TEMPORAL ANALYSIS OF CRANIOFACIAL TRAUMA IN PREHISTORIC CALIFORNIA’S CENTRAL VALLEY

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in
Anthropology

by
Kristin L. Chelotti
Spring 2013
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ABSTRACT

TEMPORAL ANALYSIS OF CRANIOFACIAL TRAUMA IN
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by

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Master of Arts in Anthropology

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Anthropological analyses of skeletal remains from prehistoric and historic populations have aided in the reconstruction of human behavioral patterns with reference to topics such as diet, activity patterns, and violence. Observation of skeletal trauma can be suggestive of interpersonal violence, particularly when consideration is given to the type, location, concentration, and patterning of injuries. Specifically, trauma to craniofacial elements is more commonly associated with intentional acts rather than accidental injury.

Prehistoric violence in California’s Central Valley has been attributed to increased human populations during the late Holocene, which, coupled with climatic instability, strained the availability of resources in the region. Such pressures are argued to have resulted in greater levels of violence due to the struggle over declining resources,
which may be evident through the prevalence of craniofacial trauma through time. To test this, the present study includes the analysis of craniofacial trauma using skeletal remains from prehistoric archaeological sites dated between the Early and Late Periods and situated in the Central Valley of California.

From a sample of 212 individuals, 44 traumatic injuries, primarily in the form of antemortem cranial vault depressions and nasal fractures, were noted in 29 males and females. Comparisons by time period and anatomical location of injuries revealed no significant difference in the prevalence of trauma. The highest levels of traumatic injury were noted during the Middle Period followed by a considerable decline in the Late Period, which does not support the expectation that behavioral patterns associated with rapid population expansion and competition over resources resulted in an increase in interpersonal violence during the late Holocene.

The positive relationship between trauma prevalence and sex indicated males were more frequently affected. The uneven distribution of trauma within both sexes suggested injuries were intentional and the distinct patterning of cranial vault trauma observed between males and females implied differential exposure to violence. Based on these patterns, males were more likely involved in face-to-face violent encounters while female involvement is open to wider interpretation.

Though this study did not affirm each research expectation, the association between population expansion, resource competition, and violence is supported by the craniofacial trauma prevalence of 13.7 percent within the total sample, a level that can-
not be underemphasized as it exceeds the majority of those reported in similar studies within central California.
CHAPTER I

INTRODUCTION

The Central Valley of California covers 450 miles from Shasta County in the north to Kern County in the south (Umbach 1997) and is surrounded by the Siskiyou Mountains to the north, the Coast Ranges to the west, and the Sierra Nevada and Cascades to the east. The valley’s concave surface rests just below sea level at its shallowest point, and reaches a maximum elevation of 400 feet at its northern and southern margins (Schoenherr 1992). Due to heavy winter precipitation and arid summers, various types of biological communities are present throughout the valley floor (e.g., valley grassland and oak foothill) while valley margins generally consist of foothill woodland habitats (Schoenherr 1992).

Prior to the impacts of post-contact settlement, valley grassland, freshwater marsh, and riparian woodland communities dominated the valley. Unspoiled valley grasslands primarily consisted of perennial bunchgrasses, annual grasses and herbs, wildflowers, and thistles (Schoenherr 1992). Wetland regions, in the form of once abundant swamps and freshwater marshes, developed in areas that received considerable mountain runoff (Schoenherr 1992). Tulare Lake, Buena Vista Lake, Kern Lake and their associated marshes and sloughs formed the largest wetland region in prehistoric central California, which spanned over 2,100 miles of shoreline (Schoenherr 1992). The abundance of moisture and sunlight in wetland regions allowed for the survival of a large
number of plants (e.g., tules, reeds, willows, watercress, and ferns) and animals (e.g., ducks, geese, swans, muskrats, and beavers). Gallery forests, riparian woodland habitats composed of willows, sycamores, elders, cottonwoods and oaks, originally lined the Sacramento and San Joaquin rivers, but like grassland and freshwater marsh environments, post-contact human activity has depleted their numbers (Schoenherr 1992).

The Sacramento-San Joaquin Delta is unlike other deltas in that it is more interiorly located (Shlemon 1971). More recently modified through the construction of levees and drainage systems for municipal development, the delta region was once a tidal marshland veined with sloughs (Heizer 1976) and preferred by prehistoric populations for its raised natural levees (Rosenthal et al. 2007).

Prevailing accounts of California’s Central Valley describe a fixed environment in which the flora, fauna, and climatic conditions remained largely unchanged for thousands of years despite exploitation by prehistoric populations (Schenck and Dawson 1929). Early populations residing along the waterways of the delta region have long been described as living in “the most favorable area of the valley” (Heizer and Elsasser 1980:72) as it provided “an edible landscape so abundant that people rarely went hungry” (Fagan 2002:271). While the delta region did offer increased opportunities for access to resources than other areas of the valley floor, e.g., the more arid southwestern San Joaquin Valley, these prior statements exaggerated the true state of the Sacramento-San Joaquin Delta as experienced by its prehistoric inhabitants and perpetuated the misconception that in light of such resource abundance, prehistoric peoples lived peacefully among their neighbors.
Perspectives on Prehistoric Violence

The renewed recognition of human violence in North American prehistory is a relatively recent concept that has drawn increased attention from the anthropological community within the last few decades (Keeley 1996; Martin and Frayer 1997; Milner 2005; Allen and Arkush 2008). Earlier theories of prehistoric violence were primarily based on two prominent and opposing philosophical models: 1) humans were innately influenced by their own selfish concerns, particularly the fear of violent death (i.e., the brutish savage); or 2) humans were inherently good, resorting to violence only as a result of a society governed by unnatural laws (i.e., the noble savage) (Keeley 1996). The concept of the brutish savage prevailed during the European missionization and colonization of the 19th century, followed by the gradual pacification of primitive peoples in what Keeley (1996:7) describes as “one of the principal apologies for Western imperialism.”

The anthropological research that ensued increasingly upheld, deliberately or by avoiding the topic, the collective view that native populations were void of violent tendencies (Keeley 1996), a perception supported by the myriad descriptions of pre-contact societies as peaceful. Or, if acknowledged, violence was qualified solely as a means of avenging an earlier transgression (Kroeber 1925). But the assumption of peace in the “simpler times” of prehistory has been challenged by more recent archaeological and osteological research from ancient societies throughout the world, revealing that many of the crimes plaguing modern societies (e.g., warfare, homicide, domestic abuse, and cannibalism) are, in fact, problems with a lengthy history (Martin and Frayer 1997; Allen and Arkush 2008).
Archaeological evidence of violence typically includes the recovery of defensive structures, weaponry, and iconography, though none of these can offer the same level of certainty that injuries to bone can provide. Skeletal trauma can offer convincing evidence of violence if, for example, projectile points are found embedded in bone, particularly along the spine (Walker 2001). Though alternate explanations may be applied to an injury of this nature, the possibilities are narrowed when assessed in the greater archaeological context, for example, if found in conjunction with other skeletal trauma within a single individual or other individuals within the same population.

Assessment of skeletal trauma in archaeological populations includes the distinction of antemortem (before death) and perimortem (around the time of death) trauma (both of which bear significance on interpretations of human behavior), from postmortem (after death) damage. Additional consideration is given to the cause of trauma. For example, blunt force trauma is typically produced by an object with a flat surface such as a club or a stone. Bladed weapons or projectiles typically result in sharp force trauma characterized by cut marks or puncture wounds. Even the absence of bones offers strong evidence of violence as observed by the removal of skulls, forearms, and lower legs taken as trophies in prehistoric central California (Andrushko et al. 2005; Andrushko et al. 2010).

