and chaos of a night battle. The authors state that incised wounds are present in about 21% of the material, while blunt force trauma to the skull is present in 41% of skull fragments; however, they caution that the incomplete and fragmentary nature of the sample limits quantification of the amount of mutilation of the remains (Scott et al. 1989). The exact method used for the calculation of these prevalence figures is not specified, and it is unclear whether any fragments were excluded based on their level of completeness.

In the battle of the Little Bighorn assemblage, blunt force trauma is predominantly present in the form of extensive fragmentation of the cranial and facial elements, with massive comminuted fractures evident in many crania (Snow and Fitzpatrick 1989). Aside from one potential perimortem fracture to a frontal bone, the Smith's Knoll cranial fragments do not show evidence of blunt force trauma; despite extensive fragmentation the breakage present does not display perimortem characteristics. This may be due to

postmortem weathering at the edges of the cranial fragments erasing the sharp edges associated with perimortem breakage. It may also be related to preservation, as facial bones generally do not preserve well and more delicate facial elements such as the nasal bones are not well represented in the Smith's Knoll collection. Alternatively, soldiers may not have commonly experienced blunt force trauma to the cranium during the War of 1812. Cranial mutilation in the form of blows to the head appears to have been a common practice at the battle of the Little Bighorn based on contemporary accounts, whereas no historical evidence exists for such a practice at the battle of Stoney Creek. The Native American participants at the battle of the Little Bighorn are said to have used tomahawks, a weapon that generally causes injuries with a much higher blunt force component than many of the European weapons that predominated at the battle of Stoney Creek. Given the differences in weapons used, participants involved, and strategies pursued during each of these two battles, some differences in traumatic injuries are to be expected.

The Little Bighorn skeletal material displays sharp force traumatic lesions in the upper and lower extremities (humerus, clavicle, hand and toe phalanges, carpals and tarsals, femora) as well as the torso (vertebrae). Incised cut marks and shearing fractures or slices are both present within the sample. This presents a similar pattern to that found at Smith's Knoll, with cut and slice marks appearing in the long bones as well as the carpals, vertebrae, and potentially phalanges (Snow and Fitzpatrick 1989). One major difference between the two samples is the presence of many triangular nicks potentially associated with bayonet wounds to the ribs at Smith's Knoll. This may reflect the difference in weapon technology utilized during these two battles, and the different

wound profiles of hatchets and knives from the Little Bighorn contrasted with bayonets and swords from Stoney Creek.

Projectile trauma in the form of gunshot wounds was found in the ribs and forearms associated with three markers from the battle of the Little Bighorn, as well as in a number of crania and two innominates (Scott et al. 1989; Willey and Scott 1996). While gunshot injuries were similarly observed in the Smith's Knoll material, the distribution of the lesions is different. At Smith's Knoll, musket injuries were observed in the flat bones of the cranium, innominate, and scapula, while no projectile injuries were found in the long bones or ribs. This difference in observed distribution is quite interesting, and may reflect the differential element distributions of the two samples. If elements such as the scapulae were missing from the Little Bighorn assemblage, any potential lesions would not be detectable. At the same time, it is possible that fragmentation in the long bones of the Smith's Knoll sample may have masked evidence of musket injuries to the long bones, if it had been present. Alternatively, the difference in distribution may result not from differential preservation but from variation in battle conditions and fighting strategies.

Snow and Fitzpatrick (1989) conclude based on the historical accounts of the battle of the Little Bighorn that it is likely that many soldiers suffered projectile injuries, but that most of these would probably not have caused immediate fatality. Given the similarity in effectiveness of weapons used at this time and during the War of 1812, it is likely that many musket injuries sustained during the battle of Stoney Creek would similarly not have been fatal immediately, which is especially relevant to the formation of

that assemblage as only soldiers who died on the battlefield were buried in the mass grave and contributed to the Smith's Knoll sample. As some of the Little Bighorn skeletal elements present could be associated into individuals, Snow and Fitzpatrick (1989) were able to discern that one individual had suffered one or two gunshot wounds to the chest as well as an injury to the forearm. The inability to link any skeletal elements to the same individual, and therefore to examine the potential occurrence of multiple injuries, is a major limitation of the Smith's Knoll sample. Historical accounts of the battle of the Little Bighorn suggest that wounded soldiers were killed by their opponents using a blow to the head (Scott et al. 1989), meaning that all wounded soldiers potentially contributed to the assemblage. During the battle of Stoney Creek, however, medical treatment for non-fatal injuries was likely possible; any individuals treated this way would have been removed from the battle field and would therefore not be present in the skeletal assemblage. This would likely contribute to the differences seen in the distribution of skeletal lesions between the two sites.

The traumatic lesions seen in both of these samples have been discussed quite differently based on the historical information available on the conditions of battle during the two conflicts. While the sharp force trauma present in the Little Bighorn sample is discussed mainly in the context of postmortem or 'paramortem' mutilation and dismemberment, the possibility of close-range fighting during the battle is not mentioned (Scott et al. 1989). Conversely, for the Smith's Knoll material sharp force trauma is attributed to hand-to-hand combat during the battle, while post or paramortem mutilation is not mentioned as a possibility (Griffin-Short 2000; Liston 2000). It is therefore evident

that the nature of the historical accounts and the details of the battles contained therein have determined the possibilities discussed in terms of lesion causation. The ability to determine the range of possibilities from historical data is definitely an advantage of historical bioarchaeology, however given the questionable reliability of witness accounts it may also be limiting.

7.2.2 Snake Hill, 1814

The skeletal sample from the Snake Hill site in southern Ontario is also comprised of soldiers from the War of 1812, making it in some ways an ideal comparison for the Smith's Knoll material. However, while Smith's Knoll is composed of individuals who perished on the battlefield and were consequently buried there following the battle, Snake Hill is thought to be a cemetery site associated with a military hospital. The Snake Hill individuals are hypothesized to have survived a siege and later fallen victim to disease or violent injuries during skirmishing following the major conflict (Litt et al. 1993). Therefore, the injuries observed in these two War of 1812 sites may be expected to differ based on the varying situations of the individual soldiers of which the two samples are composed.

The differential compositions of the Snake Hill and Smith's Knoll samples are reflected in both the burial contexts and the nature of the remains themselves. The Snake Hill sample consists of 31 relatively complete individuals in discrete burials, as well as three medical waste pits containing amputated limbs. This is significantly different from the fragmented, disarticulated, commingled assemblage comprising Smith's Knoll. The

mass grave containing the Smith's Knoll remains defies normative burial practice and is a reflection of the social upheaval in the Stoney Creek area at the time of the battle and the subsequent need for quick disposal of the bodies due to extraordinary circumstances. The discrete individual burials containing the Snake Hill remains, on the other hand, reflect the fact that these burials likely occurred in a relatively calm situation while no battle was occurring and an established military hospital was undergoing regular operation (Litt et al. 1993), allowing increased attention to normative burial practices. This is demonstrative of the fact that while mass graves are often associated with conditions of warfare (Knüsel 2005), this is by no means the only type of burial context in which military remains can be found.

The Snake Hill site also proved unique in that archaeological evidence was available to assist in determining the national affiliations of the individuals buried there. Military buttons located in situ in the graves of the Snake Hill individuals were identified as components of the American military uniform, identifying these soldiers as belonging to the American army (Litt et al. 1993). The burial context of the remains was very important in allowing this association. While many military buttons were discovered associated with the Smith's Knoll remains, these buttons were identified as belonging to both American and British uniforms and were scattered amongst the remains with no specific arrangement corresponding to a uniform actually clothing a skeletonized individual (Griffin-Short 2000). Because none of the buttons could be associated with a complete uniform, they have little value for revealing the identity of the Smith's Knoll remains. The loss of such archaeological evidence due to disturbance presents a major

limitation for the analysis of the Smith's Knoll material. The ability to more effectively use three separate sources of evidence in the analysis of the material from Snake Hill allowed the formation of stronger conclusions than is possible at most other archaeological sites, including Smith's Knoll.

While there were definitely perimortem lesions observed in the Snake Hill material, discussion of these injuries by Owsley et al. (1991) is quite limited. Frequent occurrence of perimortem fracture is noted, being present in 50% of individuals at the site. Of 53 total perimortem fractured elements in the sample, the highest percentage is said to be found in the ribs (28%) although fractures were also observed in the femora (25%), crania (9.1%), ulnae (10%), clavicles, vertebrae, and fibulae (no prevalence figures given; Owsley et al. 1991). The authors indicate that several of these were consistent in appearance with projectile injuries, and several were fatal although evidence of medical intervention including amputation was observed in the sample (Owsley et al. 1991). All injury prevalence figures are given as individual counts, and the number of each element present for lesions to be observed is not discussed. The lesions are not discussed in any more detail than this, and no photographs are provided for a visual comparison with the lesions present in the Smith's Knoll material.

In general, the frequencies of perimortem injury are quite a bit higher in the Snake Hill material than those calculated for the Smith's Knoll sample. The only two figures that may be directly compared are the individual count prevalence values calculated for the femora and ulnae of the two samples. While perimortem lesions are seen in 25% of the Snake Hill femora, they are observed in only 4.55% of femora from Smith's Knoll.

Perimortem lesions to the ulna, on the other hand, are present in 10% of this element at Snake Hill and 4.35% at Smith's Knoll. The prevalence values for the ulnae therefore display less of a difference between the two sites than the prevalence of lesions seen in the femora. However due to the very different nature of the two samples and the difficulty in calculating individual prevalence rates in the Smith's Knoll material, it is not clear how meaningful this relationship is.

The distribution of lesions observed in the Snake Hill collection does display some similarity to Smith's Knoll, with the highest frequency of lesions being in the ribs. However, the prevalence figures for lesions in the ribs are not directly comparable between the two sites as due to the nature of the Smith's Knoll sample an individual count figure could not be generated for the ribs, and an element count figure is not given for the Snake Hill lesions. As well, sharp force lesions in the ribs of the Smith's Knoll sample were correlated with bayonet injuries based on experimental data, whereas the lesions in the Snake Hill ribs were simply classed as fractures or were associated with musket trauma (Owsley et al. 1991). The absence of bayonet lesions in the Snake Hill ribs almost certainly reflects the different character of the conflict these individuals would have been involved with, as the close-range fighting during the battle of Stoney Creek resulted in atypical use of the bayonet. The possibility that some unrecognized bayonet-related lesions are present in the Snake Hill material cannot be corroborated, due to the lack of photographic representation or detailed description of the relevant injuries.

While lesions in the cranium, torso, and long bones were observed in both samples, the clear perimortem trauma seen in the Smith's Knoll innominates and scapulae

is not displayed in the material from Snake Hill. It is unclear whether this is a result of differential preservation, differential expression of lesions in the bone, differences in injuries sustained by soldiers during the two different phases of the conflict, differences in injuries sustained by individuals who died on the battlefield and those who survived to reach a hospital, or variations in the attention paid by anthropologists working in different academic and temporal environments to perimortem trauma. Given the presence of a significant number of injuries to the scapula and innominate in surgical collections from the same period (Kaufman 2003), it is unlikely to be a reflection solely of the fact that the Snake Hill sample is associated with a medical facility.

7.2.3 Surgical collections from the first half of the 19th century

Many examples of musket ball and sabre injuries are present in Ballingall's museum collection associated with his class of military surgery, analyzed by Kaufman (2003). This collection consists of pathological skeletal samples accompanied by notes and case histories on the condition and treatment of each patient. All of the samples are the remains of soldiers who participated in British military conflicts during the first half of the 19th century, mainly the Carlist Wars (1833-76) and the Waterloo campaign (1815). The abundant documentary evidence associated with the majority of these pathological preparations makes them well-suited to comparative analysis, as the circumstances surrounding the original injury as well as the progression of its treatment and any complications are known. Such a well-documented collection comprised of pathological specimens injured using the same weapons and during the same time period as the

Smith's Knoll material is of great benefit for comparison; however, the surgical collection differs from the archaeological one in several important ways that may affect comparability. One of the difficulties associated with this collection corresponds to a major bias of clinical data itself, in that the only types of injuries reflected in the preparations are those that were considered suitable for surgical treatment. Lesions that proved immediately fatal, or those that were considered more suitably treated clinically, are not represented in the collection (Kaufman 2003). Unfortunately the perimortem lesions present in the Smith's Knoll collection, the focus of this analysis, represent only wounds that proved immediately fatal and resulted in death on the battlefield and subsequent burial in a mass grave. None of the individuals represented in this sample would have had access to medical care, surgical or clinical, as those receiving medical aid would have been removed from the battle field to the respective camps. While the surgical collection can therefore provide an idea of the type of injuries that were typically experienced by soldiers involved in conflicts like the War of 1812, the injuries depicted in the collection may not be specifically relevant in many cases to the individuals of the Smith's Knoll sample. Although immediately fatal lesions are not represented in the surgical collection, contemporary speculation by surgeons on the most common cause of immediate death on the battlefield did suggest that it might have been exsanguination resulting from gunshot wounds, likely to the chest and head (Kaufman 2003).

Many different types of musket ball and sabre injuries are represented in the surgical collection, including wounds of the skull and facial skeleton, upper and lower extremities, abdomen and pelvis, and torso. Several of the lesions contained within these preparations correspond quite well with injuries sustained by individuals in the Smith's Knoll sample. The collection contains numerous examples of musket ball injuries to the pelvis, involving passage of the ball through the bone of the ilium or the embedding of the ball within the iliac crest (Kaufman 2003; Figure 7.6). While injuries of the pelvis depicted by Kaufman (2003) represent individuals who survived these injuries temporarily, death was the almost inevitable outcome of injury to the pelvis as well as the vertebrae and many musket injuries of the skull. Penetrating wounds of the abdomen are associated with high mortality during this time period, given the danger of damaging major arteries and nerves within the abdominal region as well as the high risk of infection associated with potential injury of the intestines and possible leaking of the abdominal contents (Connor and Mowat 1915). When discussing other cases reported in the contemporary literature of musket ball injuries to the pelvis, Kaufman (2003) mentions that in some of these further examples the ball entered through one of the buttocks, a situation

Figure 7.6. Musket ball and associated wound of the iliac crest from Ballingall's surgical collection, representing one of the pelvic injuries described from this time period. Image taken from Kaufman (2003,154).

that corresponds well with the entry lesions on the posterior aspect of the iliac crest within the Smith's Knoll sample. All of the injuries to the pelvis observed in the Smith's Knoll sample were sustained on the posterior aspect of the element, which may relate to the fact that posterior wounds can be shown to cause a larger portion of deaths than the anterior, based on the observation of military firearm wounds of the abdomen by Wallace (1916). Examples of musket and nonspecific perimortem injury to the scapula are also observed in the Smith's Knoll material; injury to the scapula is described for several of the preparations in the surgical collection, often associated with damage to the humerus (Kaufman 2003).

Within the Smith's Knoll collection, no lesions associated with musket trauma to the long bones of the upper or lower extremities were observed, an omission that is unexpected based on the lesions observed in contemporaneous collections (see Section 7.1.5). Ballingall's collection contains numerous examples of musket-related trauma to long bones of the upper and lower limbs, many of which display clear lesions that would undoubtedly be recognized if observed in skeletal material (see Figure 7.2). However, Kaufman (2003) also specifies that musket ball impacts in the long bones are extremely violent, commonly producing compound comminuted fractures, with characteristic splitting and splintering, as well as damage to soft tissues and nerves. Such extensive damage to the bone would likely result in the separation of fragments from a single injury given the high amount of disturbance experienced by the Smith's Knoll remains, and the high degree of weathering would likely act to disguise the margins of any fragments that were recovered. Injury to the long bones would appear to have less serious consequences

than injury to the torso or abdomen, given the concentration of major organs in these areas. As such, part of the reason these injuries do not appear to be present at Stoney Creek may be related to their lower fatality rate, making them less likely to appear in a sample consisting only of individuals who died on the battlefield from the immediate or short-term effects of their injuries. However, especially given the quality of medical care at the time, injuries of the upper and especially the lower limbs could have very serious consequences if a major artery were severed directly by the impact or secondarily by a fragment of bone (Kaufman 2003). With the commonly compound and comminuted nature of the fractures produced from a musket ball impact, the danger of trauma to one of the major vessels by a sharp displaced bony fragment would not have been insignificant. As well, in a battle context injuries are rarely present in isolation, so non-fatal wounds should still be represented in even such a sample as Smith's Knoll. The absence of musket-related trauma to the long bones can therefore be considered notable.

While numerous bayonet lesions are observed in the ribs of the Smith's Knoll individuals, other than a passing mention of a superficial bayonet lesion to the chest in one of the individuals represented in Ballingall's collection no preparations from this sample display lesions attributed to the bayonet. This echoes the absence of these lesions in contemporaneous archaeological collections (Scott et al. 1989; Litt et al. 1993). Wallace (1916) observes that surgeons rarely encounter abdominal wounds caused by the bayonet, as they are typically fatal on the field. It is unclear whether this may also be the case for bayonet wounds of the torso, given the high fatality of injuries that impact the heart or great vessels in the chest but also the relatively common observation of lesions

resulting from other types of penetrating trauma to the chest, such as musket injuries (Kaufman 2003). The relatively uncommon use of the bayonet during normal battle conditions may also contribute to the paucity of these lesions in the archaeological record and clinical literature.

7.2.4 Historical accounts of the battle of Stoney Creek

Historical evidence is very valuable in bioarchaeological analysis for its ability to reveal the range of possibilities for lesions that may have been experienced by the individuals represented in the skeletal remains under study. Skeletal assemblages for which comparative historical data is available are well-suited to analysis as features observed by the bioarchaeologist can be compared with an additional source of evidence that has different limitations and biases from skeletal data, ultimately resulting in stronger conclusions and a better supported interpretation. A significant amount of historical evidence is available detailing the events of the battle of Stoney Creek, in the form of both primary accounts and secondary literature (see Chapter 4).

The types of weapons and ammunition present at the battle of Stoney Creek and therefore available as potential causes for the lesions observed in the assemblage are detailed by historical accounts of the battle. While most of the weapons discussed are standard equipment for the British and American armies during this time period and would likely have been considered without the help of the historical literature, historical sources were instrumental in considering the importance of buckshot ammunition in producing lesions at Stoney Creek. As noted in Section 7.1.1, lesions related to the impact

of buckshot had not been noted in the collection during the previous analyses and are not discussed in the bioarchaeological or surgical literature. As such, without specific information in historical sources noting the use of this ammunition by the American army as well as mention within the primary accounts of the battle of its particular importance at the battle of Stoney Creek (Fredriksen 1984) it may not have been considered as a possible cause of the lesions observed in the sample. Historical sources were also important in denoting exactly who was involved in the battle, informing on the relative scarcity of Canadian militia members and Native American warriors, as well as the limited potential for the use of cavalry during the battle. Having a clear idea of the participants in the battle allows a more nuanced consideration of the likely weapons present in addition to the possible identities of the individuals in the sample.

The historical record is also extremely informative with regard to the conditions experienced during the battle of Stoney Creek. Accounts of the battle indicate that conditions were chaotic and confused, alerting the researcher to the potential for friendly fire and the significant differences in strategy when compared to a "typical" War of 1812 battle experience (Hitsman 1965; Horsman 1969; Fredriksen 1984; Fredriksen 1989; Elliott 2009). This valuable information regarding the experience of participants in the battle allows better-informed interpretations of the lesions observed and how they may compare to those found in other contemporary collections. The consideration of lesions in the context of a typical battle with massed infantry formations differs greatly from how these lesions would be contextualized at Stoney Creek, where close-range fighting was the dominant strategy employed during the conflict. Mention within the historical sources

of different types of injuries sustained by individual soldiers during the battle also allows the researcher to make note of lesions that are not observed in the collection but may be expected based on primary accounts. This is particularly relevant at Stoney Creek with respect to the paucity of long bone musket ball lesions (see Section 7.1.5).

For the Smith's Knoll collection, historical information is important not only in terms of accounts of the battle but also to reveal details regarding the post-depositional taphonomic history of the remains. Details of site use after the burial of the remains are instrumental in contextualizing the postmortem trauma and breakage observed in the remains, and allow this damage to be more fully understood and accounted for in its potential effects on the perimortem traumatic lesions present on the skeletal elements. Historical evidence therefore allows the elucidation of events at the site not only during the battle but also following the burial of the remains. The availability of this detailed contextual information results in a fuller interpretation of the lesions observed on the skeletal remains, both perimortem and postmortem. The presence of such detailed information regarding activity at the site both resulting in and following the deposition of the skeletal remains under study is relatively unique, and as a result the Smith's Knoll assemblage can be considered particularly valuable in revealing information regarding violence and warfare in the early nineteenth century, and in the bioarchaeological record more generally.

7.3 Consideration of the Smith's Knoll sample in the context of bioarchaeological studies of violence

Many bioarchaeological studies have investigated skeletal evidence for violence and warfare in the archaeological record; it is therefore important to consider the Smith's Knoll skeletal material and its analysis in the context of this body of previous work. The methodology utilized by others to examine perimortem traumatic lesions in the skeleton, particularly in terms of quantitative methods, can be used to contextualize the analytical decisions made in the current treatment of the Smith's Knoll material as well as to highlight the difficulties and values inherent in such analyses. The information contained within the Smith's Knoll collection can also be seen to make several key contributions to bioarchaeological studies of warfare and also of violence more generally.

7.3.1 Methodology of quantitative analyses

Since the publication of Lovejoy and Heiple's (1981) study of perimortem fractures at the Libben site (Ohio, USA), quantitative analysis of perimortem traumatic lesion frequencies has become common within the bioarchaeological literature. However, despite the push toward standardization and recognition of the value of comparability between the results of different studies, not all researchers utilize the same techniques for the calculation of lesion prevalence values. In many cases, authors are not specific about the methods they have used to calculate prevalence, making the comparability of their values to those calculated by others questionable. In the case of fragmented, disarticulated, and commingled remains, many researchers rely solely on description and do not even attempt to perform a quantitative analysis. For example, Bennike (2006)

examines the skeletal remains found in a medieval mass grave in Denmark; the analysis focuses almost exclusively on cranial material, and besides a brief mention of the percentage of skulls within the sample that display perimortem lesions no quantitative analysis is performed. Cunha and Silva's (1997) analysis of perimortem traumatic lesions in a skeletal sample from the Portuguese medieval battle of Aljubarrota also involves a collection that is very fragmentary. Due to extensive surface exposure of the remains, the sample mainly consists of long bone fragments. This analysis relies on description of the lesions potentially sustained during the battle, but the authors do not attempt to represent the lesions quantitatively.

The skeletal sample examined by White (1992) from Mancos Canyon (Colorado, USA) is fragmentary and commingled, similar to the condition of the Smith's Knoll collection. In quantifying the perimortem traumatic lesions present in this sample, the author presents the frequency of lesions by element in the form of the number of individuals displaying lesions out of the number of "available individuals" (White 1992). The possible available number of individuals is based on the minimum number of individuals as determined for each element separately. Prevalence values are calculated to illustrate the frequency of traumatic lesions by element, however the exact method used to calculate these figures is not specified. It is possible that calculation of these values involved simply dividing the number of fragments that display lesions by the total number of fragments of each element found in the collection. White (1992) does specify that quantification of lesions was calculated using the number of individual fragments or conjoined sets (if the fragment could be associated in this way) exhibiting the lesion

relative to the total number of fragments capable of exhibiting this type of lesion. This is done in order to ensure that what is being assessed is the real incidence of perimortem lesions; many analyses are said to express only what percentage of an element displays lesions without also providing information on the number of this element that were preserved and had the relevant area available for observation (White 1992). Given this statement it seems unlikely that the prevalence values given would have been calculated without some consideration of differential preservation, however without specific information regarding how this may have been accounted for in the calculations it is impossible to fully evaluate or replicate the methods used.

White (1992) evaluates percent completeness differently than has been done during the current analysis. While divisions somewhat similar to the zonation method are used to describe the patterning of fragmentation in the ribs and vertebrae, all other elements were classified merely as whole or fragmentary based subjectively on whether or not at least 50% of the element was present. In addition to the consideration of elemental completeness, this analysis also considered surface preservation. Differences in surface preservation can have quite a serious impact on whether evidence of cut marks will be observable, an issue that has been widely overlooked in many analyses (White 1992). In order to evaluate this, the percentage of intact cortical surface was recorded for each element. However, the effect of this differential surface preservation on the frequencies of traumatic lesions observed is considered only at the level of the entire assemblage rather than as a built-in consideration in the calculation of prevalence values. When overall prevalence values for several collections are presented, White (1992)

considers them in the context of differing surface preservation values. This is significantly different than the approach taken during the analysis of the Smith's Knoll material. While surface erosion and weathering damage was recorded, it was only noted as fitting into one of six stages rather than a percentage present being estimated. The estimation of completeness was given more attention during the Smith's Knoll analysis, and this information was considered in the calculation of lesion prevalence values for each class of element. These two systems both attempt to account for some of the effects of taphonomic processes that may have affected the preservation and visibility of lesions within the relevant skeletal samples. Increased consideration of differences in surface preservation as implemented by White (1992) would likely have been useful in the analysis of the Smith's Knoll collection, especially given the number of lesions classed as indeterminate due to the lack of surrounding cortical surface, had it been built into the cataloguing process.

7.3.2 Contributions to the bioarchaeological conceptualization of warfare in the past

The Smith's Knoll collection exhibits many features that have been traditionally associated with skeletal samples that represent the remains of individuals involved in warfare. For example, burial in mass graves is commonly associated with the occurrence of an "unusual preceding event" resulting in a significant number of deaths (Bennike 2006, 305). The discovery of a mass grave does not necessarily indicate the occurrence of warfare, as other events such as a plague or massacre can occasion the formation of a mass grave; however, these events may be differentiable based on the demographic

profile of the remains within the burial feature (Redfern and Chamberlain 2011). There are several features that are considered to define the presence of a mass grave, including the presence of multiple skeletons with disorder in the orientation of the bodies, which are generally commingled, in contact with one another, and display evidence of traumatic injuries (Knüsel 2005). An important feature of mass graves is that they do not follow normative burial practices and therefore represent a departure from traditional treatment of the dead, often representing the need to bury dead individuals quickly (Knüsel 2005; Bennike 2006). The reason for this abandonment of traditional practice is often thought to be the period of social upheaval caused by a conflict or epidemic of infectious disease, causing other concerns to become more important than proper or respectful burial of the dead (Knüsel et al. 2007). Departure from tradition often extends to burial location, as mass graves are often placed in non-cemetery locations; this may result in continued use of the deposition site, indicating that it was not intended for use solely as a burial site (Knüsel et al. 2007). Continued use of the site often increases the amount of disturbance of skeletal remains, resulting in more extensive disarticulation and postmortem damage to the bones. This extensive post-depositional disturbance by the living can be seen in the Smith's Knoll remains, providing increased evidence for burial outside of normative practice.

As the circumstances surrounding the burial of the Smith's Knoll skeletal remains are known through corroborating historical sources, this collection can be informative regarding the relationship of warfare to the use of mass graves during the 19th century in North America. The burial of the remains of deceased soldiers following the battle of

Stoney Creek represents a much larger departure from normative burial practice than does the burial of the Snake Hill individuals. This may be related to unique features of the battle of Stoney Creek itself as well as of the community in which it took place, as in many other respects the circumstances in which these individuals died were very similar. It is clear from historical accounts of the battle that following the conflict, the remains of the soldiers who had died remained on the battlefield while the Americans began their retreat. The British army and possibly civilians living in the area collected the bodies and buried them in two mass graves (Hannay 1905). It is interesting to note that some of the soldiers were buried in the cemetery of the Methodist church, while others were buried in a pit on the battlefield (Elliott 2009). It is possible that due to the small size of the community and the relatively few number of settlers in the area at the time, the traditional burial ground was too small to contain all of the remains. The small number of civilians available to help with the burial may also represent part of the reason for the departure from normal burial practices, as digging individual graves requires a significant amount of labor. It is likely that the occurrence of the battle in this community and the relatively large number of dead requiring immediate burial represented a unique episode of social disruption, causing normative burial practices to be put aside. While similar situations have been hypothesized for prehistoric remains or samples for which historical context is less securely established (Bennike 2006; Knüsel et al. 2007), Smith's Knoll represents a collection for which this association can be clearly made.

The Smith's Knoll remains also exhibit significant evidence of perimortem traumatic injury. Perimortem lesions are displayed by elements in all areas of the

skeleton, both cranial and postcranial. Varied trauma is generally considered to be a feature of armed conflict, with its varied weapon types and changing postural positions (Knüsel et al. 2007). The chaos and lack of normal battle rules present in the close-range fighting at Stoney Creek may mean that this variation is even more prevalent than in many warfare-related assemblages where fighting may have been more structured. However despite the demonstration of lesions associated with different weapon types and the spread of lesions throughout the skeleton including injuries to locations commonly associated with violent trauma such as the cranium, the prevalence of lesions within the sample is quite low. Even when considering the highest calculated prevalence values, those being the individual count figures, only as high as 15 percent of individuals demonstrate skeletal evidence of perimortem traumatic injury. Since it is known that all individuals present in the sample died violently during the battle of Stoney Creek, the amount of trauma that can be seen in the collection is very low relative to the actual number of injuries sustained by these individuals. This under-estimation of violent injury in the sample is likely related to several limitations of the Smith's Knoll collection, including the inability to associate the skeletal elements into discrete individuals (see Section 7.4).

The recognition of warfare in prehistory is made especially difficult by the fact that there is no universal signature of warfare, either in physical remains or archaeological features (Rogers 2004). This is especially clear when examining and comparing sites such as Smith's Knoll and Snake Hill, which were both formed from the same conflict yet exhibit such variant features that without corroborating documentary evidence this close

connection would be difficult or even impossible to make. Sites such as Smith's Knoll, which contain skeletal and archaeological remains associated with significant documentary evidence to securely establish a context of warfare, can be informative about the features that may be observed in a warfare-related assemblage. However, significant variation exists between and even within conflicts, and as such the appearance of the resulting archaeological sites can differ greatly. It is therefore important not to limit interpretation of the patterning of lesions and burial features observed at a site based on preconceived conceptions of the "typical" appearance of a warfare-related assemblage.

7.3.3 Contributions to the bioarchaeological conceptualization of violence in the past

The Smith's Knoll assemblage can also be considered in the context of bioarchaeological studies of violence more generally. A major contribution of the Smith's Knoll collection is the representation of postcranial lesions in addition to the cranial trauma generally dealt with in bioarchaeological treatments of violent behavior in the past. While several other studies make mention of postcranial lesions sustained in a violent context, much less attention (if any) is paid to these injuries than to the cranial traumatic lesions sustained by the individuals involved (Novak 2000; Bennike 2006). With the exception of parry fractures of the forearm and projectile trauma, postcranial evidence of violent interaction is not commonly discussed within the literature. While the connection between cranial trauma and targeting of the head and face during interpersonal violent encounters has been fairly securely established based on the clinical and forensic literature (Ortner 2003; Lovell 2008), postcranial lesions are not always a result of

accident and deserve attention as potentially violence-related injuries, especially when context can be fairly reliably determined. There are some exceptions to the overwhelming focus on cranial trauma, for example White's (1992) analysis of the Mancos Canyon skeletal material. His analysis considers all areas of the body separately, and concentrates significant attention on the postcranium; he states that postcranial elements are easier to treat systematically due to the fact that they are present as individual and isolated elements in the adult skeleton. This perspective is relatively unique given the general focus on the craniofacial skeleton as a major target and the often superficial treatment of postcranial elements.

The value of the postcranium may be considered especially significant when dealing with fragmentary material that is commingled or cannot be observed in situ, given the fact that perimortem trauma is much more difficult to observe in un-reconstructed crania (Novak 2000; Knüsel et al. 2007). The presence of perimortem violent injury may actually make cranial fragments more difficult to refit in the first place, as perimortem impacts can cause permanent deformation of the bone that impedes the ability to fit fragments together properly (Moraitis et al. 2009). It became evident during the cataloguing process of the current analysis that small cranial fragments are extremely difficult to reconstruct into complete crania, especially if the remains are commingled. The difficulty of reconstructing crania and the ability of perimortem traumatic lesions to impede refitting of fragments and consequently mask their own presence in the sample increases the importance of postcranial lesions for the examination of violent injuries in fragmentary, commingled assemblages like Smith's Knoll. Therefore, investigations of

postcranial lesions resulting from violent activity in a sample that can be securely linked to a violent context have value for the potential recognition of similar lesions in other such collections.

The Smith's Knoll collection also demonstrates relatively good preservation of elements that may commonly be injured in violent activities but are often excluded from analyses due to insufficient preservation, such as the ribs, the scapulae, and the hand and foot bones. While the ribs can often be fractured with violent impact to the torso and may clearly display sharp force traumatic lesions (Kaufman 2003), they are often poorly preserved in archaeological contexts, precluding analysis of lesions contained therein (Brickley 2006). Lesions to the scapula are similarly occasionally documented archaeologically, but the fragility of the scapular blade often prevents good preservation. Lesions of the small bones of the hands and feet are also rarely considered in bioarchaeological evaluations of perimortem trauma. However these elements are well represented at Smith's Knoll and one carpal displays a possible perimortem lesion. The fact that these elements are generally poorly preserved and left out of analyses most likely contributes to the underestimation of traumatic injury in the torso and the hands and feet in archaeological samples, and the patterns of injury observed in the skeleton are therefore clearly affected by differential element survival and differential consideration during analysis (Bennike 2008). Clear perimortem lesions in all three of these elements are present in the Smith's Knoll assemblage, providing excellent examples of relatively uncommon osteological injuries that may serve as comparative lesions for other skeletal samples. Several unique features of the Smith's knoll collection therefore contribute to

bioarchaeological studies of violence by illustrating the presence and value of violence-related lesions in the postcranium and in generally poorly preserved skeletal elements of the torso.

7.4 Limitations of the Smith's Knoll Sample

The remains of the individuals within the Smith's Knoll assemblage are fragmented, disarticulated, commingled, and have been heavily damaged since their deposition at the site. The fragmentary nature of the sample as well as the amount of postmortem damage it has undergone has had a significant impact on the preservation and visibility of perimortem traumatic lesions within the collection, affecting interpretations made based on the appearance and prevalence of the injuries therein. These features of the Smith's Knoll sample have created difficulties for the preservation of lesions, the recognition of lesions, and the ability to quantitatively assess the presence of lesions.

The first major effect of the fragmentary nature of the Smith's Knoll assemblage is the possible destruction of elements displaying perimortem injury, and therefore the removal from the collection of lesions that were present in the skeletal material when it was first deposited. Postmortem disturbance of the collection by human and non-human agents related to farming at the site, exhumation and reburial of the remains, and taphonomic processes in the two hundred years since the original deposition of the remains has resulted in significant postmortem breakage. Fragmentation has been so extensive within the collection that hundreds of tiny fragments are unidentifiable even at a basic elemental level. Significant damage to the skeletal elements has almost certainly

resulted in the removal of aspects of the bone that once displayed evidence of perimortem injury. This is especially likely to occur as perimortem injury and fracturing of bone is known to increase its susceptibility to fragmentation, masking its own presence in the assemblage (Morlan 1984). Different rates of fragmentation by element are also likely to have affected the patterns of injury observed in the sample (Bennike 2008), as fragile elements such as the facial skeleton are more easily fragmented and therefore injuries in these areas may be even further under-represented.

In addition to removing lesions from the record altogether, taphonomic damage to the remains can disguise evidence of lesions that are technically still present, thereby reducing their visibility. Weathering damage on the Smith's Knoll remains is significant, which affects the amount of cortical surface available for the observation of characteristics associated with perimortem injury (White 1992). Weathering at the edges of fragments has likely also concealed evidence of perimortem fracture and breakage associated with injuries sustained during the battle; this may be particularly relevant to the apparent lack of musket trauma in the long bones of the limbs (see Section 7.1.5). The postmortem impact of farm implements, shovels used during exhumation, and excavation tools has caused a large amount of postmortem trauma on the remains in the form of cut marks, slice marks, and fractures. Postmortem cut marks have the potential to cover evidence of or even mimic perimortem injuries; such taphonomic overprint may be quite difficult to differentiate from actual perimortem damage (White 1992), confounding interpretation.

Quantitative analysis of perimortem traumatic lesions is made considerably more difficult by the fragmentation, disarticulation, and commingling of skeletal remains; many researchers dealing with collections similar in preservational quality to Smith's Knoll avoid quantitative methods altogether (see Section 7.3.1). Given the assumptions inherent in the calculation of prevalence using element count methods (Lovell 2008), this method of representing the presence of perimortem trauma is not well suited to use with fragmentary assemblages. While completeness can be accounted for in the calculation of prevalence using this method (see Chapter 5), such methodological adjustment is not common in the literature (Judd 2002) and most researchers who do attempt quantitative analysis on collections like Smith's Knoll do not specify exactly how their methods were adapted to fit their sample. The commingling and disarticulation of the skeletal material in the collection places serious limitations on the ability to represent the prevalence of traumatic lesions by individual. While lesion prevalence can be represented based on the minimum number of individuals, this estimation is not optimal. The need to consider each element separately likely underestimates the prevalence by individual, as the estimate provided is very conservative. Although each of the lesions could be present in a different individual, since each element category displays very few lesions there is no way to rule out the possibility that all of the affected elements could belong to only a few individuals. This potentially increases the under-estimation of prevalence even further.

In addition to its effects on prevalence calculations, the lack of discrete individuals in the sample impedes the evaluation of multiple injuries per individual. Many studies of perimortem trauma assess injury recidivism (Lovell 2008). The Smith's Knoll

sample is composed of soldiers who at the very least had seen one year of action since the beginning of the war. If some of the individuals were members of the British army, they were likely to have been career soldiers with several years of experience. The significant combat experience of these individuals makes them much more likely to exhibit multiple injuries, possibly including some more minor lesions in the early stages of healing as a large battle at Fort George occurred just days before Stoney Creek (Elliott 2009). The inability to assess the number of lesions per individual therefore precludes access to valuable information on injury recidivism in a particularly vulnerable population.

Taphonomic alteration to the skeletal material in the Smith's Knoll assemblage has therefore acted to significantly limit the amount of information that can be gained from bioarchaeological analysis. These limitations must be considered in addition to the biases that already affect the expression of perimortem traumatic lesions in the skeleton and reliance on archaeological evidence for interpretations of violence in the past. However, in spite of this the Smith's Knoll collection has clear value for the examination and characterization of violent injuries associated with early nineteenth century warfare, and may contribute much to bioarchaeological studies of violence in the past.

Chapter 8: Conclusions

Postcranial perimortem traumatic lesions sustained during the battle of Stoney Creek were examined, described, and quantified as part of the current analysis of the skeletal remains comprising the Smith's Knoll collection. This skeletal assemblage, consisting of the fragmented, disarticulated, and commingled remains of soldiers killed during the battle of Stoney Creek in the War of 1812, is relatively unusual in its securely documented context. Significant historical evidence in the form of both primary accounts and secondary literature documents the events leading up to and occurring during the battle, as well as the history of site use following deposition of the remains. This documentary evidence provides comparative material to illustrate the range of possibilities for lesions that may have been sustained during the battle, as well as for postmortem damage that may be observed on the remains and has the potential to mask, mimic, or complicate the visibility of the perimortem lesions that provide the focus of this analysis.

Several types of lesions attributable to perimortem injuries were observed in the remains, including sharp force trauma, musket trauma, and fractures. These lesions were present throughout the postcranial skeleton as well as in the cranium, with sharp force injuries observed in several of the ribs as well as one fibula, one femur, one carpal, one vertebra, one patella, and one ulna, musket injuries observed in three innominates and one scapula, and perimortem fractures observed in one rib and one scapula. The sharp force injuries displayed in the bones of the torso can mostly be associated with bayonet injuries,

while those found in the bones of the extremities were more likely caused by a cutting implement such as a sword. The projectile injuries correspond to the impacts of both musket balls and buckshot ammunition, the latter of which has not been previously reported archaeologically. The lesions classed as perimortem fractures contain no characteristic features suggestive of a more specific cause, and therefore must retain the non-specific fracture classification. The collection also contained some sharp force injuries for which a clear diagnosis of perimortem or postmortem could not be securely made due to the absence of the cortical surface surrounding the lesion. Other lesions were almost certainly masked or erased in a similar way by the significant degree of surface erosion, fragmentation, and other postmortem damage observed in the collection; it is known that the post-depositional taphonomic history of the assemblage includes farming at the site, exhumation and re-burial of the remains, and other processes that resulted in the taphonomic overprint observed on the skeletal remains. There is a rather conspicuous lack of perimortem musket injuries to the long bones of the limbs, which is likely related to the fragmentation caused by such injuries and the removal of perimortem edge characteristics by post-depositional weathering and surface erosion. During the analysis it was noted that some of the lesions are quite severe and would have involved an excessive use of force in their formation, potentially representing the phenomenon of overkill.