When traumatic injuries are observed on craniofacial elements, a phenomenon more commonly associated with interpersonal violence in modern populations (Walker 2001), the patterning, such as their concentration in particular areas, can suggest the individual was intentionally injured during a violent encounter. Some patterns include increased frequency of trauma to the frontal and parietal bones of the cranial vault and
the nasal bones of the face (Walker 2001). In face-to-face fighting, the head is frequently targeted, with the nose and forehead more often affected, perhaps due to these generally being the most forwardly projecting features of the head. Walker (2001:582) suggests a more concrete explanation based in the cultural acceptance of “socially sanctioned fighting” such as sport fighting in which the techniques used to win are transferred outside the sport’s domain to influence the injury patterns observed in the general populace. This may also contribute to the higher frequency of trauma to the left side of the skull as an indication of intentional injury due to the more dominant use of the right hand. In a face-to-face encounter, right-handed individuals are expected to inflict more damage to the left side of the head of their opponent, though this pattern may not be consistently evident as a considerable amount of movement by participants in a physical struggle is customary.

Contemporary research on interpersonal violence indicates sex and age are significant factors in patterns of violence as young males are more likely to be both the perpetrator and the victim (Walker 2001). Though modern trends cannot necessarily be applied to ancient populations, much bioarchaeological research has supported the greater prevalence of trauma in males (Walker 1989; Martin and Frayer 1997; Standen and Arriaza 2000).

The social implications of violence-related skeletal trauma in prehistoric North American hunter-gatherer groups include population expansion, increasing social complexity, and sedentism, while climatic fluctuations and resource intensification offer insight into the ways the prehistoric landscape was affected (Lambert and Walker 1991). Significant environmental oscillations that threatened the success of prehistoric human
populations included extinctions of faunal species, wetland flooding, repeated formation and evaporation of lakes, and climatic fluctuations great enough to alter the geographic distribution of flora and fauna (Moratto 1984). Particularly in California, while plant diversity has remained relatively stable since the late Pleistocene, plant density has been drastically altered by climate change (West et al. 2007), which undoubtedly affected the migratory patterns of and possibly the resource competition among the human and animal populations relying upon them.

Human population expansion contributed to environmental degradation through the adoption of intensive hunting practices, which triggered large vertebrate population decreases and a greater human reliance on more costly, lower ranked resources (Broughton 1994). The greater use of food processing tools like mortars and pestles in the Middle Period, suggest a heavier reliance on acorns (Rosenthal et al. 2007), a seasonal crop whose intensification also suggests a move toward sedentism (Wohlgemuth 1996; LeBlanc 2008). The consequence of increased human populations and resource depression was resource competition, which in turn is expected to have prompted the escalation of interpersonal violence in prehistoric central California.

Central California Chronology and Cultural Sequences

Early development of a central California sequence was based on presumed discrete “cultural levels” (Early, Intermediate, and Late) identified through artifact typology, burial patterns, and human remains recovered from archaeological excavations (Lillard and Purves 1936). Continued site excavations in central California that included analyses of midden soils, human and animal bones, and baked clay artifacts instead
suggested a pattern of cultural succession among prehistoric groups through time (Moratto 1984). Additional research by Lillard et al. (1939) modified the sequence to include Early, Transitional, and Late Periods and proposed cultural specialization originated in the delta and spread to other areas throughout the region.

Beardsley (1954) challenged this proposal with the development of the Central California Taxonomic System (CCTS), which included the San Francisco Bay Area, and suggested a uniform cultural succession from the coast to the valley. This cultural sequence introduced the concept of horizons, replacing the Transitional Period with the Middle Horizon. However, these early attempts to formulate a central California sequence were viewed as troublesome in that the methods used to define periods of time produced variable results (Moratto 1984). From this criticism, Ragir (1972) developed a cultural sequence based on radiocarbon dates and charmstone and projectile point seriation that introduced the Windmiller, Consumnes, and Hotchkiss Cultures, a sequence that understated temporal variation and emphasized regional patterns.

Following this, Bennyhoff and Hughes (1987) developed a chronology that combined the Early, Middle, and Late Periods of the CCTS with Early/Middle and Middle/Late Transition periods. Burial seriation information for many of the skeletal populations in central California is based on this chronology. The majority of these seriations are based on shell bead typologies, though other dating techniques include radiocarbon dating and obsidian hydration, “charmstone” and projectile point typologies, mortuary patterns, and burial features.

Groza (2002) developed an updated version of Bennyhoff and Hughes’ (1987) Scheme B1, which is primarily based on radiocarbon dates from beads manufactured
from *Haliotis* or *Olivella biplicata* shells from 81 sites in the western Great Basin. More recently, Scheme B1 radiocarbon dates have been recognized as problematic partly due to the inclusion of a number of materials of variable age in addition to shells, such as bone collagen and charcoal, which may have produced inaccurate dates (Bennyhoff and Hughes 1987, Groza 2002). Scheme D represents a recalibration of 162 of the 180 dates analyzed for the development of Scheme B1 plus the AMS-dating of another 103 *Olivella* beads (Groza 2002). Scheme D provides a more accurate calibration of dates for the Early through Late Periods. Table 1 provides an adapted version of Scheme D used in the present study.

**TABLE 1. Central California chronology.**

<table>
<thead>
<tr>
<th>Period</th>
<th>Calibrated Dates (Scheme D) (Groza 2002)</th>
<th>Present Study</th>
<th>Calibrated Dates (Scheme D) (Groza 2002)</th>
<th>Present Study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B.P.</td>
<td>B.C./A.D.</td>
<td>B.P.</td>
<td>B.C./A.D.</td>
</tr>
<tr>
<td>Late Period</td>
<td>740-230 B.P.</td>
<td>A.D. 1210-1720</td>
<td>940 - 230 B.P.</td>
<td>A.D. 1010-1720</td>
</tr>
<tr>
<td>Middle/Late</td>
<td>940-740 B.P.</td>
<td>A.D. 1010-1210</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Middle Period</td>
<td>2450-2160 B.P.</td>
<td>500-210 B.C.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Early/Middle</td>
<td>&gt;3450-2450 B.P.</td>
<td>&gt;1500-500 B.C.</td>
<td>&gt;3450-2450 B.P.</td>
<td>&gt;1500-500 B.C.</td>
</tr>
<tr>
<td>Period</td>
<td>Early Period</td>
<td></td>
<td></td>
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Source: Adapted from Bartelink, Eric J. (2006) Resource Intensification in Pre-Contact Central California: A Bioarchaeological Perspective on Diet and Health Patterns among Hunter-Gatherers from the Lower Sacramento Valley and San Francisco Bay. Ph.D. dissertation, Department of Anthropology, Texas A&M University.

The time periods listed in Table 1 are loosely associated with cultural sequences characteristic of different areas within central California. The suggested descendants of groups adapted to riverine and wetland habitats (Moratto 1984), Early
Period populations (circa 4950-2150 B.P.) precluded the emergence of the majority of large valley settlements and coastal shellmounds characteristic of the Middle and Late Periods (Heizer and Cook 1949). Particularly noted for the west-facing, ventral extension of burials (Moratto 1984) and sophisticated modification of stone, bone, and shell beads of *Haliotis* and *Olivella*, this period is also characterized by large chert and slate projectile points, quartz crystals, charmstones, and baked clay (Lillard et al. 1939; Heizer and Elsasser 1980).

Beads of olive shell (*Olivella biplicata* or *Olivella pycna*), beads and ornaments of abalone (*Haliotis* spp.), charmstones, quartz crystals, flaked chert and obsidian unworked colored pebbles, and bone implements are some of the noted items recovered with burials from CA-SJO-068 and CA-SJO-142 (Heizer 1976). Charmstones are most commonly colorful lithics, likely fashioned to suspend from a cord. Often quite large and heavy, charmstones were likely used for ceremony as they were not worked or worn as were objects with a known utilitarian purpose (Heizer 1976). Clear quartz crystals seem to have had a similar purpose as charmstones, and like charmstones, quartz crystals were found in association with the burials of adult males and females as well as children (Heizer 1976). These sites also present likely evidence of basketry from the Early Period in the form of large, clay-molded objects stamped with a woven surface prior to firing (Heizer 1976).

Many of the above mentioned items were not local to the Delta and were possibly acquired through trade. The Coast Range was a likely source for obsidian, *Haliotis* ornaments, and *Olivella* shells, while the Sierra Nevada may have been an additional source of obsidian and quartz crystals (Moratto 1984). However, the summer
movements of some Windmiller groups into the Sierra Nevada would have provided the opportunity to transport distant materials.

The Early/Middle Transition (circa 2450-2160 B.P.) witnessed climatic stabilization to cooler and wetter conditions, an increase in the use of mortars and pestles associated with more intensive acorn use, and the development of village mounds associated with the Berkeley Pattern cultural tradition, which emerged in the San Francisco Bay Area and replaced the Windmiller Culture at least in the eastern Sacramento Delta (Moratto 1984; Rosenthal et al. 2007).

Modifications of stone, bone, and shell continued to increase in complexity into the Middle Period with the more common appearance of awls, needles, harpoons, large projectile points, bipoints, millingstones, cobble mortars, pestles, shell beads, and baked clay objects (Lillard et al. 1939; Heizer and Elsasser 1980). Additional features include tightly flexed burials of variable orientation and occasional grave goods (Lillard et al. 1939). Homogeneity of Middle Period settlements suggests a single cultural occupancy within the Central Valley (Heizer and Cook 1949).

By the Late Period (740-230 B.P.), the Augustine Pattern emerged in the lower Sacramento Valley and many of the technologies representing older cultures, such as the atlatl (spear thrower), were replaced by newer ones, like the bow and arrow, indicating more intensive hunting, fishing, and gathering practices (Heizer and Elsasser 1980; Moratto, 1984; Rosenthal et al. 2007). At this time, populations began to increase dramatically as did the complexity of social, political, and economic systems (Moratto 1984).
Elaborately fashioned *Haliotis* ornaments and *Olivella* beads, modified bird bone and serrated obsidian points are also typical of this period (Lillard et al. 1939). Further observation of increased tool complexity resulted from the volume of tools recovered from Late Period sites, and the number of tools manufactured for the processing of one type of food product: acorns (Heizer and Elsasser 1980). The recovery of intact and fragmented baskets, larger numbers of increasingly more complex bone awls, and the presence of baked clay coils (Cosumnes Brown Ware) and cooking balls suggest increased use of basketry for the purpose of acorn processing (Heizer and Elsasser 1980; Moratto 1984). Burials in this period are almost always flexed, though some extended interments are noted along with cremations and burning of artifacts prior to burial (Lillard et al. 1939).

**Research Design**

This study provides a temporal analysis of craniofacial trauma in prehistoric California’s Central Valley and through its findings, makes inferences about the pervasiveness of interpersonal violence. Craniofacial remains of 212 adult individuals from six archaeological sites located in the Central Valley of California provide the test sample. The sites in geographic location from north to south include CA-SAC-043 (Brazil Mound), CA-SAC-006 (Johnson Mound), and CA-SAC-060 (Hicks I Mound) of the lower Sacramento Valley and CA-SJO-142 (McGillivray Mound), CA-SJO-068 (Blossom Mound), and CA-SJO-154 (Cardinal Mound) of the northern San Joaquin Valley. Temporally, these sites represent a period of approximately 4,500 years of prehistory.
Documentation and analysis of antemortem and perimortem injury prevalence observed throughout the cranial vault and face test the three research expectations of this study. First, the prevalence of craniofacial trauma is expected to increase through time as a consequence of pressures imposed by human population expansion and resource competition. Second, the greater frequency of craniofacial injuries on the left side of the skull is expected as a result of face-to-face violent encounters with predominantly right-handed participants. Third, males are expected to exhibit a higher prevalence of craniofacial injuries due to the greater likelihood of their involvement in more dangerous behavior than females.

To test these expectations, statistical analyses will compare the prevalence of craniofacial trauma through time using the chronology developed for central California noted previously. Similar analyses will be applied to the comparison of craniofacial trauma by location on the skull and by sex. Evaluation of the combined results of this study is expected to provide support for interpersonal violence in central California prehistory through temporal increases and identifiable patterns of craniofacial trauma.

Thesis Organization

The following chapters provide the framework in which to apply the craniofacial trauma data collected for this study. Chapter II opens with a discussion of the meaning of interpersonal violence and how it differs from warfare. Theoretical explanations for the presence of interpersonal violence in prehistory are considered from the perspectives of biology, sociology, and human behavioral ecology.
Chapter III discusses the interpretation of interpersonal violence in prehistoric populations through the analysis of human skeletal remains. Categorization and identification of craniofacial injuries precede a literature review of interpersonal violence throughout the United States, with specific attention given to the geographic variability of trauma patterns and prevalence in southern and central California. This is followed by the introduction and discussion of the research expectations of the present study.

The methodology used in the collection of data and statistical analyses that assess the prevalence of craniofacial trauma through time, location on the cranium, and by sex are detailed in Chapter IV. This is followed by a summary of the archaeological sites mentioned in the previous section with particular attention given to the location and excavation of each.

Chapter V reviews the results of the three research expectations. Additional results beyond those specifically related to the research expectations, such as a description of several noteworthy traumatic injuries by craniofacial element and the overall prevalence of trauma within the sample, are also addressed.

Chapter VI provides an interpretation of the results with consideration given to the theoretical perspectives on violence and human behavioral models discussed in Chapter II. Finally, Chapter VII summarizes the research conclusions, identifies research limitations, and offers suggestions for future investigations of prehistoric interpersonal violence.
CHAPTER II

THEORETICAL PERSPECTIVES ON VIOLENCE

Introduction

Interpersonal violence and warfare in North American prehistory was inconceivable to early anthropologists, particularly in California, as indigenous groups were initially described as inhabiting an idyllic environment lacking in social complexity (Kroeber 1922). Though considered primitive peoples, little archaeological attention was devoted to Native American violence prior to the bloody encounters that characterized European contact and colonization (Lambert 2002; Milner 2005). Contrary to early written accounts, archaeological research within the past 25 years supports frequent warfare throughout human history. LeBlanc (2007) reports an absence of prehistoric societies that have witnessed more than three to four hundred years without warfare, a relatively short expanse of time given the antiquity of human civilization, noting most prehistoric societies could go no more than a single generation without violent bloodshed. It has been suggested such large-scale violence emerged as a result of the arrival of Europeans as pre-contact North American societies lacked the social and technological complexity to execute extreme violence (Blick 1988). However, the acknowledgement of aggression and violence as commonly observed behaviors among Homo sapiens has propelled bioarchaeological inquiry into prehistoric intergroup relations.
This chapter opens with a discussion of the difference between interpersonal violence from warfare, a necessary distinction as variable bioarchaeological evidence is associated with each. This is followed by a theoretical discussion of the evolution of violent behavior, taking into account social responses to drastic climatic fluctuations, increasing human populations, and resource competition.