Quantitative analysis was performed to determine the prevalence of these different types of perimortem lesions in the collection. Due to the fragmentation, commingling, and disarticulation of the remains the methodology that should be used was unclear; this was made more difficult by the lack of clear discussion regarding this process within the

bioarchaeological literature, and the relative paucity of studies that have attempted quantitative analysis of such fragmentary material. Using the element count method, several different prevalence values were calculated for the group of fragments belonging to each element, attempting to account for the variation in percent completeness found within each group. In addition the minimum number of individuals was calculated for each element excluding the ribs, carpals, and vertebrae, and this figure was used to represent the prevalence of perimortem lesions by individual for each element. The individual count prevalence figures were generally found to represent the highest values for the prevalence of perimortem traumatic lesions, the highest being 15% for the innominate, followed by the fibula (8.33%), patella (7.69%), scapula (5%), femur (4.55%), and ulna (4.35%). The ribs, carpals, and vertebrae, for which this calculation was not possible, yielded total element count prevalence values of 3.02%, 2.22%, and 1.64% respectively. Given the fact that all of the individuals in this assemblage are known to have died violently during the battle of Stoney Creek, these prevalence values represent a dramatic under-estimation of the number of injuries that were likely present in the remains when they were originally deposited. Evidence of these injuries is no longer visible within the collection, due to a combination of biases and limitations inherent in skeletal samples in general and this sample in particular. Only a fraction of soft-tissue lesions impact the skeleton in the first place, and the evidence of those that did has likely been masked by postmortem damage and breakage within the collection. The lack of discrete individual skeletons also negatively impacts the ability to associate multiple injuries in a single individual, as well as to rule out the possibility of lesions seen in

different elements as belonging to the same individual, thereby potentially increasing the individual count prevalence of perimortem lesions.

Supplementary to the direct analysis of the Smith's Knoll material, experimental analyses were performed to provide additional information on the lesions observed. Using replica weapons based on those that would have been used during the War of 1812, comparative lesions were created on replica ribs and lower legs to provide some indication of the possible cause of lesions observed in the sample. This work allowed the association of lesions in the Smith's Knoll ribs with bayonet injury, as well as the association of a lesion on the distal fibula of a Smith's Knoll fragment with likely sword injury. Flintlock musket lesions were also created on replica buttocks to attempt to determine the range of fire and type of ammunition involved in the formation of the lesions on the three iliac crests in the assemblage. While the results of the experiment indicated that the behavior of musket ammunition was too erratic to make any reliable conclusions and that a larger sample size would be needed to obtain any useful information on range of fire, the broad similarity in size and appearance of the experimental and archaeological lesions resulted in strengthened confidence in the interpretation of these lesions as associated with musket ball and buckshot impacts.

The interpretation of the presence and specific features of the lesions observed in the assemblage is assisted by comparison with skeletal material from other roughly contemporaneous archaeological battle sites as well as with a well-documented surgical collection displaying military injuries from the first half of the 19th century. Similarities and differences were noted in the types of lesions observed in these collections, and both

were useful in providing an indication of the meaningful features of the Smith's Knoll sample. Musket trauma was observed in all three of the comparative collections, including projectile injuries to the limbs that were not present at Smith's Knoll. It also became evident by examining these contemporaneous collections that bayonet injuries and lesions due to the impact of buckshot have rarely or never been noted in other analyses, which appears to make these lesions unique features of the Smith's Knoll assemblage. These differences between Smith's Knoll and other battle sites from the War of 1812 and other 19th century military conflicts may relate to unique battle conditions and strategy implemented during the battle of Stoney Creek, or to differential preservation and taphonomic processes occurring at the burial site. Aside from these significant differences, the types of lesions observed in the collections were broadly similar. The lesions observed in the Smith's Knoll sample were also compared with the types and features of lesions that would be expected to occur in the collection based on historical accounts of the battle of Stoney Creek. The historical literature regarding the battle provides important information on battle conditions including the likely occurrence of friendly fire, the importance of buckshot ammunition, and the large amount of damage caused to the long bones by musket ball injuries. These features of soldiers' experiences at Stoney Creek had a significant effect on the appearance and visibility of the lesions displayed in the skeletal remains, and knowledge gained from historical data therefore allows for a more nuanced interpretation of the perimortem trauma seen in the collection.

Analysis of the Smith's Knoll skeletal material was also considered in the context of bioarchaeological studies of violence and warfare in the past, both methodologically

and theoretically. The difficulties of implementing quantitative methods in fragmentary material were discussed, and the methods chosen for use in the current analysis placed in context of those reported in the literature as having been used on collections with similar features. There are many features of the Smith's Knoll collection that are similar to other assemblages attributed to battle contexts, such as burial in a mass grave and the significant presence of varied traumatic lesions. However, it is clear from the numerous differences that exist between skeletal assemblages even within the same conflict, such as Smith's Knoll and Snake Hill, that there is no characteristic and universal pattern associated with the occurrence of warfare in the past; this has implications for the potential recognition of prehistoric conflict in the archaeological record. The patterning of the Smith's Knoll skeletal lesions is also quite important in bioarchaeological studies of violence given the traditional focus on cranial trauma and the relative lack of attention given to postcranial lesions associated with interpersonal violent encounters. In collections displaying a high degree of cranial fragmentation, the significance of postcranial lesions may increase due to the difficulty of recognizing perimortem trauma in un-reconstructed crania and the associated difficulty of refitting cranial pieces given the deformation caused by perimortem fractures themselves. Despite the widely repeated generalization that cranial trauma is associated to a greater degree with violence while postcranial trauma is more related to accidental causes, postcranial lesions can be associated with violent confrontation. The examination of postcranial violent trauma in collections with securely established contexts of warfare might assist in the recognition of this fact.

Finally, this study examined the many limitations inherent in the Smith's Knoll collection due to issues with preservation, taphonomic overprint, extensive fragmentation, disarticulation, and commingling. There are undoubtedly many difficulties associated with the condition of the assemblage, the abandonment of normative burial practices, and the lack of provenience for the skeletal remains contained therein, that impede analysis using traditional methods. However, given the large amount of information that can still be accessed regarding perimortem injuries sustained by the soldiers in this sample and the secure association of the remains with a battle context for which several independent sources of information are available, the value of analysis is indisputable.

Much can be and has been learned regarding the experience of soldiers during the battle of Stoney Creek, skeletal manifestations of early 19th century warfare, and the interaction of perimortem and postmortem processes in skeletal remains. This information has definite applications for the bioarchaeology of warfare and violence as well as for future studies that may be done. While such analyses utilizing fragmentary and commingled skeletal material have been avoided in the past, hopefully with the recognition of all that stands to be gained from the analysis of this type of material researchers of the future will not shy away from such studies. The analysis of the skeletal material from the Smith's Knoll assemblage illustrates that fragmentary assemblages still have much information to contribute, and demonstrates the value of integrating varied and complementary forms of evidence such as osteological, archaeological, and historical data to produce fuller and more nuanced interpretations of violence and warfare in the past.

References Cited

Alunni-Perret V, Muller-Bolla M, Laugier JP, Lupi-Pégurier L, Bertrand MF, Staccini P, Bolla M, Quatrehomme G. 2005. Scanning electron microscopy analysis of experimental bone hacking trauma. Journal of Forensic Science 50: 1-6.

Alunni-Perret V, Borg C, Laugier JP, Bertrand MF, Staccini P, Bolla M, Quatrehomme G, Muller-Bolla M. 2010. Scanning electron microscopy analysis of experimental bone hacking trauma of the mandible. American Journal of Forensic Medical Pathology 31: 326-329.

Bailey J, Mitchell PD. 2007. A case for Sherlock Holmes: forensic investigation of a gunshot wound to the head dating from Victorian London. International Journal of Osteoarchaeology 17: 100-104.

Bennike P. 2006. Rebellion, combat, and massacre: a medieval mass grave at Sandbjerg near Naestved in Denmark. In Otto T, Thrane H, Vandkilde H (eds.). Warfare and society: archaeological and social anthropological perspectives. Langelandsgade: Aarhus University Press. p 305-318.

Bennike P. 2008. Trauma. In Pinhasi R, Mays S (eds.). Advances in human paleopathology. Chichester: John Wiley & Sons. p 309-328.

Berryman HE, Symes SA. Recognizing gunshot and blunt cranial trauma through fracture interpretation. In Reichs K (ed.). Forensic osteology: advances in the identification of human remains. Springfield: Charles C Thomas.

Blyth L. 2003. Who was left on the battlefield? Unpublished MA thesis. University of Western Ontario, London, Canada.

Brickley M. 2006. Rib fractures in the archaeological record: a useful source of sociocultural information? International Journal of Osteoarchaeology 16: 61-75.

Brickley M, Smith M. 2006. Culturally determined patterns of violence: biological anthropological investigations at a historic urban cemetery. American Anthropologist 108: 163-177.

Brink O, Vesterby A, Jensen J. 1998. Pattern of injuries due to interpersonal violence. Injury 29:705-709.

Buikstra JE, Ubelaker DH, editors. 1994. Standards for data collection from human skeletal remains. Arkansas Archaeological Survey Research Series No. 44. Fayetteville: Arkansas Archaeological Society.

Caffrey K. 1977. The twilight's last gleaming: Britain vs. America 1812-1815. New York: Stein and Day.

Calce, SE and Rogers, TL. 2007. Taphonomic changes to blunt force trauma: a preliminary study. Journal of Forensic Science 52: 519-527.

Coles HL. 1965. The War of 1812. Chicago: The University of Chicago Press.

Connor MRF, Mowat LH. 1915. Some notes on gunshot and other wounds. The British Journal of Surgery 3: 135-141.

Cruikshank EA. 1913. A history of the Battle of Stoney Creek, written for the County of Wentworth Veterans Association on the occasion of the one hundredth anniversary of the battle. In The Battle of Stoney Creek Scrapbook, Volume 1 (1873-1949). Hamilton: Hamilton Public Library Archives.

Cunha E, Silva AM. 1997. War lesions from the famous Portuguese medieval Battle of Aljubarrota. International Journal of Osteoarchaeology 7: 595-599.

Daegling DJ, Warren MW, Hotzman JL, Self CJ. 2008. Structural analysis of human rib fracture and implications for forensic interpretation. Journal of Forensic Science 53: 1301-1307.

Dale RJ. 2001. The invasion of Canada: battles of the war of 1812. Toronto: James Lorimer & Company Ltd.

Darwent CM, Lyman RL. 2002. Detecting the postburial fragmentation of carpals, tarsals, and phalanges. In Haglund WD, Sorg MD (eds.). Advances in forensic taphonomy: method, theory, and archaeological perspectives. New York: CRC Press. p 355-377.

de la Cova C. 2010. Cultural patterns of trauma among 19th-century-born males in cadaver collections. American Anthropologist 112: 589-606.

Dobney KM, Rielly K. 1988. A method for recording archaeological animal bones: the use of diagnostic zones. Circaea 5: 79-96.

Duhig C, Martinsen N. 2007. Many layers of taphonomy: dismemberment and other body processing. In Brickley M, Ferllini R (eds.). Forensic anthropology: case studies from Europe. Springfield: Charles C Thomas. p 86-98.

Elliott JE. 2009. Strange fatality: the Battle of Stoney Creek, 1813. Toronto: Robin Brass Studio.

Fiorato V, Boylston A, Knüsel C (eds.). 2000. Blood red roses. Oxford: Oxbow Books.

Frekriksen JC. 1984. Memoirs of Captain Ephraim Shaler: a Connecticut Yankee in the War of 1812. New England Quarterly 57: 411-420.

Fredriksen JC and Burn J. 1989. Colonel James Burn and the War of 1812: the letters of a South Carolina officer. The South Carolina Historical Magazine 90: 299-312.

Fryer MB. 1986. Battlefields of Canada. Toronto: Dundurn Press.

Galloway A. 1999. Broken bones: anthropological analysis of blunt force trauma. Springfield: Charles C Thomas.

Gill GW. 1994. Skeletal injuries of pioneers. In Owsley DW, Jantz RL (eds.). Skeletal biology in the Great Plains: migration, warfare, health, and subsistence. Washington: Smithsonian Institution Press. p 159-172.

Goodman AH, Leatherman TL. 1998. Traversing the chasm between biology and culture: an introduction. In Goodman AH, Leatherman TL, editors. Building a new biocultural synthesis: political-economic perspectives on human biology. Ann Arbor: University of Michigan Press, p 3-41.

Grauer AL. 2008. Macroscopic analysis and data collection in paleopathology. In Pinhasi R, Mays S (eds.). Advances in human paleopathology. Chichester: John Wiley & Sons. p 57-76.

Griffin-Short R, editor. 2000. Battle of Stoney Creek burials bioarchaeology essay. In Griffin-Short R, editor. 1999 Field work at Smith's Knoll historic cemetery for the city of Stoney Creek, Ontario. RGS Archaeological Services.

Griffin-Short R, editor. 1998. Report: archaeological assessment, Smith's Knoll historic cemetery 1998. RGS Archaeological Services.

Haglund WD, Connor M, Scott DD. 2002. The effect of cultivation on buried human remains. In Haglund WD, Sorg MD (eds.). Advances in forensic taphonomy: method, theory, and archaeological perspectives. New York: CRC Press. p 133-150.

Hannay J. 1905. History of the War of 1812 between Great Britain and the United States of America. Toronto: Morang & Co. Limited.

Hickey DR. 1989. The War of 1812: a forgotten conflict. Chicago: University of Illinois Press.

Hitsman JM. 1966. The incredible War of 1812: a military history. Toronto: University of Toronto Press.

Horsman R. 1969. The War of 1812. New York: Alfred A. Knopf, Inc.

Humphrey JH, Hutchinson DL. 2001. Macroscopic characteristics of hacking trauma. Journal of Forensic Science 46: 228-233.

Jacobs JR and Tucker G. 1969. The War of 1812: a compact history. New York: Hawthorn Books, Inc.

Johnson E. 1985. Current developments in bone technology. Advances in Archaeological Method and Theory 8: 157-235.

Jordana X, Galtes I, Turbat T, Batsukh D, Garcia C, Isidro A, Giscard PH, Malgosa A. 2009. The warriors of the steppes: osteological evidence of warfare and violence from Pazyryk tumuli in the Mongolian Altai. Journal of Archaeological Science 36: 1319-1327.

Judd MA. 2002. Comparison of long bone trauma recording methods. Journal of Archaeological Science 29: 1255-1265.

Judd MA. 2008. The parry problem. Journal of Archaeological Science 35: 1658-1666.

Jurmain R. 1999. Stories from the skeleton: behavioral reconstruction in human osteology. Amsterdam: Gordon and Breach Publishers.

Kaufman MH. 2003. Musket-ball and sabre injuries from the first half of the nineteenth century. Edinburgh: The Royal College of Surgeons of Edinburgh.

Knight B. 1996. Forensic pathology. New York: Oxford University Press.

Knüsel C, Outram AK. 2004. Fragmentation: the zonation method applied to fragmented human remains from archaeological and forensic contexts. Environmental Archaeology 9: 85-97.

Knüsel C. 2005. The physical evidence of warfare – subtle stigmata? In Pearson MP, Thorpe IJN (eds.). Warfare, violence and slavery in prehistory: proceedings of Prehistoric Society conference at Sheffield University. Oxford: Archaeopress. p 49-66.

Knüsel C. 2007. The human remains, with comments on the paleopathology of animals and humans. In Harding A, Sumberová R, Knüsel C, and Outram A (eds.). Velim: Violence and death in Bronze Age Bohemia. Prague: Oxbow Books. p 85-89.

Knüsel C, Outram A, Knight S. 2007. A comparison of human and animal deposition at Velim-Skalka through an integrated approach. In Harding A, Sumberová R, Knüsel C, and Outram A (eds.). Velim: Violence and death in Bronze Age Bohemia. Prague: Oxbow Books. p 97-136.

Komar DA, Grivas C. 2008. Manufactured populations: what do contemporary reference skeletal collections represent? A comparative study using the Maxwell museum documented collection. American Journal of Physical Anthropology 137: 224-233.

Larsen CS, Huynh GP, McEwan BG. 1996. Death by gunshot: biocultural implications of trauma at Mission San Luis. International Journal of Osteoarchaeology 6: 42-50.

Larsen CS. 1999. Bioarchaeology: interpreting behavior from the human skeleton. Port Hope: Cambridge University Press.

Lewis JE. 2008. Identifying sword marks on bone: criteria for distinguishing between cut marks made by different classes of bladed weapons. Journal of Archaeological Science 35: 2001-2008.

Liston MA, Baker BJ. 1996. Reconstructing the massacre at Fort William Henry, New York. International Journal of Osteoarchaeology 6: 28-41.

Liston M. 2000. Smith's Knoll 1999 osteological report. In Griffin-Short R, editor. 1999 Field work at Smith's Knoll historic cemetery for the city of Stoney Creek, Ontario. RGS Archaeological Services.

Litt P, Williamson RF, Whitethorne JWA. 1993. Death at Snake Hill: secrets from a War of 1812 cemetery. Toronto: Dundurn Press.

Love JC, Symes SA. 2004. Understanding rib fracture patterns: incomplete and buckle fractures. Journal of Forensic Science 49: 1153-1158.

Lovejoy, CO and Heiple, KG. 1981. The analysis of fractures in skeletal populations with an example from the Libben site, Ottowa County, Ohio. American Journal of Physical Anthropology 55: 529-541.

Lovell NC. 1997. Trauma analysis in paleopathology. Yearbook of Physical Anthropology 40: 139-170.

Lovell NC. 2008. Analysis and interpretation of skeletal trauma. In Katzenberg MA, Saunders SR (eds.) Biological anthropology of the human skeleton. John Wiley & Sons, Inc. p 341-386.

Lucas, CP. 1906. The Canadian War of 1812. Oxford: Clarendon Press.

Lynn KS, Fairgrieve SI. 2009. Macroscopic analysis of axe and hatchet trauma in fleshed and defleshed mammalian long bones. Journal of Forensic Science 54: 786-792.

Mairs S, Swift B, Rutty GN. 2004. Detergent: an alternative approach to traditional bone cleaning methods for forensic practice. American Journal of Forensic Medical Pathology 35: 276-284.

Marquis TG. 1926. Battlefields of 1813. In Pierce L (ed.) The Ryerson Canadian History Readers. Toronto: The Ryerson Press.

McKinley JI. 2004. Compiling a skeletal inventory: disarticulated and commingled remains. In Brickley and McKinley (eds.) Guidelines to the Standards for Recording Human Remains. Reading: BABAO. p 14-17.

McVeigh C. 1998. Human bone report. In Griffin-Short R, editor. Report: archaeological assessment, Smith's Knoll historic cemetery 1998. RGS Archaeological Services. p 1-13.

Merbs CF. 1989. Trauma. In Iscan MY, Kennedy KAR (eds.). Reconstruction of life from the skeleton. New York: Wiley-Liss. p 160-189.

Moraitis K, Eliopoulos C, Spiliopoulou C. 2009. Fracture characteristics of perimortem trauma in skeletal material. The Internet Journal of Biological Anthropology 3.

Morlan RE. 1984. Toward the definition of criteria for the recognition of artificial bone alterations. Quaternary Research 22: 160-171.

Murphy MS, Gaither C, Goycochea E, Verano JW, Cock G. 2010. Violence and weapon-related trauma at Puruchuco-Huaquerones, Peru. American Journal of Physical Anthropology 142: 636-649.

Novak SA. 2000. Battle-related trauma. In Fiorato V, Boylston A, Knüsel C (eds.). Blood red roses. Oxford: Oxbow Books. p 90-102.

Ortner DJ. 2003. Identification of pathological conditions in human skeletal material. San Diego: Elsevier Inc.

Outram AK. 2001. A new approach to identifying bone marrow and grease exploitation: why the "indeterminate" fragments should not be ignored. Journal of Archaeological Science 28: 401-410.

Outram AK, Knüsel CJ, Knight S, Harding AF. 2005. Understanding complex fragmented assemblages of human and animal remains: a fully integrated approach. Journal of Archaeological Science 32: 1699-1710.

Owsley DW, Mann RW, Murphy SP. 1991. Injuries, surgical care, and disease. In Pfeiffer S, Williamson RF (eds.). Snake Hill: an investigation of a military cemetery from the War of 1812. Toronto: Dundurn Press.

Pfeiffer S, Williamson RF, editors. 1991. Snake Hill: an investigation of a military cemetery from the War of 1812. Toronto: Dundurn Press.

Prieto JL. 2007. Stab wounds: the contribution of forensic anthropology. In Brickley M, Ferllini R (eds.). Forensic anthropology: case studies from Europe. Springfield: Charles C Thomas. p 19-37.

Redfern RC, Chamberlain AT. 2011. A demographic analysis of Maiden Castle hillfort: evidence for conflict in the late Iron Age and early Roman period. International Journal of Paleopathology 1: 68-73.

Roberts C, Manchester K. 2005. The archaeology of disease. Ithaca: Cornell University Press.

Rogers J. 2004. Recognizing interpersonal violence: a forensic perspective. In Roksandic M, editor. Violent interactions in the Mesolithic, BAR International Series, vol. 1237. Oxford: Archaeo Press. p 9-21.

Sansoni G, Cattaneo C, Trebeschi M, Gibelli D, Porta D, Picozzi M. 2009. Feasibility of contactless 3D optical measurement for the analysis of bone and soft tissue lesions: new technologies and perspectives in forensic sciences. Journal of Forensic Science 54: 540-545.

Sauer NJ. 1998. The timing of injuries and manner of death: distinguishing among antemortem, perimortem, and postmortem trauma. In Reichs K (ed.). Forensic osteology: advances in the identification of human remains. Springfield: Charles C Thomas. p 321-332.

Schaefer MC, Black SM. 2007. Epiphyseal union sequencing: aiding in the recognition and sorting of commingled remains. Journal of Forensic Science 52: 277-285.

Schaefer M, Black S, Scheuer L. 2009. Juvenile osteology: a laboratory and field manual. San Diego: Academic Press.

Scheuer L, Black S. 2000. Developmental juvenile osteology. San Diego: Academic Press.

Schmidt U. 2010. Sharp force injuries in “clinical” forensic medicine. Forensic Science International 195: 1-5.

Schmidt U, Pollak S. 2006. Sharp force injuries in clinical forensic medicine: findings in victims and perpetrators. Forensic Science International 159: 113-118.

Scott DD, Fox RA, Connor MA, Harmon D. 1989. Archaeological perspectives on the Battle of the Little Bighorn. Norman: University of Oklahoma Press.

Scott DD, Willey P, Connor MA. 1998. They died with Custer: soldiers' bones from the Battle of the Little Bighorn. Norman: University of Oklahoma Press.

Shaw KP, Chung JH, Chung FC, Tseng BY, Pan CH, Yang KT, Yang CP. 2011. A method for studying knife tool marks on bone. Journal of Forensic Science 56: 967-971.

Shepherd JP, Shapland M, Pearce NX, Scully C. 1990. Pattern, severity and aetiology of injuries in victims of assault. Journal of the Royal Society of Medicine 83: 75-78.

Simmons T. 2007. Fleeing Srebrinica: a surprise attack on a group of men and boys in the mountains. In Brickley M, Ferllini R (eds.). Forensic anthropology: case studies from Europe. Springfield: Charles C Thomas. p 165-182.

Smith OC, Pope EJ, Symes SA. 2009. Look until you see: identification of trauma in skeletal material. In Steadman DW (ed.). Hard evidence: case studies in forensic anthropology. Upper Saddle River: Prentice Hall.

Snow CC, Fitzpatrick J. 1989. Human osteological remains from the battle of the Little Bighorn. In Scott DD, Fox RA, Connor MA, Harmon D (eds.). Archaeological perspectives on the Battle of the Little Bighorn. Norman: University of Oklahoma Press. p 243-282.

Sofaer JR. 2006. The body as material culture: a theoretical osteoarchaeology. Cambridge: Cambridge University Press.

Sutherland S (ed.). 2001. "A desire of serving and defending my country": the War of 1812 journals of William Hamilton Merritt. Toronto: Iser Publications.

Symes SA, Williams JA, Murray EA, Hoffman JM, Holland TD, Saul JM, Saul FP, Pope EJ. 2002. Taphonomic context of sharp-force trauma in suspected cases of human mutilation and dismemberment. In Haglund WD, Sorg MD (eds.). Advances in forensic taphonomy: method, theory, and archaeological perspectives. New York: CRC Press. p 403-434.

Turner WB. 2000. The War of 1812: the war that both sides won. Toronto: The Dundurn Group.

Ubelaker DH. 2002. Approaches to the study of commingling in human skeletal biology. In Haglund WD, Sorg MD (eds.). Advances in forensic taphonomy: method, theory, and archaeological perspectives. New York: CRC Press. p 331-351.

Walker PL. 2001. A bioarchaeological perspective on the history of violence. Annual Review of Anthropology 30:573-596.

Wallace C. 1916. A study of 1200 cases of gunshot wounds of the abdomen. The British Journal of Surgery 4: 679-743.

Warren MW. 2007. Interpreting gunshot wounds in the Balkans: evidence for genocide. In Brickley M, Ferllini R (eds.). Forensic anthropology: case studies from Europe. Springfield: Charles C Thomas. p 151-164.

Wenham SJ. 1989. Anatomical interpretations of Anglo-Saxon weapon injuries. In Hawkes SC (ed.). Weapons and warfare in Anglo-Saxon England. Oxford: Oxford University. p 123-139.

Wheatley BP. 2008. Perimortem or postmortem bone fractures? An experimental study of fracture patterns in deer femora. Journal of Forensic Science 53: 69-72.

White TD. 1992. Prehistoric cannibalism at Mancos 5MTUMR-2346. Princeton: Princeton University Press.

Wieberg DAM, Wescott DJ. 2008. Estimating the timing of long bone fractures: correlation between the postmortem interval, bone moisture content, and blunt force trauma fracture characteristics. Journal of Forensic Science 53: 1028-1034.

Willey P, Scott DD. 1996. 'The bullets buzzed like bees': gunshot wounds in skeletons from the Battle of the Little Bighorn. International Journal of Osteoarchaeology 6: 15-27.

Williamson MA, Johston CA, Symes SA, Schultz JJ. 2003. Interpersonal violence between 18th century Native Americans and Europeans in Ohio. American Journal of Physical Anthropology 122: 113-122.

Wood JW, Milner GR, Harpending HC, Weiss KM, Cohen MN, Eisenberg LE, Hutchinson DL, Jankauskas R, Cesnys G, Katzenberg MA, Lukacs JR, McGrath JW, Roth EA, Ubelaker DH, Wilkinson RG. 1992. The osteological paradox: problems of inferring prehistoric health from skeletal samples. Current Anthropology 33: 343-370.

Zych GA, Kalandiak SP, Owens PW. 2008. Gunshot wounds to the musculoskeletal system. In Browner BD, Jupiter JB, Levine AM, Trafton PG, Krettek C, Green NE (eds.). Skeletal trauma: basic science, management and reconstruction. Philadelphia: Elsevier. p 431-452.

Appendix I: Detailed Breakdown of Fragments Included in Prevalence Calculation Categories by Element

This appendix contains complete information on the fragments contained in the collection for each element that displayed some evidence of perimortem trauma. For elements in which no traumatic lesions were observed, no information is included. Information on the carpals and tarsals is restricted to the scaphoid (SCP) and navicular (NAV), as these are the only bones in which lesions were observed. Information on the phalanges is restricted to the hand phalanges, as no lesions were observed in the foot phalanges. Information on the vertebrae is restricted to the thoracic vertebrae, as no lesions were observed in cervical vertebrae, lumbar vertebrae, or vertebrae to which a type could not be definitively assigned.

Abbreviations used within the tables are as follows:

P = Present
A = Absent
I = Indeterminate
R = Right
L = Left
PM F = Perimortem Fracture
PM M = Perimortem Musket Trauma
PM S = Perimortem Sharp Force Trauma
Z = Zone

A score of '?' in the side column indicates that the side of a fragment could not be determined. If side can be assigned but not with complete confidence, it is scored as 'R?' or 'L?'. If ambiguity exists as to which zone was present, as is the case for many of the very small fragments, all possible zones that a fragment could represent are scored as

'P?'. When calculating percent completeness, two 'P?' scores were therefore taken to be equal to one 'P' score. Diagrams indicating the positioning of the numbered or lettered zones on each element are provided in Knüsel and Outram (2004).

Carpals and Tarsals

# Present	Bone	Side	PM F	PM M	PM S
SK1759	SCP	L?	A	A	A
SK1807	SCP	L	A	A	P
SK1808	SCP	L	A	A	A
SK1809	SCP	R?	A	A	A
SK1895	SCP	R	A	A	A
SK1683	NAV	L	A	A	A
SK1687	NAV	R?	A	A	A
SK1767	NAV	L?	A	A	A
SK1768	NAV	?	A	A	A
SK1769	NAV	?	A	A	A
SK1825	NAV	L	A	A	A
SK1826	NAV	R	A	A	A
SK1827	NAV	L?	A	A	I
SK1828	NAV	R	A	A	A
SK1829	NAV	L	A	A	A
SK1830	NAV	L	A	A	A
SK1831	NAV	R	A	A	A
SK1832	NAV	R	A	A	A
SK1833	NAV	R	A	A	A
SK1836	NAV	L	A	A	A
SK1843	NAV	L?	A	A	A
SK1845	NAV	R?	A	A	A
SK1846	NAV	L	A	A	A
SK1851	NAV	?	A	A	A
SK1877	NAV	?	A	A	A
SK1890	NAV	L	A	A	A
SK1900	NAV	L	A	A	A

Clavicles

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	% Complete
SK1063	R	A	A	A	P	P	P	100
SK1064	R	A	A	A	P	P	P	100
SK1065	R	A	A	A	P	P	P	100
SK1066	R	A	A	A	P	P	P	100
SK1067	L	A	A	A	P	P	P	100
SK1068	R	A	A	A	P	P	P	100
SK1070	R	A	A	A	P?	P	P	100
SK1071	R	A	A	A	P	P	P	100
SK1072	R	A	A	A	P?	P	P	100
SK1073	?	A	A	A	A	A	P	33
SK1074	?	A	A	A	P?	P	P?	67
SK1075	?	A	A	A	A	P	A	33
SK1076	R	A	A	A	P	P	P	100
SK1077	R	A	A	A	P	P	P	100
SK1078	L	A	A	A	P	P	P	100
SK1079	?	A	A	A	A	A	P	33
SK1080	L	A	A	A	P	P	P	100
SK1081	?	A	A	A	A	A	P	33
SK1082	L	A	A	A	P	P	P	100
SK1083	R	A	A	A	P	P	P	100
SK1084	R	A	A	A	A	P	P	67
SK1085	R	A	A	A	P	A	P?	67
SK1086	L	A	A	A	P	A	P	67
SK1087	L	A	A	A	P	P	P	100
SK1088	L?	A	A	A	P	P	P	100
SK1089	L	A	A	A	P?	P	P	100
SK1090	L	A	A	A	A	P	P	67
SK1091	R	A	A	A	P	A	P	67
SK1092	?	A	A	A	A	A	P	33
SK1093	L	A	A	A	P	A	P	67
SK1094	L	A	A	A	P	A	P	33
SK1095	?	A	A	A	P?	P?	P	67
SK1096	R?	A	A	A	A	P	P	67
SK1097	L?	A	A	A	P	A	P	67
SK1098	L	A	A	A	A	P	P	67
SK1099	R?	A	A	A	P?	A	P	67

SK1100	R?	A	A	A	A	P	A	33
SK1101	R	A	A	I	P	P	P	100
SK1102	R	A	A	A	A	P	P	67
SK1103	R?	A	A	A	A	A	P	33
SK1104	?	A	A	A	A	A	P	33
SK1105	L	A	A	A	P	P	P	100

Femora

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	% Complete
SK0001	L	A	A	A	A	P	P	P	P	P	P	P	A	A	A	64
SK0002	L	A	A	A	P	P	P	P	P	P	P	P	A	A	A	73
SK0003	R	A	A	A	A	P	P	A	P	P	P	P	A	A	A	55
SK0004	R	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0005	R	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0007	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0008	R?	A	A	A	A	A	A	P	P	A	A	A	A	A	A	18
SK0009	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0010	R?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	9
SK0011	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0012	L?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0013	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0014	?	A	A	A	A	A	A	P	P	A	A	A	A	A	A	18
SK0015	R?	A	A	A	A	A	A	A	A	A	A	A	P	A	P	18
SK0016	R	A	A	A	A	A	A	A	A	A	A	A	P	A	A	9
SK0017	L?	A	A	A	A	A	A	A	A	A	A	A	P	A	P	18
SK0018	?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	A	9
SK0019	R?	A	A	A	P	A	A	A	P	A	A	A	A	A	A	18
SK0021	R	A	A	A	P	P	P	P	P	A	A	A	A	A	A	45
SK0022	?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	P?	18
SK0023	L	A	A	A	A	P	P	A	P	A	A	A	A	A	A	27
SK0024	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0025	L	A	A	A	A	P	A	A	P	A	A	A	A	A	A	18
SK0026	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0027	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9
SK0028	L	A	A	A	A	P	P	A	A	A	A	A	A	A	A	18
SK0029	?	A	A	A	A	A	A	P	P?	A	A	A	A	A	A	18
SK0030	R	A	A	A	A	P	P	A	A	A	A	A	A	A	A	18
SK0031	R?	A	A	A	A	A	P	A	A	A	A	A	A	A	A	9
SK0032	R?	A	A	A	A	A	A	A	A	A	P	P	A	A	A	18
SK0034	L	A	A	A	A	P	P	P	P	P	P	P	P	P	P	91
SK0035	R	A	A	A	A	P	P	P	P?	P	P	P	A	A	A	64
SK0036	R	A	A	A	A	P	P	P	P	P	P	P	P	P	P	91
SK0037	R?	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0038	R	A	A	A	A	P	P	A	P	P	P	P	P	P	P	82
SK0039	R	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45

SK0040	L	A	A	A	P	P	P	P	P	P	P	P	A	A	A	73
SK0041	R	A	A	A	P	P?	P	P	P	A	A	A	A	A	A	45
SK0042	L	A	A	A	A	P	P	P	P	P	P	P	P	P	P	91
SK0043	R	A	A	A	P	P	P	P	P	P	P	P	P	P	P	100
SK0044	L	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0045	L	A	A	A	P	P	P	A	P	P	P	P	A	A	A	64
SK0046	R	A	A	A	A	P	P	P	P	P	P	P	A	A	A	64
SK0047	R	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0048	R	A	A	A	A	P	P	A	A	P	P	P	P	P	P	73
SK0049	?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	A	9
SK0050	R	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0051	R	A	A	A	P	P	P	P	P	P	P	P	P	A	P	91
SK0052	R	A	A	A	P	P	P	P	P	P	P	P	A	A	A	73
SK0053	R	A	A	A	A	P	P	A	P	P	P	P	A	A	A	55
SK0054	L	A	A	A	A	P	P	P	P	P	P	P	P	P	P	91
SK0055	R	A	A	A	P	P	P	P	P	P	P	P	P	P	P	100
SK0056	R	A	A	A	A	P	P	P	P	P	P	P	A	A	A	64
SK0088	L	A	A	A	P	P	P	A	A	P	P	P	P	P	P	82
SK0089	L	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0096	L	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0098	L	A	A	A	P	P	P	A	A	P	P	P	A	A	A	55
SK0099	L	A	A	A	P	P	P	P	P	P	P	P	A	A	A	73
SK0101	L	A	A	A	P	P	P	P	P	P	P	P	A	A	A	73
SK0102	R	A	A	A	A	P	P	A	P	P	P	P	A	A	A	55
SK0103	L	A	A	A	P	P	P	A	A	P	P	P	A	A	A	55
SK0104	L	A	A	A	P	P	P	A	P	P	P	P	P	P	P	91
SK0105	L	A	A	A	P	P	P	P	P	P	P	P	P	P	P	100
SK0106	L	A	A	A	A	A	A	A	A	P	P	P	A	A	A	27
SK0107	L	A	A	A	A	P	P	A	P	P	P	P	A	A	A	55
SK0111	L	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0116	L	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0119	L	A	A	A	A	P	P	A	A	P	A	P	A	A	A	36
SK0122	L	A	A	I	A	P	A	A	A	P	P	P	A	A	A	36
SK0126	R	A	A	A	A	P	P	A	A	P	P	P	A	A	A	45
SK0127	L?	A	A	A	A	A	A	A	A	A	P?	P	A	A	A	18
SK0201	R	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0202	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0203	R	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0204	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0205	L?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	P	18
SK0206	L?	A	A	A	A	A	A	P	P	A	A	A	A	A	A	18
SK0207	L	A	A	A	A	A	P	P	P	A	A	A	A	A	A	27
SK0208	R	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0209	R?	A	A	A	A	A	A	P	P	A	A	A	A	A	A	18
SK0210	R	A	A	A	A	A	P	A	A	A	A	A	A	A	A	9
SK0211	R?	A	A	A	A	P?	A	A	P	A	A	A	A	A	A	18
SK0212	R?	A	A	A	A	A	A	A	A	A	P?	P?	A	A	A	9
SK0213	L?	A	A	A	A	A	A	A	A	A	A	A	A	A	P	9
SK0214	L?	A	A	A	P?	A	A	A	A	A	A	A	A	A	A	9
SK0260	?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	A	9
SK0261	?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	A	9

SK0262	?	A	A	A	A	A	A	A	A	A	A	A	P?	A	P?	9
SK0311	L	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0312	L	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0313	L	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0314	L?	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0315	R	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0317	L?	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0318	L	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0319	R?	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0320	L	A	A	P	A	A	A	A	A	A	P	P	P	P	P	45
SK1863	?	A	A	A	A	A	A	A	A	A	A	A	P?	P?	A	9
SK2653	?	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9

Fibulae

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	% Complete
SK0128	L?	A	A	A	A	A	P	P	P	P	67
SK0129	R	A	A	P	A	P	P	P?	A	A	50
SK0130	R?	A	A	A	A	A	A	A	P	P	33
SK0131	R	A	A	A	P?	A	P	P	P	P	83
SK0146	R	A	A	A	A	A	P	P	A	A	33
SK1288	L	A	A	A	A	P	A	A	A	A	17
SK1289	L	A	A	A	A	P	A	A	A	A	17
SK1290	L	A	A	A	A	P	A	A	A	A	17
SK1291	L	A	A	A	A	P	P?	A	A	A	33
SK1292	L	A	A	A	A	P	P	A	A	A	33
SK1293	L	A	A	A	A	P	P	A	A	A	33
SK1294	L?	A	A	A	P?	A	A	A	A	A	17
SK1295	L	A	A	A	A	P	P	P	P	P	83
SK1296	L	A	A	A	A	A	P	P	P	P	67
SK1297	L	A	A	A	A	A	P	P	P	P	67
SK1298	L	A	A	A	A	A	P	P	P	P	67
SK1299	L	A	A	A	A	A	P	P	P	P	67
SK1300	L	A	A	A	A	A	P	P	P?	A	50
SK1301	L	A	A	A	A	A	P	P	A	A	33
SK1302	L	A	A	A	A	A	P	P?	A	A	33
SK1303	L	A	A	A	A	A	P	A	A	A	17
SK1304	L?	A	A	A	A	A	P	A	A	A	17
SK1305	L	A	A	A	A	A	P	A	A	A	17
SK1306	R	A	A	A	A	P	A	A	A	A	17
SK1307	R	A	A	A	A	P	A	A	A	A	17
SK1308	R	A	A	A	A	P	A	A	A	A	17
SK1309	R	A	A	A	A	P	P?	A	A	A	33
SK1310	L	A	A	A	A	A	P	P	P	A	50