Definitions of Violence

Interpersonal violence is defined here as physical aggression between as few as two people with the express goal and expectation of inflicting injury or death upon the victim(s) (Geen 1990; Anderson and Bushman 2002). While extensions of the definition can include psychological trauma, social ostracism, neglect, and threats or intimidation, forms of injury that leave little to no physical evidence, the present study assesses skeletal injury (e.g., cranial vault depressions or nasal fractures in various stages of repair) likely to have resulted from aggression. Additionally, interpersonal violence involves individuals whose relationship is often familial (Solometo 2008).

Warfare has been minimally defined as socially permissible “collective lethal violence against other groups” (Ferguson 2008:469). Bamforth (1994:95) suggests a more comprehensive interpretation to include violence “which is intended to acquire territory and/or destroy enemy populations and is often accompanied by mutilation of the bodies of the vanquished (including scalping, taking of trophy heads, and removal of other body parts),” resulting in a high number of fatalities. War is organized and purposeful (Solometo 2008), leading to deaths that are premeditated and “morally appropriate and justified by circumstances or prior events” (Kelly 2000:4), for example,
retribution and revenge killing (Blick 1988; Gat 2006a). In addition to physical conflict, warfare includes the “mobilization of people and resources and other preparations” even in times of low threat (Solometo 2008:25) and the destruction or appropriation of enemy supplies or shelters (Kelly 2000).

Warfare differs from interpersonal violence in that it is a collective pursuit directed toward other groups whereas interpersonal violence is physical aggression between as few as two people whose relationship is often familial (Solometo 2008). However, no specific number of participants is required to surpass the threshold from interpersonal violence to warfare. Because evidence of interpersonal violence may be as minor as a single fracture, it is often difficult to identify archaeologically, whereas the expectation for multiple fatalities and numerous skeletal injuries is more characteristic of warfare. While both interpersonal violence and warfare are often represented through skeletal remains (particularly mass burials in the case of the latter), archaeological remains of defensive structures, iconography depicting battles, and the large presence of weaponry are typically associated with warfare.

Causes of Violence

Interest in the causes of violence has been noted in various disciplines with explanations posed from evolutionary, moral, and sociopolitical perspectives, to name a few. Though evident, it is important to note that there are many factors that influence violent behavior, none of which is universal to all societies past or present.
Evolutionary Explanations

One predominant evolutionary argument for the violence within humans is based on reproductive success. Females throughout the animal kingdom, by nature, are less capable than males of producing large numbers of offspring. Male fecundity, in turn, is limited by access to females, which is usually constrained by other males. Such competition among males sometimes results in violent encounters, but the degree to which this type of violence is present is directly related to the type of sexual strategy (e.g., polygyny, polyandry, etc.) each group or species exhibits (Gat 2000a). Human sexuality is variable, though many societies practice monogamy, which means securing a quality mate is of greater importance as that mate selection may last a lifetime. Prehistoric violence among hunter-gatherer groups regularly included stealing women as a cause or result of raids, which sometimes led to a “shortage” of females and the perpetuation of competition over them (Gat 2000a).

Gil-White (2001) argues distinct cultures developed from the evolution of social conformity under the premise that interactions with people who subscribe to a different set of societal norms are more costly from the perspective of evolutionary fitness than interactions with people who share the same norms. Gradual cultural distinctions eroded similarities between early human populations and led to the recognition of separate communities (Vencl 1984). It is widely understood that people tend to gravitate toward like-minded people, and relatives are more likely to maintain similar ideologies and behaviors. Gil-White (2001:519) takes this concept further by suggesting people began to associate “membership in the norm group” with biological relatedness.
It has been further suggested that high levels of violence require competing groups to dehumanize one another through cultural pseudospeciation, the concept that cultures segregate much like biological organisms speciate so that other cultures are classified as different, inferior species (Eibl-Eibesfeldt 1979). Blick (1988) contends humans by nature consider their own groups superior to other culturally dissimilar groups meaning large-scale violence is more likely to be directed toward outside groups. The institutionalization of warfare adds to the “us versus them” mentality and acts to increase collective involvement as societies would much rather have the advantage over their neighbor in a battle than be dominated (LeBlanc 2007). Additionally, the recognition of the enemy as physically weaker reduces the perception of risk of injury to oneself; the weaker the opponent whether due to helplessness, unpreparedness, or the inability to attack in return, the more likely the attack will be fatal (Gat 2006a).

Sociopolitical Explanations

Applicable to both large-scale battles and lesser acts of aggression is the desire to gain submission from one’s foe. This impulse may not serve any other purpose than to humiliate, torture, or avenge a previous trespass, all of which illustrate a play of power upon those who were defeated (Gat 2000b). Such “control over bodies…is a way of engendering political power. And of all the modes of controlling bodies the violence of physical assault is an irresistible mode of domination” (Whitehead 2007:10-11).

Violent impulses may also lack reason. LeBlanc (2006) offers the example of raids between non-neighboring populations who otherwise elicit no threat to one another. The example suggests the possibility that the ancestors of each group may have competed for resources, creating the “us versus them” mentality that endured for generations. While
the original rationale for warfare in earlier generations was logical, the continuation of such reasoning in later generations was not (LeBlanc 2007).

**Environmental and Demographic Pressure**

Proposed explanations for the frequency of brutal combat often rest in environmental or societal circumstance (e.g., severe climatic alterations, resource shortage, and population growth) that culminates in violent struggles over resources. Expeditious population growth among animals and humans is curbed by the limitations of any given ecological setting as well as by the resource rivals and predators within that environment. Prehistorically, as increasing populations diminished the resources within their territory, the remaining options were to stay and expand the territorial range or leave and attempt to find another habitable area. Under either circumstance, populations came to defend territories through brute force for the probability of expanding into or finding habitable (and unoccupied) land with sufficient resources significantly decreased as populations increased (Gat 2000a). Additionally, territories could shift ownership or endure encroachment as a result of the availability of resources within them. For instance, the unpredictable nature of buffalo herds’ migration patterns often caused animal trackers of the Great Plains to cross territorial boundaries into battlefields (Keeley 1996).

While much research seems to support a correlation between warfare and resource scarcity as brought about by population explosions (Gat 2000a; LeBlanc 2007), Keeley (1996) argues violence originating from population pressure serves as an overly simplistic explanation as it makes assumptions about the abundance of a territory and the expectations and behaviors of its occupants. Less densely populated territories do not necessarily have a greater abundance of untapped resources. Similarly, large populations
do not necessarily equate to violent populations, particularly given that modern societies go to battle less frequently and experience fewer deaths when they do than did prehistoric societies, suggesting instead a correlation between increased population size and decreased large-scale violent encounters (Keeley 1996). This is due in large part to the amount of time and energy that must be devoted toward organizing and mobilizing a massive army of soldiers. While weeks or months may be needed for planning modern warfare, only a few hours is needed to arrange a small raid (Keeley 1996), and such surprise attacks could reveal a weak or unprepared opponent (LeBlanc 2007). Further, resources need not be scarce for groups to quarrel over them as simply the possibility of intrusion by foreign entities can elicit strong reactions by existing inhabitants. Even if the intent is merely to pass through a territory, failure to provide an offering or request proper consent may be reason enough for a fight to ensue (Keeley 1996).