SK1311	R	A	A	A	A	A	P	P?	A	A	33
SK1312	R	A	A	A	A	A	P	A	A	A	17
SK1313	R	A	A	A	A	A	P	P?	A	A	33
SK1314	R?	A	A	A	A	A	P	P?	A	A	33
SK1315	R	A	A	A	A	A	P	P	P	P?	67
SK1316	R	A	A	A	A	A	P	P	P	P	67
SK1317	R	A	A	A	A	A	P	P	P	P	67
SK1318	R?	A	A	A	A	A	P	P	P	P	67
SK1319	R?	A	A	A	A	A	A	A	P	P	33
SK1320	R?	A	A	A	A	A	A	A	P	P	33
SK1321	L?	A	A	A	A	A	P	P	P	P	67
SK1322	L?	A	A	A	A	A	P	A	A	A	17
SK1323	L?	A	A	A	A	A	A	P	P	P?	50
SK1324	L?	A	A	A	A	A	P	P	A	A	33
SK1325	R?	A	A	A	A	A	P	P	A	A	33
SK1326	?	A	A	A	A	A	P	P	A	A	33
SK1327	?	A	A	A	A	A	A	A	P?	P?	17
SK1328	R?	A	A	A	A	P	P	A	A	A	33
SK1329	?	A	A	A	A	A	P	P?	A	A	33
SK1330	?	A	A	A	A	A	A	P	P	A	33
SK1331	R?	A	A	A	A	A	A	P	P	A	33
SK1332	?	A	A	A	A	A	A	P?	P?	P?	33
SK1333	?	A	A	A	A	A	A	P?	P?	P?	33
SK1334	R?	A	A	A	A	A	P	P?	A	A	33
SK1335	?	A	A	A	A	A	P?	P?	P?	P?	33
SK1336	R?	A	A	A	A	A	P	P	P?	A	50
SK1337	?	A	A	A	A	A	P?	P?	P?	A	33
SK1338	R?	A	A	A	A	A	A	A	P?	P	33
SK1339	?	A	A	A	A	A	A	P?	P?	P?	33
SK1340	?	A	A	A	A	A	A	P?	P?	P?	33
SK1341	L?	A	A	A	A	A	A	P	P	A	33
SK1342	R?	A	A	A	A	A	A	P	P	A	33
SK1343	?	A	A	A	A	A	A	P	P	A	33
SK1344	R?	A	A	A	A	A	P?	P	P?	A	33
SK1345	?	A	A	A	A	A	P?	P?	A	A	17
SK1346	?	A	A	A	A	A	A	A	P?	P?	17
SK1347	?	A	A	A	A	A	A	A	P?	P?	17
SK1348	L	A	A	A	A	A	P	P?	A	A	33
SK1349	?	A	A	A	A	A	A	P?	P?	P?	33
SK1350	?	A	A	A	A	A	A	P?	P?	P?	33
SK1352	L?	A	A	A	A	A	A	A	P	P	33
SK1353	?	A	A	A	A	A	A	P?	P?	A	17
SK1354	?	A	A	A	A	A	A	P?	P?	A	17
SK1355	L?	A	A	A	A	P	P	A	A	A	33
SK1356	R?	A	A	A	A	A	P	A	A	A	17
SK1357	R?	A	A	A	P	A	A	A	A	A	17

SK1358	?	A	A	A	A	A	P?	A	A	A	17
SK1359	?	A	A	A	A	A	P?	P?	P?	A	33
SK1360	R?	A	A	A	A	A	A	P?	P	P	50
SK1697	R	A	A	A	A	P	A	A	A	A	17
SK1857	R	A	A	A	A	P	A	A	A	A	17
SK2642	R	A	A	A	A	P	A	A	A	A	17
SK2643	L	A	A	A	P	A	A	A	A	A	17
SK2651	?	A	A	A	A	A	A	P	A	A	17

Humeri

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	% Complete
SK0143	L	A	A	A	A	A	P	P	P	P	P	P	A	A	A	55
SK0144	L	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0168	R	A	A	A	A	A	A	P	P	P	P	P	P	P	P	73
SK0169	R	A	A	A	P	P	A	A	A	A	A	A	A	A	P	27
SK0170	R	A	A	A	A	A	A	P	P	P	A	A	A	A	A	27
SK0171	L?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK0172	R	A	A	A	A	A	P	A	P	P	A	A	A	A	A	27
SK0173	L?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK0174	R	A	A	A	P	A	A	P	P	P	P	P	P	P	P	82
SK0175	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0176	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0177	L	A	A	A	P	A	P	P	P	P	P	P	P	P	P	91
SK0178	L	A	A	A	P	A	P	P	P	P	P	P	P	P	P	91
SK0179	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0180	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0181	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0182	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0183	R	A	A	A	A	A	P	A	P	P	P	P	P	P	P	73
SK0184	R	A	A	A	A	A	A	P	P	P	P	P	P	P	A	64
SK0185	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0186	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0187	R?	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0188	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0189	L	A	A	A	A	A	A	A	A	A	A	A	P	P	P	27
SK0190	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0191	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0192	L	A	A	A	A	A	A	P	P	P	P	P	P	P	P	73
SK0193	L	A	A	A	A	A	A	P	A	A	P	P	P	P	P	55
SK0215	L	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0216	R	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0217	R	A	A	A	P	P	P	P	P	P	P	P	P	P	P	100
SK0218	R	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0219	L	A	A	A	A	A	A	P	A	A	P	P	P	P	P	55
SK0220	L	A	A	A	P	P	A	P	P	P	P	P	P	P	P	91
SK0221	L	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0222	L	A	A	A	A	P	P	P	P	P	P	P	P	P	P	91
SK0223	L	A	A	A	A	A	A	P	P	P	P	P	P	P	P	73
SK0224	L	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0225	R	A	A	A	A	A	A	A	A	A	A	A	A	A	P	9
SK0226	R	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0227	R	A	A	A	A	A	A	A	P	P	P	P	P	P	P	64

SK0228	L	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0229	R	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0230	L	A	A	A	A	A	A	A	A	A	P	P	P	P	P	45
SK0231	R	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0232	R	A	A	A	A	A	P	P	P	P	P	P	P	P	P	82
SK0233	R	A	A	A	P	A	P	P	P	P	P	P	P	P	P	91
SK0234	R	A	A	A	P	A	A	P	A	A	P	P	P	P	P	64
SK0235	R	A	A	A	A	A	A	P	P	P	P	P	P	P	P	73
SK0236	R	A	A	A	A	A	A	P	A	A	P	P	P	P	P	55
SK0237	R	A	A	A	P	P	A	A	A	A	A	A	A	A	P	27
SK0238	R?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0239	?	A	A	A	A	P	A	A	A	A	A	A	A	A	P	18
SK0240	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0241	R	A	A	A	A	A	A	A	A	A	A	A	A	A	P	9
SK0242	?	A	A	A	A	P	A	A	A	A	A	A	A	A	P	18
SK0243	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0244	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0245	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0246	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0247	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0248	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0249	L	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK0250	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0251	L	A	A	A	A	A	A	A	P	P	P	A	A	A	A	27
SK0252	?	A	A	A	A	P	A	A	A	A	A	A	A	A	A	9
SK0253	R	A	A	A	A	A	A	A	P	P	A	A	A	A	A	18
SK0254	?	A	A	A	A	A	A	A	A	P	A	A	A	A	A	9
SK0255	?	A	A	A	A	A	A	P	A	P	A	A	A	A	A	18
SK0256	R?	A	A	A	A	A	A	A	A	P	A	A	A	A	A	9
SK0257	R?	A	A	A	A	A	A	P	A	P	A	A	A	A	A	18
SK0258	?	A	A	A	A	A	A	P	A	P	A	A	A	A	A	18
SK0259	?	A	A	A	A	A	A	A	A	P	A	A	A	A	A	9
SK1860	L	A	A	A	A	A	P	A	P	A	A	A	A	A	A	18

Innominates

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	Z 12	% Complete
SK1122	R	A	A	A	A	A	A	A	A	P	A	A	A	A	P?	A	17
SK1123	R	A	A	A	A	P	A	A	A	P	A	A	A	A	P?	A	25
SK1124	L	A	A	A	A	P?	A	P?	A	P	A	A	A	A	P	A	33
SK1125	L	A	A	A	A	P	A	A	A	P	A	A	A	A	P	A	25
SK1126	L	A	A	A	P?	P	A	P	A	P	A	A	A	A	P	A	42
SK1127	R	A	A	A	A	A	A	P?	A	P	A	A	A	A	A	A	17
SK1128	R	A	A	A	A	P	A	P?	A	P	A	A	A	A	P	A	33
SK1129	L	A	A	A	A	P	A	A	A	P	A	A	A	A	A	A	17
SK1130	L	A	A	A	A	A	A	A	A	P	A	A	A	A	P?	A	17
SK1131	R	A	A	A	A	P	A	P	A	P	A	A	A	A	P	A	33
SK1132	R	A	A	A	A	P	A	P?	A	P	A	A	A	A	P	A	33
SK1133	L	A	A	A	A	P?	A	P?	A	P	A	A	A	A	P?	A	25
SK1134	L	A	A	A	A	P	A	P	A	P	A	A	A	A	P?	A	33
SK1135	L	A	A	A	P	P	A	P	A	P	A	A	A	A	P	A	42
SK1136	L	A	A	A	P	P	P	P	P	P	P	A	A	P	P	P	83
SK1137	R	A	A	A	P	P	P?	P	P	P	P	A	A	P	A	A	67
SK1138	L	A	A	A	P	P	P	P	P	P	P	A	A	P	A	A	67
SK1139	L	A	A	A	P	P	P	P	P	P	P	A	A	P	P	P	83
SK1140	L	A	A	A	P	P	P	P	P	P	P	A	A	P	P	P	83

SK1141	R	A	A	A	P	P	P	P	P	P	P	A	A	P	P	A	75
SK1142	R	A	A	A	P	P	P?	P	P	P	P	A	A	P	P?	A	67
SK1143	L	A	A	A	P	P	P?	P	P	P	P	A	A	P	P	A	75
SK1144	L	A	A	A	P	P	P	P	P	P	P	A	A	P	P	P	83
SK1145	R	A	A	A	P	P	P?	P	P	P	P	A	A	P	A	A	67
SK1146	L	A	A	A	P	P	A	P	P	P	P	A	A	P	A	A	58
SK1147	R	A	P	A	P	P	P	P	P	P	P	A	A	P	P	P	83
SK1148	R	A	A	A	P	P	P	P	P	P	P	A	A	P	A	A	67
SK1149	R	A	A	A	P	P	P	P	P	P	P	A	A	P	P	A	75
SK1150	R	A	A	A	P	P	P	P	P	P	P	A	A	P	P	A	75
SK1151	R	A	A	A	P	P	A	P	P	A	P?	A	A	P	A	P	58
SK1152	R	A	A	A	A	P	A	P	A	P	A	A	A	A	P?	A	33
SK1153	R	A	A	A	A	P	A	P?	A	P	A	A	A	A	A	A	25
SK1154	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	P	50
SK1155	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK1156	?	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	8
SK1157	?	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	8
SK1158	?	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	8
SK1159	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1160	L	A	A	A	P	A	A	A	P	A	P	A	A	P	A	A	33
SK1161	L	A	P	A	P	A	P	P	P	A	P	A	A	P	A	P	58
SK1162	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1163	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1164	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1165	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1166	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1167	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1168	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1169	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1170	L	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1171	L	A	A	A	A	P	A	A	A	P?	A	A	A	A	A	A	17
SK1172	L	A	A	A	P	A	A	P	P	A	A	A	A	P	A	A	33
SK1173	L	A	A	A	A	A	A	A	P	A	P	A	A	P	A	A	25
SK1174	R	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17
SK1175	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1176	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1177	R	A	A	A	P	A	P?	P	P	A	P	A	A	P	A	P	58
SK1178	R	A	P	A	P	A	A	P	P	A	P	A	A	P	A	P	50
SK1179	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1180	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1181	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1182	R	A	A	A	P?	A	A	P	P	A	P	A	A	P	A	A	42
SK1183	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	A	42
SK1184	R	A	A	A	P	A	A	P	P	A	P	A	A	P	A	P	50
SK1185	R	A	A	A	P	A	A	A	P	A	A	A	A	P	A	A	25
SK1186	L	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17
SK1187	L	A	A	A	A	A	A	A	A	A	A	P	P	A	A	A	17
SK1188	L	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17
SK1189	L	A	A	A	A	P	A	A	A	P?	A	A	A	A	A	A	17
SK1190	R	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	8
SK1191	L	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	8
SK1192	R	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	8
SK1193	L	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17
SK1194	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1195	R	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	8
SK1196	R	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	8
SK1197	?	A	A	A	P	A	A	P	A	A	A	A	A	A	A	A	17
SK1198	L	A	A	A	A	P	A	A	A	A	A	A	A	A	A	A	8
SK1199	L	A	A	A	A	A	A	A	A	A	A	P	A	A	A	A	8
SK1200	L?	A	A	A	A	P?	P	A	A	A	A	A	A	A	A	A	17
SK1201	R?	A	A	A	P	A	P?	A	A	A	A	A	A	A	A	A	17

SK1202	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1203	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1204	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1205	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1206	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1207	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1208	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1209	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1210	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1211	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1212	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1213	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1214	?	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	8
SK1215	?	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	8
SK1216	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	P	17
SK1217	L?	A	A	A	P	A	P?	A	A	A	A	A	A	A	A	A	17
SK1218	?	A	A	A	P?	P?	A	A	A	A	A	A	A	A	A	A	8
SK1219	?	A	A	A	P?	P?	A	A	A	A	A	A	A	A	A	A	8
SK1220	R?	A	A	A	P	A	P?	A	A	A	A	A	A	A	A	A	17
SK1221	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK1222	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK1223	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK1224	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK1225	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK1226	R	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17
SK1227	L?	A	A	A	A	A	A	A	A	P	A	A	A	A	P?	A	17
SK1228	?	A	A	A	A	A	A	A	A	P?	A	A	A	P?	P?	A	17
SK1229	L	A	A	A	A	A	P	A	A	A	A	P	A	A	A	A	17
SK1230	L	A	A	A	A	A	A	A	A	A	A	P	A	A	A	A	8
SK1231	L	A	A	A	A	A	A	A	A	A	A	P	A	A	A	A	8
SK1232	L	A	A	A	A	A	A	A	A	A	A	P	A	A	A	A	8
SK1233	R	A	A	A	A	A	A	A	A	A	A	P	P	A	A	A	17
SK1234	R	A	A	A	A	A	P?	A	A	A	A	P	P?	A	A	A	17
SK1235	R	A	A	A	A	A	A	A	A	A	A	A	P	A	P	A	17
SK1236	R	A	A	A	A	A	A	A	A	A	A	A	P	A	A	A	8
SK1237	R	A	A	A	A	A	A	A	A	A	A	P?	P	A	A	A	17
SK1238	R?	A	A	A	A	A	A	A	A	A	A	A	P	A	A	A	8
SK1239	L?	A	A	A	A	A	A	A	A	A	A	A	A	A	P	A	8
SK1240	L	A	A	A	A	P?	A	P	A	P	A	A	A	A	P	A	33
SK1241	R?	A	A	A	A	P?	A	P	A	P	A	A	A	A	P	A	33
SK1242	L?	A	A	A	A	A	A	A	A	A	A	A	A	P?	A	A	8
SK2659	?	A	A	A	A	A	A	A	A	A	A	A	A	P	A	A	8
SK2660	?	A	A	A	A	P	P	A	A	A	A	A	A	A	A	A	17
SK2661	R?	A	A	A	A	P	P	A	A	A	A	A	A	A	A	A	17
SK2662	?	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	8
SK2663	?	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	8
SK2664	?	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17
SK2665	?	A	A	A	A	A	P	A	A	A	A	A	A	A	A	A	8
SK2666	?	A	A	A	P	A	A	A	P	A	A	A	A	A	A	A	17

Patellae

# Present	Side	PM F	PM M	PM S	% Complete
SK1361	R	A	A	P	76-100
SK1992	L	A	A	A	76-100
SK1993	R	A	A	A	76-100
SK1994	L	A	A	A	76-100
SK1995	R	A	A	A	76-100
SK1996	R	A	A	A	76-100
SK1997	R	A	A	A	76-100
SK1998	L	A	A	A	76-100
SK1999	R	A	A	A	76-100
SK2000	L	A	A	A	76-100
SK2001	R	A	A	A	76-100
SK2002	L	A	A	A	76-100
SK2003	L	A	A	A	51-75
SK2004	R	A	A	A	51-75
SK2005	R	A	A	A	76-100
SK2006	R	A	A	A	76-100
SK2007	L	A	A	A	51-75
SK2008	L	A	A	A	51-75
SK2009	R	A	A	A	51-75
SK2010	R	A	A	A	51-75
SK2011	R?	A	A	A	0-25
SK2012	L	A	A	A	76-100
SK2013	L	A	A	A	76-100
SK2014	L	A	A	A	51-75
SK2015	L?	A	A	A	0-25
SK2667	?	A	A	A	25-50

Phalanges (Hand)

# Present	Type	Z 1	Z 2	Z 3	% Complete
SK0919	?	A	P	A	33
SK0922	Proximal	P	P	P	100
SK0925	Proximal	P	P	P	100
SK0930	Intermediate	P	P	P	100
SK0965	Proximal	A	P	P	67
SK0977	Proximal	A	P	P	67
SK0978	Proximal	A	P	P	67
SK0979	Proximal	A	P	P	67
SK0980	Proximal	A	P	P	67
SK0981	Proximal?	A	A	P	33
SK1045	Distal	P	A	P	67
SK1046	Proximal?	A	P	P	67
SK1047	Proximal?	A	P	P	67
SK1048	Intermediate	P	P	P	100
SK1049	Proximal?	A	P	P	67
SK1051	Intermediate	A	P	P	67
SK1052	Proximal	A	A	P	33
SK1053	Proximal	A	A	P	33
SK1054	Proximal	A	A	P	33
SK1055	Proximal	A	A	P	33
SK1056	Proximal	A	A	P	33
SK1057	Proximal	P	P	P	100
SK1362	Proximal	P	A	P	67
SK1363	Intermediate	P	A	P	67
SK1364	Proximal	A	A	P	33
SK1365	Proximal	A	P	P	67
SK1366	Proximal	A	P	P	67
SK1367	Proximal?	A	A	P	33
SK1368	Proximal	A	A	P	33
SK1369	Proximal	A	A	P	33
SK1370	Proximal	A	A	P	33
SK1371	Proximal	A	A	P	33
SK1372	Intermediate	A	A	P	33
SK1373	Proximal	A	P	P	67
SK1374	Proximal	A	P	P	67
SK1375	Intermediate?	A	P	P	67
SK1385	Proximal	A	A	P	33
SK1386	Distal	A	A	P	33
SK1387	Proximal	A	P	P	67
SK1388	Proximal	A	P	P	67
SK1389	Proximal	A	A	P	33
SK1391	Proximal	A	P	P	67
SK1393	Proximal	A	A	P	33
SK1394	Proximal	A	A	P	33
SK1395	Intermediate?	A	P	P	67

SK1396	Proximal	A	A	P	33
SK1397	Proximal	A	P	P	67
SK1398	Proximal	A	A	P	33
SK1399	Proximal	A	A	P	33
SK1400	Proximal	A	A	P	33
SK1401	Proximal	P	P	P	100
SK1402	Proximal	P	P	P	100
SK1403	Proximal	A	P	P	67
SK1404	Proximal	P	A	P	67
SK1405	Proximal	P	P	P	100
SK1406	Proximal	P	P	P	100
SK1407	Proximal	P	P	P	100
SK1408	Intermediate	P	P	P	100
SK1409	Proximal	P	P	P	100
SK1410	Proximal	A	P	P	67
SK1411	Proximal	P	P	P	100
SK1412	Proximal	A	P	P	67
SK1413	Proximal?	P	P	P	100
SK1414	Proximal	P	P	P	100
SK1415	Proximal	P	P	P	100
SK1416	Proximal	A	P	P	67
SK1417	Proximal	A	P	P	67
SK1418	Proximal	A	P	P	67
SK1419	Proximal	A	P	P	67
SK1420	Proximal	P	A	P	67
SK1421	Intermediate?	P	P	P	100
SK1422	Intermediate?	A	P	P	67
SK1423	Intermediate	P	P	P	100
SK1424	Proximal?	A	A	P	33
SK1425	Distal	P	P	P	100
SK1426	Intermediate	P	P	P	100
SK1427	Intermediate	P	P	P	100
SK1428	Intermediate	P	A	P	67
SK1429	Intermediate	P	P	P	100
SK1430	Intermediate	P	P	P	100
SK1431	Proximal	P	P	P	100
SK1432	Proximal	P	P	P	100
SK1433	Intermediate	P	P	P	100
SK1434	Intermediate	P	P	P	100
SK1435	Intermediate	P	P	P	100
SK1436	Intermediate	P	P	P	100
SK1437	Intermediate	p	p	p	100
SK1438	Proximal?	A	P	P	67
SK1439	Distal	P	P	P	100
SK1440	Proximal	P	P	P	100
SK1441	Intermediate	A	P	P	67
SK1442	Intermediate	P	P	P	100
SK1443	Intermediate	A	P	P	67

SK1444	Intermediate	P	P	P	100
SK1445	Proximal?	A	P	P	67
SK1446	Intermediate	P	A	P	67
SK1447	Intermediate	P	P	P	100
SK1448	Intermediate	P	P	P	100
SK1449	Distal	P	P	P	100
SK1450	Distal	P	P	P	100
SK1451	Proximal	P	P	P	100
SK1452	Proximal	P	P	P	100
SK1453	Proximal	A	P	P	67
SK1454	Distal	P	P	P	100
SK1455	Proximal	P	P	P	100
SK1457	Proximal	P	P	P	100
SK1458	Proximal	P	P	P	100
SK1459	Intermediate	P	P	P	100
SK1460	Proximal	P	P	P	100
SK1461	Proximal	P	P	P	100
SK1462	Distal	P	P	P	100
SK1463	Intermediate	P	P	P	100
SK1464	Proximal	P	P	P	100
SK1465	Proximal	A	P	P	67
SK1466	Proximal	P	P	P	100
SK1467	Intermediate	P	P	P	100
SK1468	Proximal	P	P	P	100
SK1469	Proximal	P	P	P	100
SK1470	Distal	P	P	P	100
SK1471	Intermediate	P	P	P	100
SK1472	Intermediate	P	P	P	100
SK1473	Proximal	A	P	P	67
SK1474	Intermediate	P	P	P	100
SK1475	Proximal	A	P	P	67
SK1476	Intermediate	A	P	P	67
SK1477	Distal	P	P	P	100
SK1478	Intermediate	A	P	P	67
SK1479	Intermediate	P	P	P	100
SK1480	Intermediate	A	P	P	67
SK1481	Proximal	P	P	P	100
SK1482	Intermediate	P	P	P	100
SK1483	Intermediate	P	P	P	100
SK1484	Intermediate	P	P	P	100
SK1485	Intermediate	P	P	P	100
SK1486	Proximal?	A	P	P	67
SK1487	Intermediate	P	P	P	100
SK1488	Intermediate	P	P	P	100
SK1489	Distal	P	P	P	100
SK1490	Distal	P	P	P	100
SK1491	Distal	P	P	P	100
SK1492	Distal	P	P	P	100

SK1493	Intermediate	A	P	P	67
SK1494	Intermediate	P	P	P	100
SK1495	Distal	A	P	P	67
SK1496	Distal	P	P	P	100
SK1497	Distal	P	P	P	100
SK1498	Intermediate	P	P	P	100
SK1499	Distal	P	P	P	100
SK1500	Distal	P	A	P	67
SK1501	Intermediate	P	P	P	100
SK1502	Proximal	P	P	P	100
SK1503	Proximal?	A	P	P	67
SK1504	?	A	P	P	67
SK1505	Intermediate?	P	P	P	100
SK1506	Proximal?	A	P	P	67
SK1507	Proximal	A	P	P	67
SK1508	Proximal	A	P	P	67
SK1509	Intermediate?	A	P?	P	67
SK1510	Proximal?	A	P	P	67
SK1511	Intermediate?	A	P	P	67
SK1512	Intermediate	P	P	P	100
SK1513	Proximal	A	A	P	33
SK1514	Proximal?	A	P	P	67
SK1515	Intermediate	P	P	P	100
SK1516	Distal	P	P	P	100
SK1517	Intermediate?	A	P	P	67
SK1518	Proximal?	A	P	P	67
SK1519	Proximal	P	P	P	100
SK1520	Proximal	A	P	P	67
SK1521	?	A	A	P	33
SK1522	Intermediate	A	P	P	67
SK1523	Distal	P	P	P	100
SK1524	Intermediate	P	A	P	67
SK1525	Proximal	A	P	P	67
SK1526	Proximal	A	A	P	33
SK1527	Proximal	A	P	P	67
SK1528	Intermediate	A	P	P	67
SK1529	Intermediate?	A	P	P	67
SK1530	Intermediate	A	A	P	33
SK1531	Intermediate	P	P	P	100
SK1532	?	P	A	P	67
SK1533	Intermediate	P	P	P	100
SK1534	?	A	P	P	67
SK1535	Distal	P	A	P	67
SK1537	Distal	P	P	P	100
SK1543	Proximal	P	P	P	100
SK1544	Proximal	P	P	P	100
SK1545	Proximal	A	P	P	67
SK1546	Proximal	P	P	P	100

SK1575	Proximal	P	P	P	100
SK1589	Proximal	P	A	A	33
SK1666	Intermediate	P	P	P	100
SK1667	Proximal	A	P	P	67
SK1668	?	A	A	P	33
SK1669	Proximal	A	P	P	67
SK1670	Intermediate	P	A	P	67
SK1672	?	A	P	P	67
SK1673	Proximal	A	P	P	67
SK1674	Intermediate	P	P	P	100
SK1675	Distal	P	P	P	100
SK1677	Intermediate	A	P	P	67
SK1721	?	A	P	P	67
SK1724	?	A	A	P	33
SK1725	?	A	A	P	33
SK1730	Intermediate?	A	P	P	67
SK1735	Proximal	P	A	A	33
SK1736	Intermediate?	P	A	A	33
SK1737	?	A	A	P	33
SK1738	?	A	A	P	33
SK1741	?	A	P	P	67
SK1745	?	A	A	P	33
SK1748	?	A	A	P	33
SK1751	Proximal	P	A	A	33
SK1752	?	A	A	P	33
SK1756	Proximal	P	A	A	33
SK1885	?	A	A	P	33
SK1966	Intermediate	P	A	P	67
SK1967	?	A	P	P	67
SK2656	?	A	A	P	33
SK1744	?	A	P	P	67
SK1771	Proximal	P	A	A	33
SK1898	Proximal	P	A	A	33
SK2633	Proximal	P	A	A	33

Radii

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z J	% Complete
SK0986	R?	A	A	A	A	A	A	A	A	P	P	P	A	A	A	27
SK0987	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0988	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0989	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0990	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0991	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0992	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0993	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0994	R?	A	A	A	A	A	A	A	P	P	P	P	A	A	A	36
SK0995	L	A	A	A	P	P	A	A	P	P	P	P	P	P	A	73
SK0996	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0997	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0998	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK0999	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1000	L?	A	A	A	A	A	A	A	P	P	P	P	A	A	A	36
SK1001	L	A	A	A	A	A	P	P	P	P	P	P	P	P	A	73
SK1002	L	A	A	A	A	A	A	A	P	P	P	P	A	A	A	36
SK1003	L	A	A	A	P	P	A	A	P	P	P	P	P	P	A	73
SK1004	L	A	A	A	A	A	P	P	A	A	A	A	P	P	P	45
SK1005	L	A	A	A	P	P	A	A	P	P	P	P	P	P	A	73
SK1006	R	A	A	A	A	A	P	P	A	A	A	A	P?	P?	P	36
SK1007	L	A	A	A	A	A	P	P	A	A	A	A	A	A	P	27
SK1008	L	A	A	A	P	P	A	A	P	P	P	P	P	P	A	73
SK1009	L	A	A	A	A	A	P	P	A	A	A	A	P?	P?	P	36
SK1010	R?	A	A	A	A	A	A	A	P	A	A	A	A	A	A	9
SK1011	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1012	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1013	L	A	A	A	A	A	P	P	P	P	P	P	P?	P?	A	64
SK1014	L	A	A	A	P	P	P	P	P	P	P	P	P	P	P?	100
SK1015	L	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1016	R	A	A	A	P	P	P	P	P	P	P	P	P	P	A	91
SK1017	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1018	R	A	A	A	A	A	A	A	A	A	A	P?	P	P	A	27
SK1019	R	A	A	A	P	P	A	A	P	P	P	P	P	P	A	73
SK1020	?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK1021	?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK1022	?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK1023	?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK1024	R	A	A	A	A	A	A	A	P	P	P	P?	A	A	A	36
SK1025	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1026	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1027	R	A	A	A	P	P	A	A	P	P	P	P	P	P	A	73
SK1028	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1029	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1030	R	A	A	A	A	A	A	A	A	P	P	P	P	P	A	45
SK1031	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1032	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1033	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1034	R	A	A	A	A	A	A	A	P	P	P	A	A	A	A	27
SK1035	R	A	A	A	A	A	A	A	P	P	P	P	P?	P?	A	45
SK1036	R?	A	A	A	A	A	A	A	A	P	P	P	P?	P?	A	36
SK1037	R	A	A	A	A	A	A	A	P	P	P	P	P	P	A	55
SK1038	R	A	A	A	A	A	A	A	P	P	P	A	A	A	A	27
SK1039	R	A	A	A	A	A	A	A	P	P	P	P	A	A	A	36
SK1040	R?	A	A	A	A	A	A	A	P	P	P	P	A	A	A	36
SK1041	R?	A	A	A	A	A	A	A	P?	P	P	P?	A	A	A	27

SK1042	?	A	A	A	A	A	A	A	A	P	P	P?	A	A	A	27
SK1043	R?	A	A	A	A	A	A	A	P	P?	P?	A	A	A	A	18
SK1044	R?	A	A	A	A	A	A	A	P?	P	P	P	A	A	A	36
SK2640	?	A	A	A	P	P	A	A	A	A	A	A	A	A	A	18
SK2641	R	A	A	A	A	A	A	P	A	A	A	A	A	A	A	9

Ribs

# Present	Number	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	% Complete
SK0316	?	R	A	A	A	P	P	A	67
SK0321	11?	L?	A	A	A	A	P	P	67
SK0322	?	L	P	A	A	A	P	P	67
SK0323	?	R	A	A	A	A	P	P	67
SK0324	?	L	A	A	P	P	P	P	100
SK0325	?	R	A	A	A	P	P	P	100
SK0326	?	R	A	A	A	P	P	P	100
SK0327	?	R	A	A	P	A	P	P	67
SK0328	?	L	A	A	A	P	P	A	67
SK0329	2?	R	A	A	P	P	P	P	100
SK0330	?	L	A	A	A	P	P	A	67
SK0331	?	R	A	A	A	P	P	P	100
SK0332	?	R	A	A	A	P	P	P	100
SK0333	?	L	A	A	A	A	P	P	67
SK0334	?	L	A	A	A	A	A	P	33
SK0335	?	L	A	A	P	P	P	A	67
SK0336	?	L	A	A	P	P	P	A	67
SK0337	?	R	A	A	A	A	A	P	33
SK0338	?	L	A	A	P	P	P	A	67
SK0339	?	R	A	A	P	A	P	P	67
SK0340	?	?	A	A	P	A	P	A	33
SK0341	?	R	A	A	A	A	A	P	33
SK0342	?	?	A	A	A	A	A	P	33
SK0343	?	R	A	A	A	P	P	A	67
SK0344	?	?	A	A	A	A	A	P	33
SK0345	?	L	A	A	P	P	P	A	67
SK0346	?	?	A	A	A	A	A	P	33
SK0347	?	R?	A	A	A	A	A	P	33
SK0348	?	?	A	A	A	A	A	P	33
SK0349	?	L	A	A	A	P	P	P	100
SK0350	1	R	A	A	A	P	P	P	100
SK0351	?	L	A	A	A	A	P	P	67
SK0352	?	L	A	A	A	P	P	P	100
SK0353	?	L	A	A	A	P	P	P	100
SK0354	?	L	A	A	A	P	P	P	100

SK0355	?	?	A	A	A	A	P	A	33
SK0356	?	R	A	A	A	A	P	P	67
SK0357	?	L	A	A	A	A	P	A	33
SK0358	?	?	A	A	A	A	A	P	33
SK0359	?	R	A	A	A	P	P	A	67
SK0360	?	L	A	A	A	P	P	P	100
SK0361	?	L	A	A	A	A	P	P	67
SK0362	?	?	A	A	A	A	A	P	33
SK0363	?	L	A	A	A	A	P	A	33
SK0364	?	L	A	A	A	A	P	P	67
SK0365	1	R	A	A	A	A	P	P	67
SK0366	?	L	A	A	A	A	P	A	33
SK0367	?	L	A	A	A	P	P	A	67
SK0368	?	?	A	A	A	A	A	P	33
SK0369	?	L	A	A	A	P	P	A	67
SK0370	?	L	A	A	P	P	P	A	67
SK0371	?	L	A	A	P	A	P	P	67
SK0372	?	R	A	A	A	P	A	A	33
SK0373	?	L	A	A	A	P	P	A	67
SK0374	?	L	A	A	A	A	P	A	33
SK0375	1	R	A	A	A	P	P	P	100
SK0376	?	L	A	A	A	A	P	A	33
SK0377	?	?	A	A	A	A	A	P	33
SK0378	?	?	A	A	A	A	A	P	33
SK0379	?	L?	A	A	A	A	P	A	33
SK0380	?	R?	A	A	A	A	A	P	33
SK0381	?	?	A	A	A	A	A	P	33
SK0382	?	L	A	A	A	P	A	A	33
SK0383	?	L?	A	A	A	P	P	A	67
SK0384	?	L	A	A	A	A	P?	P?	33
SK0385	?	?	A	A	A	A	A	P	33
SK0386	?	L	A	A	A	A	P	P	67
SK0387	2?	L	A	A	A	P	P	P?	100
SK0388	?	R?	A	A	A	A	A	P	33
SK0389	?	?	A	A	A	A	P	A	33
SK0390	?	L	A	A	A	P	P	P	100
SK0391	?	?	A	A	A	A	A	P	33
SK0392	?	R	A	A	A	P	P	A	67
SK0393	?	R?	A	A	A	A	P	A	33
SK0394	?	L?	A	A	A	P	A	A	33
SK0395	?	L?	A	A	A	A	P	A	33
SK0396	?	R?	A	A	A	P	A	A	33
SK0397	?	R	A	A	A	P	P	P	100
SK0398	?	R?	A	A	A	A	P	A	33
SK0399	?	?	A	A	A	A	A	P	33
SK0400	?	R?	A	A	A	P	A	A	33

SK0401	?	?	A	A	A	A	A	P	33
SK0402	?	R	A	A	A	P	P	A	67
SK0403	?	R?	A	A	A	A	P	A	33
SK0404	?	?	A	A	A	A	A	P	33
SK0405	?	R?	A	A	A	A	P	A	33
SK0406	?	L	A	A	A	P	P	A	67
SK0407	?	L?	A	A	A	P	P	A	67
SK0408	?	R?	A	A	A	A	P?	P	67
SK0409	2?	L?	A	A	A	P?	P	A	67
SK0410	5?, 6?, or 7?	L	A	A	A	P	P	P	100
SK0411	?	L?	A	A	A	A	P?	P	67
SK0412	?	?	A	A	A	A	A	P	33
SK0413	?	L	A	A	A	P	A	A	33
SK0414	?	?	A	A	A	P?	A	A	33
SK0415	?	R	A	A	A	P	P	P	100
SK0416	2	R	A	A	A	A	P	P	67
SK0417	2	L	A	A	A	A	P	P	67
Sk0418	?	L	A	A	A	P	P	P	100
SK0419	?	R?	A	A	A	A	A	P	33
SK0420	?	R	A	A	A	P	P	A	67
SK0421	?	R?	A	A	A	A	A	P	33
SK0422	?	L	A	A	A	A	P	P	67
SK0423	?	L	A	A	A	A	P	P	67
SK0424	?	?	A	A	A	A	P	A	33
SK0425	?	R?	A	A	A	A	P?	P	67
SK0426	?	?	A	A	A	A	A	P	33
SK0427	?	L?	A	A	A	A	P?	P?	33
SK0428	?	?	A	A	A	A	A	P	33
SK0429	?	R?	A	A	A	A	P?	P	67
SK0430	?	?	A	A	A	A	A	P	33
SK0431	?	?	A	A	A	A	A	P	33
SK0432	?	?	A	A	A	A	A	P	33
SK0433	?	?	A	A	A	A	A	P	33
SK0434	?	?	A	A	A	A	P?	P?	33
SK0435	2?	?	A	A	A	A	P	P	67
SK0436	?	?	A	A	A	A	P?	P?	33
SK0437	?	?	A	A	A	A	P?	P?	33
SK0438	?	R?	A	A	A	A	A	P	33
SK0439	?	R	A	A	A	A	P?	P	67
SK0440	2?	R	A	A	A	A	p	p	67
SK0441	?	?	A	A	A	A	P?	P	67
SK0442	?	L?	A	A	A	A	A	P	33
SK0443	?	?	A	A	A	A	A	P	33
SK0444	?	R?	A	A	A	A	P	A	33
SK0445	?	?	A	A	A	A	P	A	33
SK0446	?	?	A	A	A	A	A	P	33

SK0447	?	R?	A	A	A	A	P	A	33
SK0448	?	?	A	A	A	A	A	P	33
SK0449	?	?	A	A	A	A	A	P	33
SK0450	1	L	A	A	A	A	P	P	67
SK0451	?	R?	A	A	A	A	A	P	33
SK0452	?	?	A	A	A	A	A	P	33
SK0453	?	?	A	A	A	A	A	P	33
SK0454	?	?	A	A	A	A	A	P	33
SK0455	?	?	A	A	A	A	A	P	33
SK0456	?	?	A	A	A	A	A	P	33
SK0457	?	?	A	A	A	A	A	P	33
SK0458	?	?	A	A	A	A	A	P	33
SK0459	?	?	A	A	A	A	A	P	33
SK0460	?	?	A	A	A	A	A	P	33
SK0461	?	?	A	A	A	A	A	P	33
SK0462	?	?	A	A	A	A	A	P	33
SK0463	?	?	A	A	A	A	A	P	33
SK0464	?	?	A	A	A	A	A	P	33
SK0465	?	?	A	A	A	A	A	P	33
SK0466	?	?	A	A	A	A	A	P	33
SK0467	?	?	A	A	A	A	A	P	33
SK0468	?	?	A	A	A	A	A	P?	33
SK0469	?	?	A	A	A	A	A	P	33
SK0470	?	?	A	A	A	A	A	P?	33
SK0471	?	?	A	A	A	P?	A	A	33
SK0472	2?	L?	A	A	A	P?	P?	A	33
SK0473	2?	L?	A	A	A	A	P?	A	33
SK0474	?	?	A	A	A	A	P	A	33
SK0475	?	?	A	A	A	A	A	P	33
SK0476	?	?	A	A	A	A	P	A	33
SK0477	?	?	A	A	A	P	A	A	33
SK0478	?	L?	A	A	A	P	A	A	33
SK0479	?	?	A	A	A	A	A	P	33
SK0480	?	?	A	A	A	A	A	P	33
SK0481	?	?	A	A	A	A	A	P	33
SK0482	?	?	A	A	A	A	A	P?	33
SK0483	?	?	A	A	A	A	A	P	33
SK0484	?	?	A	A	A	A	P?	P?	33
SK0485	?	?	A	A	A	A	A	P	33
SK0486	?	?	A	A	A	A	P?	P	67
SK0487	?	?	A	A	A	A	A	P	33
SK0488	?	?	A	A	A	A	A	P	33
SK0489	?	?	A	A	A	A	A	P	33
SK0490	?	?	A	A	A	A	A	P	33
SK0491	1	L	A	A	A	A	P	P	67
SK0492	?	?	A	A	A	A	P?	P?	33