As previously mentioned, early historical accounts describe California as a resource-rich environment that provided its inhabitants with an abundance of plant and animal food options (Kroeber 1925; Raab and Jones 2004). However, the concept of abundance is proportionate to the number of individuals reliant upon those resources and is therefore deceptive (Gat 2000a). While there may have been many species from which to choose, such reportedly free flowing resources were subject to overexploitation in the presence of growing populations as well as landscape altering climatic changes (Broughton 1994; Raab 1996; Rosenthal et al. 2007). The Medieval Climatic Anomaly, occurring between A.D. 800 and 1350 and characterized, depending on location, by sudden recurrent droughts and aridity separated by brief intervals of precipitation, coincided with significant cultural responses such as decreases in health and population...
and increases in site abandonment and violence brought about by drought induced food shortages (Jones et al. 2004; Schwitalla and Jones 2011).

**Resource Intensification Models**

The long-held belief that prehistoric California populations were ecologically conscious and incapable of environmental degradation has been disputed by numerous archaeological analyses (Raab 1996), specifically those indicating a decrease in the exploitation of large vertebrates during the late Holocene (Broughton 2001). Rapidly increasing prehistoric populations, particularly between the Early and Late periods, taxed the California landscape (Lambert and Walker 1991).

Human behavioral ecology models focus on the transition from the hunter-gatherer lifestyle to the sedentary lifestyle associated with agriculture. Such models postulate past human populations showed a “tendency towards optimal forms of behavior” in terms of food acquisition (Winterhalder and Kennett 2006:11). Foraging efficiency models, which describe foragers’ attempts to maximize energy returns while maintaining minimal energy expenditures in terms of searching for and procuring resources, attempt to explain the human use of plants and animals in prehistoric California (Raab and Jones 2004). Proponents of optimal foraging models maintain humans make the logical choice to pursue only those resources with the highest net return rates of energy with consideration given to dietary selection, settlement and foraging sites, planning of foraging pursuits, and diet breadth (Reitz and Wing 2008). Dietary selection is directly related to resource availability and the societal elements affecting human access to them (Kennett et al. 2006), whereas the latter, diet breadth, weighs resource abundance against the amount of energy needed to hunt and acquire each
resource, the amount of time required to process each resource, and the amount of return energy each resource provides (Reitz and Wing 2008). However, the human exploitation of any one species within a landscape, without deliberate conservation, may result in resource depression, the diminished procurement rate of that species by humans (Grayson 2001).

Foraging theory’s prey choice model predicts that late Holocene populations placed a higher importance on large mammals as they offered higher return rates for the energy expended to procure them than smaller mammals. Further, the pursuit success of large game like artiodactyls (deer, elk, and pronghorn sheep) would have been greater than that of lagomorphs (primarily rabbits), both significant species to North American prehistoric hunter-gatherers, due to the greater target area and lower likelihood for concealment in dense vegetation of artiodactyls (Broughton et al. 2011). Such dependence led to large mammal population decreases and an increase in diet breadth to include more abundant, lower-ranked resources (Broughton 2001; Raab and Jones 2004). Possible responses to resource depression are the expansion of the home range or increased use of more distant patches (Grayson 2001). Bayham et al. (2012) suggest boundary areas developed in more distant locations from the home range where large prey, exposed to fewer threats of hunting, could restore their numbers. Either situation is expected to be associated with increased proximity between growing communities, leading to direct competition for limited resources, and increasing the likelihood for interpersonal conflict.

The increase in diet breadth during the late Holocene saw technological advancements in California that support a shift toward greater lower-ranking resource
reliance, such as acorns, and from the use of the atlatl towards an increased reliance on the bow and arrow as early as AD 500 (Moratto 1984; Walker and Lambert 1989; Walker 2001; Raab and Jones 2004). It has also been suggested “conflict is a prime mover that drives societies toward greater political complexity” (Lambert and Walker 1991:970). The prevalence of arrow point injuries at California sites around this time “suggests that the value of the bow and arrow in warfare was an important stimulus for its adoption” (Walker and Lambert 1989:210). While the specific motivation for the adoption of the bow and arrow remains debatable, the increase in serious injuries from these weapons throughout the Middle Period is undeniable.

Summary

Despite arguments for the cause of interpersonal conflict, the capacity for violence is an attribute of all societies, human and non-human, past and present, and the degree of which can be inferred through the analysis of human skeletal remains, among other methods. The following chapter addresses this possibility through discussion of craniofacial trauma identification and patterns. Summaries of results from similar studies on craniofacial trauma from prehistoric societies across the United States are discussed in Chapter III, with particular attention given to southern and Central California, providing the basis for a discussion of the research expectations of the present study.
CHAPTER III:

CRANIAL TRAUMA

Introduction

Indigenous peoples of North America have long been characterized as peaceful, limiting violent encounters to acts of retribution (Kroeber 1922). As discussed in the previous chapter, violence is an ordinary component of human societies past and present (Keeley 1996; Larsen 1997; Thorpe 2003; Raab and Jones 2004; Arkush and Allen 2008), and human skeletal analyses can provide insight on evidence of interpersonal violence within a population (Walker 2001). This chapter discusses the analysis of skeletal remains as a method of interpreting violent behavior in prehistoric societies first by defining injury classifications (antemortem, perimortem, and postmortem) and then by differentiating between the typical osteological responses of violent force on cranial vault and facial bones. Next is a review of similar studies on craniofacial trauma from archeological sites across the United States, with particular focus on trends in California. The chapter closes with a discussion of the research expectations for this study.

Skeletal Remains as Evidence

As noted, skeletal trauma can provide evidence for the likely cause of death of an individual, and the location and type of injuries may provide clues regarding the
mechanism of injury. Though trauma throughout the body can occur as a result of intentional, occupational, or accidental injury (Lovell 1997), the increased frequency of particular types of trauma, considered within a wider archaeological context, may narrow down the likely causes (Walker 2001). For example, the presence of embedded projectile points provides indisputable evidence of weapon wound injuries (Jurmain 2001), and the high prevalence of such wounds as well as cranial trauma within a population is more likely to represent interpersonal violence or warfare (Lambert and Walker 1991).

Analysis of multiple lines of evidence including, but not limited to, the visual and microscopic inspection of skeletal remains, radiographic images, clothing, and evidence of weaponry is of exceptional importance to the accurate assessment of skeletal trauma (Ortner 2008). Such evidence is more commonly available in cases forensic in nature, and is much less typical of prehistoric skeletal remains, even with favorable preservation and proper excavation techniques. In the event the only remaining evidence is skeletal, the examiner relies on identifiable patterns of skeletal trauma in an attempt to discern antemortem and perimortem trauma from postmortem damage, and accident from intent. Though the analysis of individual injuries in one location of the body is less revealing than the analysis of multiple injuries throughout the body (Jurmain 2001), focus is given to craniofacial trauma as the pattern and prevalence of these injuries may be suggestive of interpersonal violence. For example, Lambert (2002) cites nasal fractures and cranial vault depressions as among injuries considered to occur under violent conditions.

Knowledge of the composition of bone provides a basis for identifying the types of fractures and their associated patterns. Because fracture patterns vary between
the bone tissue of living and deceased individuals, it is possible to determine when such
fractures occurred. This chapter opens with a description of injury categorization and
fracture identification and concludes with a discussion of contemporary research in
cranial trauma analysis.

The Composition of Bone

Bone consists of two main components; approximately one-third of which is
organic matter and the remaining two-thirds, inorganic matter (Brothwell 1981). Collagen
and non-collagenous proteins form the organic component and the mineral compound
hydroxyapatite forms the inorganic component. These provide bone with both flexibility
and rigidity, properties necessary for weight bearing and fracture resistance.

Like any other living tissue, bone is subject to injury and disease, and requires
proper nourishment in the form of oxygen and nutrients. Water, polysaccharides, and
blood vessels are vital constituents of bone tissue as they help maintain general health
(Galloway 1999a). On a cellular level, bone tissue is maintained by osteoblasts and
osteoclasts, specialized cells that continuously deposit new and resorb dead tissue,
respectively. Similarly, new cartilage is produced by chondroblasts.

Though the cellular and molecular structure of bone does not vary by element
(White and Folkens 2005), the density, and therefore, strength, of bone is dependent upon
its porosity. Two types of bone are present within the body: densely packed cortical bone,
which comprises the diaphyses of long bones, and porous trabecular bone, found in long
bone epiphyses, short bones, irregular bones and in the diploë of cranial bones.
Most cranial bones are composed of distinct layers: an outer table, an inner table, and diploë, the middle layer. The outer table is tough and durable, providing protection against injury. Analogous with porcelain, the inner table is hard, but prone to fracture under impact. The spongy diploë offers shock-absorbance. These three layers of variable density give cranial bone “more strength than solid bone of the same thickness” (Rogers 1984).

Injury Categorization

**Antemortem Injury**

Skeletal injuries occurring prior to death, antemortem injuries, are generally distinguished by the presence of healing, which is characterized by the deposition of new bone cells by osteoblasts. In short, upon injury to bone, inflammation sets in, which consists of the formation of a hematoma at the trauma site (in the medullary cavity, along the fracture margin, or under the raised layer of periosteum) (Barbian and Sledzik 2008) followed by the resorption of dead bone cells via osteoclasts. Within approximately one week of injury, osteoblasts and chondroblasts begin to stabilize the fracture by forming a callus of mineralized woven bone within the hematoma (Sauer 1998; Galloway et al. 1999). Over time, the deposition of lamellar bone remodels the bony callus to a smoother surface (Steele and Bramblett 1988). In the case of a cranial fracture, the fracture margin becomes more rounded with healing (Barbian and Sledzik 2008).

Antemortem injuries may be observed in various stages of healing, the degree of which may serve as a general indicator of the amount of time elapsed since injury. However, remodeling rates vary per individual based on age, general health, severity of
the fracture, and level of blood supply to the affected area, among other factors. Low levels of blood and oxygen supply coupled with the bone instability throughout the repair process may result in the development of more cartilage than bony callus at the fracture site, potentially causing the development of a “false joint,” or pseudoarthrosis (Galloway et al. 1999; Steele and Bramblett 1988). Similarly, cranial injuries may be slow to repair, particularly in adults, if periosteal blood vessels are damaged as this prevents the traumatized region from receiving adequate oxygen and slowing the development of the callus (Rogers 1984).

**Perimortem Injury**

Injuries occurring near or at the time of death, perimortem injuries, tend to be more difficult to identify, but can often be distinguished from antemortem injuries by the absence of healing, or significant healing, or postmortem damage by the lack of discoloration of bone along fracture lines. When fractures occur, osteoclasts are first to respond, followed by osteoblastic activity more commonly in the second or third week post injury (Barbian and Sledzik 2008). Splintered, jagged, or curled edges of fractured bone are typical identifying features of perimortem skeletal injuries (Sauer 1998).

Additionally, fractures sustained to fresh bone visibly differ from those caused to desiccated bone. The high moisture content in fresh bone allows more flexibility and tensile strength under mechanical strain (Sauer 1998). Such strain often causes bone deformation in living or recently deceased individuals (Galloway et al. 1999).

**Postmortem Damage**

Naturally, fractures occurring postmortem lack evidence of healing and typically display a distinctly different color than that observed on intact skeletal elements.
As the organic components of bone tissue degrade, the yellow hue of once living bone gradually whitens and bone becomes brittle. Fractured areas of desiccated bone appear whiter than intact surfaces and produce fragments with cleaner edges (White and Folkens 2005).

Skeletal remains, whether interred or exposed, are subject to taphonomic processes, any changes that occur between death and recovery. Soil staining, sun bleaching, weathering, carnivore and rodent gnawing, burning, and erosion are among the more common forms of taphonomic damage (White and Folkens 2005). The tools and techniques of recovery, such as the use of shovels or heavy machinery, may also affect the condition of skeletal remains.

Fracture Identification

Bioarchaeological evidence suggestive of interpersonal violence includes projectile point impacts, cut marks, particularly as a result of decapitation, other forms of dismemberment and scalping, and depressed cranial fractures (Larsen 1997; Lambert 1997; Standen and Arriaza 2000; Jurmain 2001; Andrushko et al. 2005; Steadman 2008). Patterned trauma to the cranium and projectile injuries throughout the body are particularly indicative of interpersonal violence (Lambert and Walker 1991).

Significant fractures to the face and cranium are commonly fatal whether caused deliberately or by accident, however, the patterning of craniofacial lesions tends to vary between the two (Walker 1989). Accidental injuries typically result in fractures of various size and shape in no particular pattern throughout the skull, whereas intentional injuries tend to be of similar size and shape and concentrated in certain regions of the
skull (Walker 1989). Additionally, craniofacial fractures are typically the result of direct trauma (Lovell 1997), whereas injuries to long bones allow for a greater range of interpretation. Lovejoy and Heiple (1981) report a 45 percent frequency of any single individual displaying a long bone fracture from a Libben population in Ottawa County, Ohio. This strikingly high fracture prevalence is attributed to exposure to extreme physical activity rather than interpersonal violence as fracture frequencies were equivalent between males and females and only two skull fractures were observed within the entire sample (Lovejoy and Heiple 1981). Were the fractures more likely the result of violence, cranial trauma and a higher prevalence in males would be expected.

A primary factor in the type of craniofacial injury sustained is the rate of deformation due to the amount of applied force from a weapon, including its velocity, weight, and composition. The cranial response to such force is dependent upon the strength, rigidity or flexibility, and structure of the bone and associated soft tissues, characteristics that vary by location in the body (Ortner 2008; DiMaio and DiMaio 2001). Once bone has sustained plastic deformation due to a slow load force, it will not return to its original proportions (Berryman and Symes 1998).

As mentioned, bone possesses a degree of flexibility and can therefore exhibit varying results when traumatized. But damage is heavily dependent on the pressure applied and in terms of the “rate of loading common to blunt force trauma,” bone will fail before it bends inward or outward (Kroman et al. 2011:316). Bones that provide less resistance under pressure may return to their original form after the pressure is removed. However, the velocity at which the pressure is applied may result in deformation if coming on slowly, or may fracture under a heavy load (Ortner 2008). Serious cranial
vault injuries are identified as linear, penetrating, or depressed fractures while healed or healing injuries are used to assess facial trauma.

**Cranial Fractures**

Cranial injuries may consist of sharp force trauma in the form of minor lacerations, abrasions, contusions, and incised wounds to more damaging linear and depressed fractures typically caused by blunt force trauma (Lovell 2008). Though possessing the potential for greater cranial damage depending on the location and force applied, lacerations, abrasions, contusions, and incised wounds tend to produce superficial injuries (Courville 1962).

Blunt force trauma refers to injury caused by the impact of an object with a large surface area such as clubs and rocks. Blunt force trauma may also be the result of falls or crush injuries. Though no specific weapon size differentiates sharp from blunt force trauma, the former is more commonly associated with puncture or penetrating injuries while the latter associates with more severe forms of fracturing. Like sharp force trauma, the level of injury is dependent upon the instrument used, its weight and density, and the force applied (Lind 1990).