SK0493	?	?	A	A	A	A	P?	P	67
SK0494	?	R?	A	A	A	A	P	A	33
SK0495	?	?	A	A	A	A	A	P	33
SK0496	?	?	A	A	A	A	A	P	33
SK0497	?	?	A	A	A	A	A	P	33
SK0498	?	?	A	A	A	A	P?	P?	33
SK0499	1	R	A	A	A	A	P	P	67
SK0500	?	?	A	A	A	A	P?	P?	33
SK0501	?	R?	A	A	A	A	P?	P?	33
SK0502	?	?	A	A	A	A	A	P	33
SK0503	?	?	A	A	A	A	A	P	33
SK0504	?	L?	A	A	A	A	A	P	33
SK0505	?	?	A	A	A	A	A	P	33
SK0506	?	L?	A	A	A	A	A	P	33
SK0507	1	L	A	A	A	A	P	P	67
SK0508	?	?	A	A	A	A	A	P	33
SK0509	?	?	A	A	A	A	A	P	33
SK0510	?	L?	A	A	A	P?	P	A	67
SK0511	?	?	A	A	A	A	A	P	33
SK0512	?	?	A	A	A	A	A	P	33
SK0513	?	?	A	A	A	A	A	P	33
SK0514	?	?	A	A	A	A	A	P	33
SK0515	?	?	A	A	A	A	A	P	33
SK0516	?	?	A	A	A	A	A	P	33
SK0517	?	?	A	A	A	A	A	P	33
SK0518	?	?	A	A	A	A	A	P	33
SK0519	1	L	A	A	A	A	P	P	67
SK0520	?	?	A	A	A	A	A	P	33
SK0521	?	?	A	A	A	A	A	P	33
SK0522	?	?	A	A	A	A	A	P	33
SK0523	1	R?	A	A	A	A	P	A	33
SK0524	?	?	A	A	A	A	P?	P?	33
SK0525	?	?	A	A	A	A	A	P	33
SK0526	1	R	A	A	A	P	P	A	67
SK0527	?	?	A	A	A	A	A	P	33
SK0528	?	?	A	A	A	A	A	P?	33
SK0529	?	?	A	A	A	A	A	P	33
SK0530	?	?	A	A	A	A	A	P?	33
SK0531	?	?	A	A	A	A	A	P	33
SK0532	?	?	A	A	A	A	A	P	33
SK0533	?	?	A	A	A	A	A	P?	33
SK0534	?	?	A	A	A	A	A	P	33
SK0535	?	?	A	A	A	A	A	P	33
SK0536	?	?	A	A	A	A	A	P	33
SK0537	?	?	A	A	A	A	A	P	33
SK0538	?	?	A	A	A	A	A	P	33

SK0539	?	?	A	A	A	A	A	P	33
SK0540	?	?	A	A	A	A	A	P	33
SK0541	?	?	A	A	A	A	P	A	33
SK0542	?	?	A	A	A	A	A	P	33
SK0543	?	?	A	A	A	A	P?	P?	33
SK0544	?	?	A	A	A	A	P	A	33
SK0545	?	?	A	A	A	A	P	A	33
SK0546	?	?	A	A	A	A	P	A	33
SK0547	?	?	A	A	A	A	P	A	33
SK0548	?	?	A	A	A	A	P	A	33
SK0549	?	L?	A	A	A	P?	P?	A	33
SK0550	?	?	A	A	A	A	A	P	33
SK0551	?	?	A	A	A	A	P	A	33
SK0552	?	?	A	A	A	A	P?	P	67
SK0553	1	L	A	A	A	P	P	A	67
SK0554	?	L	A	A	A	P	P	A	67
SK0555	?	L?	A	A	A	A	A	P	33
SK0556	?	?	A	A	A	A	P?	P	67
SK0557	?	?	A	A	A	A	A	P	33
SK0558	?	L?	A	A	A	P	P	A	67
SK0559	?	?	A	A	A	A	A	P	33
SK0560	?	?	A	A	A	A	A	P	33
SK0561	?	?	A	A	A	A	P	A	33
SK0562	?	L	A	A	A	A	P	A	33
SK0563	1	L	A	A	A	P	P	A	67
SK0564	?	R	A	A	A	A	P	A	33
SK0565	2?	R	A	A	A	A	P	A	33
SK0566	?	?	A	A	A	A	A	P	33
SK0567	?	?	A	A	A	A	P	P?	67
SK0568	?	?	A	A	A	A	A	P	33
SK0569	?	?	A	A	A	A	A	P	33
SK0570	?	?	A	A	A	A	A	P	33
SK0571	?	?	A	A	A	A	A	P	33
SK0572	?	?	A	A	A	A	A	P	33
SK0573	?	?	A	A	A	A	P	A	33
SK0574	2?	L?	A	A	A	A	P?	A	33
SK0575	1	L	A	A	A	P	P	P	100
SK0576	?	?	A	A	A	A	A	P	33
SK0577	?	?	A	A	A	A	P?	P?	33
SK0578	?	?	A	A	A	A	A	P	33
SK0579	?	?	A	A	A	A	A	P	33
SK0580	?	?	A	A	A	A	A	P	33
SK0581	?	?	A	A	A	A	P?	P?	33
SK0582	?	?	A	A	A	A	P	A	33
SK0583	?	?	A	A	A	A	A	P	33
SK0584	?	?	A	A	A	A	P	A	33

SK0585	1?	R?	A	A	A	P	P	A	67
SK0586	?	R?	A	A	A	P	P	A	67
SK0587	?	?	A	A	A	A	A	P	33
SK0588	?	?	A	A	A	A	A	P	33
SK0589	?	?	A	A	A	A	A	P	33
SK0590	?	?	A	A	A	A	A	P	33
SK0591	?	?	A	A	A	A	A	P	33
SK0592	?	?	A	A	A	A	A	P	33
SK0593	?	?	A	A	A	A	P	A	33
SK0594	?	?	A	A	A	A	P?	P?	33
SK0595	?	?	A	A	A	A	A	P	33
SK0596	?	?	A	A	A	A	A	P	33
SK0597	?	?	A	A	A	A	P	A	33
SK0598	?	L	A	A	A	A	P	A	33
SK0599	?	?	A	A	A	A	A	P	33
SK0600	?	?	A	A	A	A	A	P	33
SK0601	?	?	A	A	A	A	A	P	33
SK0602	?	?	A	A	A	A	P?	P?	33
SK0603	?	?	A	A	A	A	A	P	33
SK0604	?	?	A	A	A	A	A	P	33
SK0605	?	?	A	A	A	A	P	A	33
SK0606	?	?	A	A	A	A	P?	P?	33
SK0607	?	?	A	A	A	A	A	P	33
SK0608	?	?	A	A	A	A	A	P	33
SK0609	?	?	A	A	A	A	A	P	33
SK0610	?	?	A	A	A	A	P	A	33
SK0611	?	?	A	A	A	A	A	P	33
SK0612	?	?	A	A	A	A	A	P	33
SK0613	?	?	A	A	A	A	A	P	33
SK0614	?	?	A	A	A	A	A	P	33
SK0615	?	?	A	A	A	A	P	A	33
SK0616	?	?	A	A	A	A	A	P	33
SK0617	2?	R?	A	A	A	A	P	A	33
SK0618	?	?	A	A	A	A	P?	A	33
SK0619	?	?	A	A	A	A	A	P	33
SK0620	?	?	A	A	A	A	P?	A	33
SK0621	?	?	A	A	A	A	A	P	33
SK0622	?	?	A	A	A	A	A	P	33
SK0623	?	?	A	A	A	A	A	P	33
SK0624	?	?	A	A	A	A	A	P	33
SK0625	?	?	A	A	A	P?	P?	A	33
SK0626	?	?	A	A	A	P?	P?	A	33
SK0627	?	L?	A	A	A	A	P	A	33
SK0628	?	?	A	A	A	A	A	P	33
SK0629	?	?	A	A	A	A	P	P?	67
SK0630	?	R?	A	A	A	A	P?	P	67

SK0631	?	?	A	A	A	A	P	A	33
SK0632	?	?	A	A	A	A	A	P	33
SK0633	?	?	A	A	A	A	P	A	33
SK0634	?	?	A	A	A	A	P	A	33
SK0635	?	?	A	A	A	A	A	P	33
SK0636	?	?	A	A	A	A	A	P	33
SK0637	?	?	A	A	A	A	A	P	33
SK0638	?	?	A	A	A	A	A	P	33
SK0639	?	?	A	A	A	A	A	P	33
SK0640	?	?	A	A	A	A	A	P	33
SK0641	2	R	A	A	A	A	P	A	33
SK0642	?	?	A	A	A	A	A	P	33
SK0643	?	?	A	A	A	A	A	P	33
SK0644	?	?	A	A	A	A	P?	P?	33
SK0645	?	?	A	A	A	A	A	P	33
SK0646	?	?	A	A	A	A	P	A	33
SK0647	?	?	A	A	A	A	A	P	33
SK0648	?	R?	A	A	A	A	P	A	33
SK0649	?	L?	A	A	A	P	P	A	67
SK0650	?	?	A	A	A	A	A	P	33
SK0651	?	?	A	A	A	A	A	P	33
SK0652	?	?	A	A	A	A	A	P	33
SK0653	?	?	A	A	A	A	A	P	33
SK0654	?	?	A	A	A	A	A	P	33
SK0655	?	?	A	A	A	A	A	P	33
SK0656	?	?	A	A	A	A	P	A	33
SK0657	?	?	A	A	A	A	A	P	33
SK0658	?	?	A	A	A	A	A	P	33
SK0659	?	?	A	A	A	A	A	P	33
SK0660	?	?	A	A	A	A	A	P	33
SK0661	?	?	A	A	A	A	A	P	33
SK0662	?	?	A	A	A	A	A	P	33
SK0663	?	?	A	A	A	A	P	A	33
SK0664	?	?	A	A	A	A	A	P	33
SK0665	?	?	A	A	A	A	A	P	33
SK0666	?	?	A	A	A	A	A	P	33
SK0667	?	?	A	A	A	A	P?	P?	33
SK0668	?	?	A	A	A	A	A	P	33
SK0669	1?	R?	A	A	A	P?	P	A	67
SK0670	1	?	A	A	A	A	P	P	67
SK0671	1?	L?	A	A	A	P?	P?	A	33
SK0672	?	?	A	A	A	A	A	P	33
SK0673	?	?	A	A	A	A	A	P	33
SK0674	?	?	A	A	A	A	A	P	33
SK0675	?	?	A	A	A	P?	P?	A	33
SK0676	?	?	A	A	A	A	A	P	33

SK0677	?	?	A	A	A	A	A	P	33
SK0678	?	?	A	A	A	A	A	P	33
SK0679	?	?	A	A	A	A	A	P	33
SK0680	?	?	A	A	A	A	A	P	33
SK0681	?	?	A	A	A	A	A	P	33
SK0682	?	?	A	A	A	A	A	P	33
SK0683	?	?	A	A	A	A	A	P	33
SK0684	?	?	A	A	A	A	A	P	33
SK0685	?	?	A	A	A	A	A	P	33
SK0686	?	?	A	A	A	A	A	P	33
SK0687	?	?	A	A	A	A	P?	P?	33
SK0688	?	?	A	A	A	A	A	P	33
SK0689	?	?	A	A	A	A	P?	A	33
SK0690	?	?	A	A	A	A	P?	P?	33
SK0691	?	?	A	A	A	A	A	P	33
SK0692	?	?	A	A	A	A	A	P	33
SK0693	?	?	A	A	A	A	A	P	33
SK0694	?	?	A	A	A	A	A	P	33
SK0695	?	?	A	A	A	A	A	P	33
SK0696	?	?	A	A	A	A	A	P	33
SK0697	?	?	A	A	A	A	A	P	33
SK0698	?	?	A	A	A	A	A	P	33
SK0699	?	?	A	A	A	P?	A	A	33
SK0700	1?	R?	A	A	A	P?	P?	A	33
SK0701	?	?	A	A	A	A	A	P	33
SK0702	?	?	A	A	A	A	A	P	33
SK0703	?	?	A	A	A	A	A	P	33
SK0704	?	?	A	A	A	A	A	P	33
SK0705	?	L	A	A	A	A	A	P	33
SK0706	?	R	A	A	A	A	P	P	67
SK0707	?	L?	A	A	A	A	A	P	33
SK0708	?	L?	A	A	P	A	A	P	33
SK0709	?	L	A	A	A	A	A	P	33
SK0710	2	L	A	A	A	A	P	A	33
SK0711	?	L	A	A	A	A	P	A	33
SK0712	?	L	A	A	A	A	P?	P	67
SK0713	?	L	A	A	A	A	P	A	33
SK0714	?	?	A	A	A	A	A	P	33
SK0715	?	?	A	A	A	A	P	P	67
SK0716	?	L?	A	A	A	A	A	P	33
SK0717	?	R?	A	A	A	A	P	P	67
SK0718	?	?	A	A	A	A	A	P	33
SK0719	?	?	A	A	A	A	A	P	33
SK0720	?	?	A	A	A	A	A	P	33
SK0721	2?	L?	A	A	A	A	P?	P?	33
SK0722	?	R?	A	A	A	A	A	P	33

SK0723	?	?	A	A	A	A	A	P	33
SK0724	?	?	A	A	A	A	P?	P	67
SK0725	?	?	A	A	A	A	P?	P?	33
SK0726	?	?	A	A	A	A	A	P	33
SK0727	?	R?	A	A	A	A	P?	P	67
SK0728	?	R?	A	A	A	A	A	P	33
SK0729	?	L	A	A	A	A	A	P	33
SK0730	?	?	A	A	A	A	A	P	33
SK0731	1?	L?	A	A	A	A	P	A	33
SK0732	?	R	A	A	A	A	P?	P	67
SK0733	2	L	A	A	A	A	P?	P	67
SK0734	?	R	A	A	A	A	P?	P	67
SK0735	?	L?	A	A	A	A	P	A	33
SK0736	?	R?	A	A	A	A	A	P	33
SK0737	?	L	A	A	A	A	P	A	33
SK0738	?	?	A	A	A	A	A	P	33
SK0739	2	L	A	A	A	A	P	P?	67
SK0740	?	?	A	A	A	A	A	P	33
SK0741	?	?	A	A	A	A	A	P	33
SK0742	?	?	A	A	A	A	A	P	33
SK0743	?	L	A	A	A	A	P	P	67
SK0744	?	L	A	A	A	A	P	P	67
SK0745	?	L?	A	A	A	A	A	P	33
SK0746	2?	R	A	A	A	P	P	A	67
SK0747	?	R	A	A	A	P?	P	A	67
SK0748	?	R?	A	A	A	A	P?	P?	33
SK0749	?	L	A	A	A	A	A	P	33
SK0750	?	R?	A	A	A	A	A	P	33
SK0751	?	L	A	A	A	A	A	P	33
SK0752	?	L	A	A	A	A	A	P	33
SK0753	?	L?	A	A	A	A	P?	A	33
SK0754	?	?	A	A	A	A	A	P	33
SK0755	?	?	A	A	A	A	A	P	33
SK0756	?	L?	A	A	A	A	P?	A	33
SK0757	?	?	A	A	A	A	P?	A	33
SK0758	?	R?	A	A	A	P	P	A	67
SK0759	2?	L?	A	A	A	A	P	P	67
SK0760	?	R?	A	A	A	P?	P	A	67
SK0761	?	?	A	A	A	P?	P	A	67
SK0762	2?	R	A	A	A	P?	P	P	100
SK0763	?	R	A	A	A	A	P	P	67
SK0764	?	L	A	A	A	A	P	P	67
SK0765	?	R	A	A	A	P	P	P	100
SK0766	?	L	A	A	A	P	P	P	100
SK0767	?	R	A	A	A	P	P	P	100
SK0768	?	L	A	A	A	P	P	P	100

SK0769	?	L	A	A	A	P	P	A	67
SK0770	?	L	A	A	A	P	P	A	67
SK0771	2?	R	A	A	A	A	P	P	67
SK0772	?	R	A	A	A	P	P	A	67
SK0773	?	R	A	A	A	P	P	A	67
SK0774	?	R?	A	A	A	A	P	P	67
SK0775	?	R	A	A	A	P	P	P	100
SK0776	?	R	A	A	A	P	P	A	67
SK0777	?	L	A	A	A	A	P	A	33
SK0778	?	?	A	A	A	A	A	P	33
SK0779	?	R	A	A	A	A	P	A	33
SK0780	?	R	A	A	A	A	P	P	67
SK0781	?	R	A	A	A	P	P	A	67
SK0782	?	R	A	A	A	P	P	A	67
SK0783	?	R	A	A	A	A	P	P	67
SK0784	2?	R	A	A	A	A	P	P	67
SK0785	?	R	A	A	A	A	P	P	67
SK0786	?	L	A	A	A	P	P	P	100
SK0787	?	R	A	A	A	P	P	A	67
SK0788	?	R	A	A	A	P	P	A	67
SK0789	?	R	A	A	A	A	P	P	67
SK0790	?	R	A	A	A	A	P	P	67
SK0791	?	?	A	A	A	A	A	P	33
SK0792	?	R?	A	A	P	A	P	P?	67
SK0793	?	L?	A	A	A	P?	P	A	67
SK0794	?	R?	A	A	A	A	P?	P	67
SK0795	?	R	A	A	A	A	P	A	33
SK0796	?	R	A	A	A	P	P	A	67
SK0797	?	?	A	A	A	A	A	P	33
SK0798	?	?	A	A	A	A	P	A	33
SK0799	?	R	A	A	A	P	P	A	67
SK0800	?	?	A	A	A	A	P?	A	33
SK0801	2?	R	A	A	A	A	P	A	33
SK0802	?	?	A	A	P	A	A	P	33
SK0803	?	?	A	A	A	P	P?	A	67
SK0804	?	L?	A	A	A	P?	A	A	33
SK0805	?	R	A	A	A	P	P	A	67
SK0806	?	?	A	A	A	A	A	P	33
SK0807	?	L	A	A	A	A	P	A	33
SK1711	?	R	A	A	A	A	P?	P?	33
SK1722	?	R?	A	A	A	P	P?	A	67
SK1750	?	?	A	A	A	P	A	A	33
SK1754	?	?	A	A	A	A	P?	A	33
SK2526	?	?	A	A	A	A	A	P	33
SK2634	?	L?	A	A	A	A	P?	P	67
SK2654	?	L	A	A	A	A	P	A	33

SK2655	?	?	A	A	A	A	A	P	33				

Scapulae

# Present	Side	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	% Complete
SK1907	R	A	A	A	P	P	P	P	P	P	P	A	A	78
SK1908	R	A	A	A	P	P	P	P	P	P	A	A	A	67
SK1909	R	A	A	A	A	P	P	P	P	A	P	A	A	56
SK1910	R	A	A	A	A	P	P	P	P	P	P	A	A	67
SK1911	R	A	A	A	P	P	A	P	P	P	A	P	A	67
SK1912	R	A	A	A	A	P	P	P	P	A	A	A	A	44
SK1913	R	A	A	A	A	P	P	P	P	P	P	P	A	78
SK1914	R	A	A	A	A	A	P	P	P	P	A	A	A	44
SK1915	R	A	A	A	A	A	P	P	P	A	A	A	A	33
SK1916	R	A	A	A	P	P	A	A	P	A	A	A	A	33
SK1917	R	A	P	A	P	P	P	P	P	A	A	A	A	56
SK1918	R	A	A	A	A	A	A	P	P	A	A	A	A	22
SK1919	R	A	A	A	A	A	A	A	P	A	A	A	A	11
SK1920	R	A	A	A	A	A	A	A	P	A	A	A	A	11
SK1921	L	A	A	A	A	A	A	A	A	P	A	P	A	22
SK1922	L	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1923	R	A	A	A	A	A	A	P	A	A	A	A	A	11
SK1924	L	A	A	A	A	P	P	P	P	P	P	A	A	67
SK1925	L	A	A	A	P	P	P	P	P	A	P	A	A	67
SK1926	L	A	A	A	P	P	P	P	P	P	P	A	A	78
SK1927	L	A	A	A	A	P	P	P	P	A	P	A	A	56
SK1928	L	A	A	A	A	P	P	P	P	P	A	A	A	56
SK1929	L	A	A	A	P	P	P	P	A	P	A	A	A	56
SK1930	L	A	A	A	P	P	P	P	A	A	A	A	A	44
SK1931	L	A	A	A	A	P	P	P	P	A	P	A	A	56
SK1932	L	A	A	A	A	P	P	P	P	A	A	A	A	44
SK1933	L	A	A	A	A	A	A	P	P	P	A	A	A	33
SK1934	L	A	A	A	A	P	A	P	P	A	A	A	A	33
SK1935	R	A	A	A	A	A	A	A	A	P	A	P	A	22
SK1936	L	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1937	R	A	A	A	A	A	A	P	P	A	A	A	A	22
SK1938	R	A	A	A	A	A	A	P	P	A	P	A	A	33
SK1939	R?	A	A	A	A	A	A	P	P	A	A	A	A	22
SK1940	L	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1941	R	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1942	L	A	A	A	A	A	A	P	P	P	P	A	A	44
SK1943	R?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1944	R	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1945	L	A	A	A	P	A	A	A	A	A	A	A	A	11
SK1946	R	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1947	L?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1948	R?	A	A	A	A	A	A	P	A	A	A	A	A	11
SK1949	?	A	A	A	A	P?	P?	A	A	A	A	A	A	11
SK1950	L	A	A	A	A	A	A	P	P	P	P	A	A	44