Linear fractures tend to radiate quickly through cranial bone, fracturing along the path of least resistance (Galloway 1999b). These fractures may be simple in that they produce a single linear break, or complex in that multiple linear fractures are produced at and radiate from the point of impact (Berryman and Symes 1998). Though typically creating a complete fracture through both inner and outer tables of cranial bone, linear fractures usually cause less significant damage as bone displacement or depression do not typically occur (Lovell 2008). Linear fractures of the cranial vault are mainly associated
with blunt force trauma, but may also result from forces administered to other regions of the body such as the spinal column (Galloway 1999b). The radiating and concentric fractures associated with multiple blunt force blows to the cranial vault can result in the flaking or delamination of bone along the fracture margin (Berryman and Symes 1998).

Depressed fractures are recognized by a distinct indentation of the inner portion of a circular fracture, and are sometimes associated with radiating linear fractures and the presence of bone fragments in the brain (Courville 1962). Depressed vault fractures are caused by low-velocity direct impact generally as a result of either falling on raised objects or sustaining blows in hand-to-hand combat (Lovell 2008). Penetrating wounds are more likely caused by objects with a sharp end such as a spear or arrow (Lovell 2008). This form of trauma is distinguished from depressed cranial fractures in that the damage is concentrated at the point of contact, producing a pit or hole in the skull. Linear, depressed, and penetrating cranial fractures vary in degree depending on the size, shape, and applied force of the implement and the thickness of the skull at the point of impact (Courville 1962; Lovell 2008).

Facial Fractures

Some bones of the face are delicate and subject to fragmentation under pressure, while other facial bones are more rigid, providing a stable base for the more fragile ones (Galloway 1999b). Blows to the face, though rare in prehistoric populations (Owens 2007), most often affect the frontonasal region producing transverse fracturing of the nasal bones, which may travel into the maxilla given enough force (Walker 1997). Galloway (1999b) describes the maxilla as the most easily fractured facial bone, the degree to which tends to be dependent upon the presence of absence of the dentition.
With the exception of maxillary and nasal injuries, it is difficult to generalize patterns of trauma in facial bones aside from their typically less dense and more fragile composition, which make them “prone to crushing fractures or distortions” (Owens 2007:470). However, the mandible is quite dense and usually requires great force to fracture (Lovell 2008). Distortions or asymmetry are good indicators of healed facial trauma (Jurmain and Bellifemine 1997).

Bioarchaeological Analyses

Increasing interest in archaeological evidence of interpersonal violence through the examination of craniofacial trauma has been noted over the last several decades. The following section reviews several studies addressing this topic using archaeological populations across the United States. Specific attention is given to archaeological studies in California as craniofacial trauma prevalence rates, particularly in southern California, are typically higher than those observed outside of the state (Jurmain et al. 2009).

The Great Plains, Southwest, and Southeast United States

While the introduction of Europeans to the New World was characterized by hostility and bloodshed, many native groups were already well aware of the perils of battle. Archaeological research, particularly in the Great Plains, Southwest, and Mississippian chiefdoms, reveals evidence suggestive of violence and warfare in prehistoric societies such as the development of defensive fortifications, communities in naturally isolated areas, advanced technology and weaponry, remains of burned sites,
artwork decorating utilitarian objects, and skeletal trauma (Solometo 2008; Steadman 2008).

Archaeological evidence from the Missouri River in the Great Plains region, particularly along the ‘Missouri Trench’ of the Dakotas, revealed remnants of defensive structures like ditches, palisades, and bastions radiocarbon dated between 800 B.P. and 700 B.P., just after the emigration of horticultural groups from present day Nebraska. The presence of defensive structures alone is not substantial evidence warfare took place. These structures may have acted as effective deterrents of warfare, or perhaps held ceremonial or symbolic meaning (Bamforth 1994).

More convincing signs of warfare come from the discovery of human skeletal remains from at least 486 individuals of varying age interred in the outer fortification ditch at Crow Creek, South Dakota, which demonstrate significant trauma in the form of depressed cranial fractures, dental fractures along the cemento-enamel junction, cut marks suggestive of scalping, decapitation, and removal of the nose and tongue while postcranial cut marks suggested removal of the hands and feet (Willey 1990). Such specific patterns of trauma sustained to a large number of people of various age groups suggest deliberate, organized brutality.

Small-scale violence prior to Crow Creek is evident in the Great Plains as observed at Fay Tolton, a small settlement of brief occupation near the Missouri River in central South Dakota dating between 920 B.P. and 850 B.P. (Bamforth 2008). The remains of a decapitated young male were recovered from one house; in a second house, two adolescent females, a juvenile of indeterminate sex, and an older male were
recovered (Bamforth 2008). Cut marks and necrosis on the skull of the juvenile were interpreted as scalping weeks prior to death (Holliman and Owsley 1994).

In east-central Arizona, between 1150 B.P. and 750 B.P., additional evidence suggestive of prehistoric warfare in North America has been noted. Prehistoric communities along the Chevelon Canyon, East Clear Creek, and Jacks Canyon, transitory channels that flow into the Little Colorado River, are characterized by an increase in the number, type, and complexity of fortified site structures through time (Solometo 2008). Small, basic rectangular structures typify the early period, 1150 B.P. to 850 B.P., while the late period, 850 B.P. to 750 B.P., sees the introduction of lookouts, blocking walls, and temporary habitation structures in defensible areas such as on top of canyon walls and steep volcanic mesas (Solometo 2008).

In addition to the construction of complex fortifications similar to those previously discussed, the introduction of the bow and arrow during the Late Woodland and Mississippian saw a sharp increase in skeletal trauma in the south. “Parry” fractures and embedded projectile point injuries are observed in 19 of 78 individuals (24%) from the Lubbub Creek chiefdom of western Alabama, while 13 percent of individuals exhibited embedded projectile point injuries in another Late Woodland site (Dye 2008). At this same site, 46 percent of males and 36 percent of females show at least one healed fracture (Dye 2008). The Koger’s Island chiefdom of the western Middle Tennessee Valley display similarly high levels of trauma: 47 percent of individuals exhibit skeletal trauma; 22 percent show cranial trauma in the form of scalping or depressed fractures; 70 percent were interred with additional body parts such as hands; and four percent were missing parts, such as heads, forearms, and hands (Dye 2008).
Archaeological evidence of palisades at Orendorf, a Middle-Mississippian site in Illinois, suggests protection from intruding populations, an interpretation further supported by the prevalence of lethal skeletal injuries more representative of intergroup violence. Evidence of decapitation, scalping, depressed cranial trauma and embedded projectile points were observed in nine percent of Orendorf residents with no difference noted between males and females (Steadman 2008).

Skeletal remains from eight Late Mississippian sites in the Chickamauga Reservoir in East Tennessee also present signs of deliberate trauma in the form of cranial blunt force trauma, embedded projectile points, and scalping (Smith 2003). While scalping and projectile point injuries are reasonably associated with lethal intent, and are therefore more indicative of intergroup violence, the majority of blunt force injuries observed in the Chickamauga Reservoir are small, nonlethal depressions. Smith (2003:314) suggests these injuries, which are more prevalent than scalping and projectile injuries, are the result of intragroup violence, more specifically, “gender specific, codified, face-to-face conflict resolution” as the majority of victims are female and their injuries non life-threatening.