SK1951	L	A	A	A	A	A	A	P	P	P	A	A	A	33
SK1952	L	A	A	A	A	A	A	P	P	P	A	A	A	33
SK1953	L	A	A	A	A	A	A	A	A	P	A	P	A	22
SK1954	R?	A	A	A	A	A	A	P	A	A	A	A	A	11
SK1955	L	A	A	A	A	A	A	A	A	P	A	P	A	22
SK1956	L	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1957	L	A	A	A	A	A	A	P	P	A	A	A	A	22
SK1958	L?	A	A	A	A	A	A	P	A	A	A	A	A	11
SK1959	L?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1960	R?	A	A	A	A	A	A	A	A	P	A	P	A	22
SK1961	L?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1962	?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1963	R?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1964	?	A	A	A	A	A	P	A	P	A	A	A	A	22
SK1965	?	A	A	A	A	A	A	A	A	A	P	A	P	22
SK1973	?	A	A	A	A	A	A	A	A	A	P	A	P	22
SK1974	?	A	A	A	A	A	A	A	A	A	P	A	P	22
SK1975	?	A	A	A	A	A	A	A	A	A	P?	A	P?	11
SK1976	?	A	A	A	A	A	A	A	A	A	P?	A	P?	11
SK1977	L	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1978	L	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1979	?	A	A	A	A	A	A	A	A	A	P?	A	P?	11
SK1980	?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1981	L?	A	A	A	A	A	A	P	A	A	A	A	A	11
SK1982	?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1983	L?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1984	L?	A	A	A	A	A	P	A	P	A	A	A	A	22
SK1985	R?	A	A	A	A	A	A	A	A	P	P	A	P?	33
SK1986	?	A	A	A	A	A	A	A	A	A	P	A	A	11
SK1987	?	A	A	A	A	A	A	A	A	P	P	A	A	22
SK1988	?	A	A	A	A	A	A	A	A	P	P	A	A	22
SK1989	?	A	A	A	A	A	A	A	A	A	P?	A	P?	11
SK1990A	L	P	A	A	A	P	P	A	P	P	P	P	P	78
SK1990B	L	A	A	A	A	A	A	A	A	A	A	P	A	11
SK1991	?	A	A	A	A	A	A	A	A	P	P	A	A	22
SK2527	?	A	A	A	A	A	A	A	A	A	A	A	P	11
SK2628	?	A	A	A	A	A	A	A	A	P?	P?	P?	P?	22
SK2629	R?	A	A	A	A	A	A	A	A	A	A	P	A	11
SK2630	?	A	A	A	A	A	A	A	A	P?	A	P?	A	11
SK2650	L	A	A	A	A	P	A	P	A	A	A	A	A	22

Ulnae

# Present	Side	PM F	PM M	PM S	Z A/B	Z C	Z D	Z E	Z F	Z G	Z H	Z J	% Complete
SK0145	R	P?	A	A	P	P	P	P	P	P	P	A	88
SK0147	R	A	A	P	A	P	P	P	P	P	P	P	88
SK0194	R	A	A	A	P	P	P	P	P	P	P	A	88
SK0199	R	A	A	A	A	A	A	P	P	A	A	A	25
SK0846	R	A	A	A	A	P	P	P	P	P	P	A	75
SK0851	R	A	A	A	P	P	P	P	P	P	A	A	75
SK0852	R	A	A	A	A	A	A	P	P	P	P	A	50
SK0853	R	A	A	A	P	P	P	P	P	P	P	A	88
SK0854	R	A	A	A	P	P	P	P	P	P	P	A	88
SK0855	R	A	A	A	A	P	P	P	P	P	P	A	75
SK0856	R	A	A	A	A	P	A	P	P	P	P	A	63
SK0857	R	A	A	A	A	P	A	P	P	P	P	A	63
SK0858	L	A	A	A	A	A	A	P	P	P	P	A	50
SK0859	R	A	A	A	A	P	A	P	P	P	P	A	63
SK0860	R	A	A	A	P	P	P	P	P	P	A	A	75
SK0861	R	A	A	A	A	P	P	P	P	P	P	A	75
SK0862	R	A	A	A	A	P	P	P	P	P	P?	A	75
SK0863	R	A	A	A	P	P	P	P	P	P	P	A	88
SK0864	R	A	A	A	A	A	A	P	P	P	A	A	38
SK0865	R	A	A	A	A	A	A	P	P	P	P	A	50
SK0866	R	A	A	A	A	A	A	A	A	A	P	P	25
SK0867	R	A	A	A	A	A	A	P	P	P	P?	A	50
SK0868	R	A	A	A	A	P	P	P	P	P	A	A	63
SK0869	L	A	A	A	P	P	P	P	P	P	P	A	88
SK0870	R	A	A	A	A	P	P	A	A	A	A	A	25
SK0871	R	A	A	A	P	P	A	A	A	A	A	A	25
SK0872	R	A	A	A	P	P	A	A	A	A	A	A	25
SK0873	L	A	A	A	P	P	P	P	P	P	P	A	88
SK0874	L	A	A	A	P	P	A	A	A	A	A	A	25
SK0875	R?	A	A	A	A	A	A	P	P?	A	A	A	25
SK0876	L	A	A	A	P	P	P	P	P	P	P	A	88
SK0877	?	A	A	A	A	A	A	A	A	A	P	A	13
SK0878	L?	A	A	A	P	P	A	A	A	A	A	A	25
SK0879	R?	A	A	A	A	A	A	P	A	A	A	A	13
SK0880	R?	A	A	A	A	A	A	A	P	P	A	A	25
SK0881	L	A	A	A	P	P	P	P	A	A	A	A	50
SK0882	R	A	A	A	P	P	A	A	A	A	A	A	25
SK0883	L	A	A	A	P	P	A	A	A	A	A	A	25
SK0884	L	A	A	A	P	P	P	P	P	P	P	A	88
SK0885	L	A	A	A	P	P	P	P	P	P	A	A	75
SK0886	L	A	A	A	P	P	P	P	P	P	P	P	100
SK0887	L	A	A	A	P	P	P	P	P	P	A	A	75
SK0888	L	A	A	A	A	P	P	P	P	A	A	A	50

SK0889	L	A	A	A	P	P	P	P	P	A	A	A	63
SK0890	L	A	A	A	P	P	P	P	P	P	P	P	100
SK0891	L	A	A	A	A	P	P	P	P	P	P	P	88
SK0892	L	A	A	A	A	P	P	P	A	A	A	A	38
SK0893	L	A	A	A	A	P	P	P	P	P	A	A	63
SK0894	L	A	A	A	P	P	P	P	P	P	P	P	100
SK0895	L	A	A	A	A	P	P	P	P	P	P	A	75
SK0896	L	A	A	A	A	P	P	P	P	P	P	A	75
SK0897	R?	A	A	A	A	P	A	A	A	A	A	A	13
SK0898	L?	A	A	A	A	A	A	P	A	A	A	A	13
SK0899	L	A	A	A	A	A	A	P	P	A	A	A	25
SK0900	L	A	A	A	A	A	A	P	P	A	A	A	25
SK0901	?	A	A	A	A	P	A	A	A	A	A	A	13
SK0902	L	A	A	A	A	A	A	A	P	P	P	P	50
SK0903	L?	A	A	A	A	A	A	P	P	P	A	A	38
SK0904	?	A	A	A	A	A	A	P	P	P?	A	A	38
SK1069	R	A	A	A	P	P	P	P	P	P	p	A	88
SK2652	L	A	A	A	A	A	A	P	A	A	A	A	13

Vertebrae

# Present	PM F	PM M	PM S	Z 1	Z 2	Z 3	Z 4	% Complete
SK1705	A	A	A	A	P	A	A	25
SK2042	A	A	A	P	P	P	P	100
SK2043	A	A	A	P	P	P	P	100
SK2044	A	A	A	P	P	P	P	100
SK2045	A	A	A	A	P	P	A	50
SK2046	A	A	A	A	P	P	P	75
SK2047	A	A	A	A	P	P	P	75
SK2048	A	A	A	A	P	P	P	75
SK2049	A	A	A	P	P	P	P	100
SK2050	A	A	A	A	A	P	P	50
SK2051	A	A	A	A	P	P	P	75
SK2052	A	A	A	A	P	A	P	50
SK2053	A	A	A	A	P	P	P	75
SK2054	A	A	A	A	P	P	P	75
SK2055	A	A	A	A	P	A	P	50
SK2056	A	A	A	A	P	P	P	75
SK2057	A	A	A	A	P	P	P	75
SK2058	A	A	A	A	P	P	P	75
SK2059	A	A	A	A	P	A	P	50
SK2060	A	A	A	A	P	P	P	75
SK2061	A	A	A	A	P	P	P	75
SK2062	A	A	A	P	P	P	P	100

SK2063	A	A	A	A	P	P	P	75
SK2064	A	A	A	P	P	P	P	100
SK2065	A	A	A	A	P	P	A	50
SK2066	A	A	A	A	P	P	P	75
SK2067	A	A	A	A	P	P	P	75
SK2068	A	A	A	A	P	P	A	50
SK2069	A	A	A	A	P	P	P	75
SK2070	A	A	A	A	P	P	P	75
SK2071	A	A	A	A	P	P	A	50
SK2072	A	A	A	A	A	A	P	25
SK2073	A	A	A	A	P	P	A	50
SK2074	A	A	A	A	P	P	A	50
SK2075	A	A	A	A	P	P	A	50
SK2076	A	A	A	A	A	P	P	50
SK2077	A	A	A	A	P	P	P	75
SK2078	A	A	P	P	P	P	A	75
SK2079	A	A	A	P	P	P	P	100
SK2080	A	A	A	A	P	A	P	50
SK2081	A	A	A	A	A	P	P	50
SK2082	A	A	A	A	P	P	A	50
SK2083	A	A	A	A	P	P	P	75
SK2084	A	A	A	A	P	P	A	50
SK2085	A	A	A	P	A	A	A	25
SK2086	A	A	A	A	P	A	P	50
SK2087	A	A	A	A	P	P	P	75
SK2088	A	A	A	P	A	A	A	25
SK2089	A	A	A	A	P	P	A	50
SK2090	A	A	A	A	P	A	P	50
SK2092	A	A	A	A	A	P	A	25
SK2093	A	A	A	A	A	P	A	25
SK2094	A	A	A	A	P	P	A	50
SK2095	A	A	A	A	P	A	A	25
SK2096	A	A	A	A	P	A	A	25
SK2097	A	A	A	A	A	P	A	25
SK2098	A	A	A	A	A	P	A	25
SK2099	A	A	A	A	A	P	A	25
SK2100	A	A	A	A	P	A	A	25
SK2101	A	A	A	A	A	P	A	25
SK2102	A	A	A	A	A	P	P	50
SK2103	A	A	A	A	P	P	A	50
SK2104	A	A	A	A	P	A	A	25
SK2105	A	A	A	A	P?	P?	A	25
SK2115	A	A	A	P	P	A	P	75
SK2196	A	A	A	P	P	P	P	100
SK2197	A	A	A	P	P	P	P	100
SK2198	A	A	A	A	P	P	P	75
SK2199	A	A	A	A	P	P	P	75

SK2200	A	A	A	A	P	P	P	75
SK2201	A	A	A	P	A	A	A	25
SK2202	A	A	A	P	A	A	A	25
SK2203	A	A	A	P	A	A	A	25
SK2204	A	A	A	P	A	A	A	25
SK2205	A	A	A	P	A	A	A	25
SK2206	A	A	A	P	A	A	A	25
SK2207	A	A	A	P	A	A	A	25
SK2208	A	A	A	A	P	P	A	50
SK2209	A	A	A	A	A	P	P	50
SK2210	A	A	A	A	P	A	P	50
SK2211	A	A	A	A	P	P	A	50
SK2212	A	A	A	A	P	P	A	50
SK2213	A	A	A	P	A	A	A	25
SK2214	A	A	A	A	P	A	A	25
SK2215	A	A	A	A	P	A	A	25
SK2216	A	A	A	A	P	A	A	25
SK2217	A	A	A	A	P	A	A	25
SK2218	A	A	A	A	A	P	A	25
SK2219	A	A	A	A	P	A	A	25
SK2220	A	A	A	A	P	A	A	25
SK2221	A	A	A	A	A	P	A	25
SK2222	A	A	A	A	P	A	A	25
SK2223	A	A	A	A	P	A	A	25
SK2224	A	A	A	P	A	A	A	25
SK2225	A	A	A	P	A	A	A	25
SK2226	A	A	A	P	A	A	A	25
SK2227	A	A	A	P	A	A	A	25
SK2228	A	A	A	A	P	A	A	25
SK2229	A	A	A	A	P	A	A	25
SK2230	A	A	A	P	A	A	A	25
SK2231	A	A	A	A	P	A	A	25
SK2232	A	A	A	P	A	A	A	25
SK2233	A	A	A	A	P?	P?	A	25
SK2234	A	A	A	P	A	A	A	25
SK2235	A	A	A	A	A	P	A	25
SK2236	A	A	A	A	P	A	A	25
SK2237	A	A	A	A	P	A	A	25
SK2238	A	A	A	A	P	A	A	25
SK2241	A	A	A	A	P	A	A	25
SK2242	A	A	A	P	P	A	A	50
SK2245	A	A	A	A	A	P	A	25
SK2247	A	A	A	A	P	A	A	25
SK2259	A	A	A	A	P	P	P	75
SK2261	A	A	A	A	A	P	A	25
SK2262	A	A	A	A	P	P	A	50
SK2263	A	A	A	A	P	P	P	75

SK2265	A	A	A	A	P	A	A	25
SK2266	A	A	A	A	P	A	A	25
SK2268	A	A	A	A	A	P	A	25
SK2292	A	A	A	A	P	P	A	50
SK2294	A	A	A	A	P	A	A	25
SK2295	A	A	A	A	A	P	A	25
SK2298	A	A	A	P	A	A	A	25
SK2299	A	A	A	P	A	A	A	25
SK2300	A	A	A	P	A	A	A	25
SK2302	A	A	A	P	A	A	A	25
SK2303	A	A	A	P	A	A	A	25
SK2304	A	A	A	P	A	A	A	25
SK2305	A	A	A	P	A	A	A	25
SK2306	A	A	A	P	A	A	A	25
SK2307	A	A	A	P	A	A	A	25
SK2308	A	A	A	P	A	A	A	25
SK2309	A	A	A	P	A	A	A	25
SK2310	A	A	A	P	A	A	A	25
SK2314	A	A	A	A	P	A	A	25
SK2317	A	A	A	A	P	A	A	25
SK2321	A	A	A	A	A	P	A	25
SK2322	A	A	A	A	A	P	A	25
SK2325	A	A	A	P	A	A	A	25
SK2326	A	A	A	P	A	A	A	25
SK2328	A	A	A	P	A	A	A	25
SK2329	A	A	A	A	P	A	A	25
SK2330	A	A	A	P	A	A	A	25
SK2333	A	A	A	P	A	A	A	25
SK2335	A	A	A	P	A	A	A	25
SK2336	A	A	A	P	A	A	A	25
SK2337	A	A	A	P	A	A	A	25
SK2338	A	A	A	A	A	P	A	25
SK2339	A	A	A	P	A	A	A	25
SK2342	A	A	A	P	A	A	A	25
SK2343	A	A	A	P	A	A	A	25
SK2353	A	A	A	A	P	A	A	25
SK2354	A	A	A	A	P	A	A	25
SK2355	A	A	A	A	A	P	A	25
SK2356	A	A	A	A	P	A	A	25
SK2357	A	A	A	A	P	P	A	50
SK2361	A	A	A	A	P?	A	A	25
SK2362	A	A	A	A	A	P?	A	25
SK2364	A	A	A	A	A	P	A	25
SK2370	A	A	A	A	A	P	A	25
SK2381	A	A	A	A	A	A	P	25
SK2384	A	A	A	A	A	P	A	25
SK2385	A	A	A	A	P	A	A	25

SK2386	A	A	A	A	A	P	A	25
SK2389	A	A	A	A	P	P	P	75
SK2397	A	A	A	A	P	A	A	25
SK2404	A	A	A	A	P	A	A	25
SK2407	A	A	A	A	A	P	A	25
SK2410	A	A	A	A	P	A	A	25
SK2413	A	A	A	A	P	A	A	25
SK2420	A	A	A	A	P	A	A	25
SK2421	A	A	A	A	P	A	A	25
SK2427	A	A	A	A	A	P	A	25
SK2435	A	A	A	A	A	P	A	25
SK2598	A	A	A	P	A	A	A	25
SK2252	A	A	A	A	P?	P?	A	25
SK2264	A	A	A	A	P	P	A	50
SK2319	A	A	A	A	P?	P?	A	25
SK2323	A	A	A	P	A	A	A	25
SK2340	A	A	A	P	A	A	A	25
SK2341	A	A	A	P	A	A	A	25
SK2399	A	A	A	A	A	P?	A	25
SK2424	A	A	A	P	A	A	A	25
SK2432	A	A	A	A	A	P	A	25
SK2436	A	A	A	A	P?	P?	A	25
SK2440	A	A	A	A	P?	A	A	25

Appendix II: Additional Photographs Documenting Potential Perimortem Lesions

Photographs documenting the majority of the potential perimortem lesions observed in the Smith's Knoll collection can be found in Section 6.1.2. Photographs of the elements not documented in that section, mainly rib fragments, are provided in this appendix.

Figure A.1. (Left) Potential perimortem cut mark on rib fragment SK0329.

Figure A.2. (Below) Potential perimortem cut mark on rib fragment SK0339.

Figure A.3. (Left) Digital microscope image of potential perimortem cut mark on rib fragment SK0339, also pictured in Figure A.2. Magnification is X30.

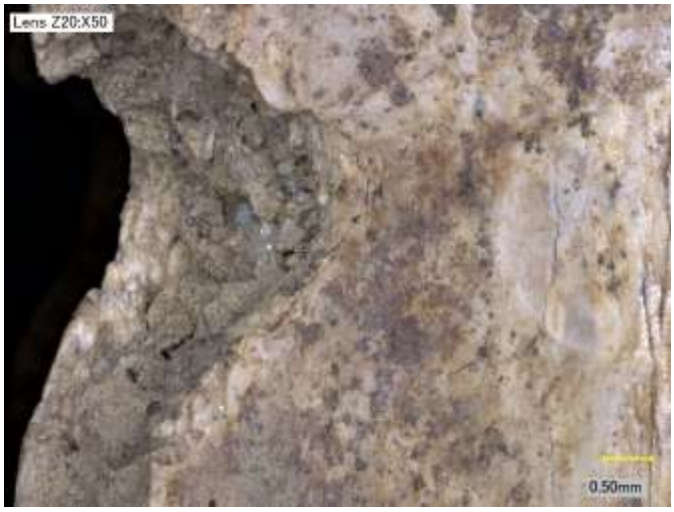

Figure A.4. (Above) Digital microscope image of potential perimortem cut mark on rib fragment SK0340, taken from the posterior side. Magnification is X50.

Figure A.5. (Right) Potential perimortem cut mark on rib fragment SK0345.

Figure A.6. Digital microscope image of potential perimortem cut mark on rib fragment SK0345, also pictured in Figure A.5, taken from anterior side. Magnification is X30.

Figure A.7. Digital microscope image of potential perimortem cut mark on SK0370, taken from the anterior side. Magnification is X50.

Figure A.8. (Above) Potential perimortem cut mark on rib fragment SK0371.

Figure A.9. (Right) Potential perimortem cut mark on rib fragment SK0708.

Figure A.10. Potential perimortem cut mark on rib fragment SK0792.