Southern California

Archaeological research, particularly within the last two decades, provides evidence for interpersonal violence in prehistoric California, though the patterns and prevalence of violence vary between populations through time (Walker 2001). While prehistoric California exhibits some of the highest levels of interpersonal violence in the world (Jurmain et al. 2009), evidence of defensive structures, though expected, is lacking in the archaeological record. The majority of evidence suggestive of interpersonal
violence is derived from the analysis of human skeletal remains. Walker (1989) observed roughly 19 percent of burials from multiple sites in the northern Channel Islands and coastal mainland to exhibit at least one cranial injury. Of these injuries, most were concentrated on the frontal and parietals, respectively, with slight preference to the left side of the skull (Walker 1989). Most cranial injuries were observed in males between the ages of 25 and 40, the age range most observed among affected females (Walker 1989). Walker (1989) notes a large number of these cranial injuries were nonlethal, therefore, suggesting the population participated in battles meant to resolve conflicts through injuring opponents.

Walker and Lambert (1989) noted a high level of violence observed in the prehistoric skeletal collection from the CA-VEN-110 site in the Santa Barbara Channel. Approximately 10 percent of adults among the 114 burials show evidence of interpersonal violence, mostly in the form of arrow point injuries (Walker and Lambert 1989). Later research from this site and others within the Santa Barbara Channel indicates a disparity between lethal and sublethal trauma based on geographical location and time, with island sites exhibiting higher numbers of sublethal injuries likely due to greater competition for more limited resources (Lambert and Walker 1991).

Additional research from the Santa Barbara Channel area indicates 17 percent of 753 individuals examined from 30 prehistoric and historic sites show signs of healed cranial fractures, most of which were spherical in shape suggesting these individuals sustained a blow from a club-like instrument (Lambert 1997). In each age category, males were more likely to have sustained cranial injuries than females, with males exhibiting more fractures to the left side of the frontal, suggesting face-to-face conflict
The high frequency of healed depressed fractures in males may indicate intratribal fighting in which the goal was to injure, but not kill the opponent (Walker 1989). Lambert (1997) also notes the increase in cranial trauma through time, reaching its height in the late Middle Period as increasing populations became more sedentary. The majority of the approximately three percent of 1,744 individuals showing projectile point injuries were male with 25 percent of these injuries having affected the head and neck (Lambert 1997).

A comparison of skeletal trauma between samples of two prehistoric San Clemente Island sites revealed a disparity in cranial injuries (Titus and Walker 2000). Individuals interred at CA-SCLI-043, an early Holocene site, display a high level of cranial trauma compared to those interred at CA-SCLI-1215, a Middle Period site, which exhibit no cranial trauma (Titus and Walker 2000). One possible explanation for such a reduction is the adoption of trade as the preferred alternative to violence (Titus and Walker 2000).

**Central California**

Jurmain (2001) reports a craniofacial trauma prevalence of 4.4 percent among individuals from CA-SCL-038, which was occupied as early as the Early/Middle Period transition. The presence of these injuries coupled with the frequency of observed embedded projectile points indicates that interpersonal violence within this cemetery sample was relatively common (Jurmain 2001). Jurmain (2001:19) notes the prevalence of craniofacial trauma in this Santa Clara Valley cemetery site is “moderately high” compared to studies worldwide, but unremarkable for prehistoric California populations.
Andrushko et al. (2005) note the frequency of absent forearms among skeletal remains from the CA-SCL-674 cemetery site, primarily occupied between 770 B.C. and A.D. 365. Fourteen of 224 burials (0.06%) were missing forearms, 12 of which show evidence of intentional forearm removal in the form of cut marks on the distal humeri (Andrushko et al. 2005). All of the affected individuals were adult males, mostly between the ages of 18 and 35, which suggest the missing forelimbs may have been removed as a form of trophy-taking as opposed to ancestor worship (Andrushko et al. 2005). While trophy-taking is associated with other prehistoric California populations, Andrushko et al. (2005) note the specific pattern of human modification of the severed forearms, which show signs of drilling and polishing, is unique to the CA-SCL-674 cemetery population.

A subsequent analysis of trophy-taking and dismemberment in a sample of 13,453 individuals from sites throughout prehistoric central California identified 87 cases of perimortem removal of the upper and lower limbs, scalping, and in one unique case, disembowelment in 76 individuals, for a total trauma prevalence of 0.56 percent (Andrushko et al. 2010). Patterns identified among “trophy victims” included the increased likelihood of randomly positioned interment with multiple other individuals, with young males (18-25 years of age) representing the most common fatalities (Andrushko et al. 2010).

The prevalence of interpersonal violence at CA-ALA-329 in the San Francisco Bay Area was assessed by Jurmain et al. (2009) through evidence of fractures to the cranial vault (3.3%), facial bones (6.1%), radius (4.3%), and ulna (5.2%). Fifteen individuals exhibit 17 embedded projectile points to the upper body, pelvis, and skull; young adults (16-34 years) show a higher prevalence (Jurmain et al. 2009). This site,
dating from 1500 B.P. to European contact, shows increases in projectile point and craniofacial trauma through time (Jurmain et al. 2009).

Additional research focusing on temporal and regional trends in interpersonal violence in 2,852 individuals from the San Francisco Bay Area dating from approximately 3000 B.C to A.D 1700 reveals elevated cranial vault trauma and trophy-taking prevalence rates, particularly during the Early/Middle Transition (Bartelink et al. 2013). These injuries as well as projectile point wounds are notably more common among males, a result in correlation with previous studies (Bartelink et al. 2013).

The previous studies note relatively low trauma prevalence rates within central California with the exception of one study by Nelson (1997) which reports a skeletal fracture frequency of 14.9 percent among craniofacial and forearm bones. The majority of these injuries, which occur more frequently in adults, are scored as sublethal antemortem trauma with their likely etiology associated with either failed attempts or intentional prevention by the opponent to deliver more serious injury (Nelson 1997).

Research Expectations

This study examines the prevalence of craniofacial trauma suggestive of interpersonal violence in the cranial remains of adult individuals recovered from multiple late Holocene archaeological sites in the Central Valley (4950-200 B.P.) through consideration of the following hypotheses:
Research Expectation One: Increase in Craniofacial Trauma Prevalence Through Time

I predict that the prevalence of cranial vault and facial injuries in the form of projectile wounds, cut marks, and depressed and linear fractures will increase from the Early Period through the Late Period. Increasing human populations and climatic changes between the Early and Late Periods in central California culminated in the overexploitation of food resources, particularly large vertebrates. The resource depression that resulted placed growing communities in greater proximity to one another, creating direct competition for limited resources, and increasing the likelihood for interpersonal conflict. Support for this hypothesis is anticipated through the observation of a temporal increase in the prevalence of cranial vault and facial trauma as evidenced by the patterned nature of the injuries. The failure to observe an increase in cranial vault and facial trauma does not support the hypothesis and instead suggests the level of interpersonal violence shows no significant difference through time.

Research Expectation Two: Greater Prevalence of Craniofacial Trauma on the Left Side of the Cranium

I predict the prevalence of cranial vault and facial injuries will be higher on the left side of the cranium as a result of face-to-face combat and the predominant use of the right hand by the opponent. A higher prevalence of injury to the left side of the cranium will support this hypothesis. An injury prevalence to the left side of the skull equal to or less than the prevalence of injury to the right side of the skull does not support one or both of the assumptions of face-to-face fighting and the predominant use of the right hand.
Research Expectation Three: Greater Prevalence of Craniofacial Trauma in Males

I predict the prevalence of cranial vault and facial injuries will be higher in males than females in each time period as males are more likely to engage in violent acts. A higher frequency of males in each time period displaying cranial vault and facial trauma will support this hypothesis. A higher prevalence of cranial vault and facial trauma among females will not support the hypothesis and may suggest either greater female involvement in violent situations, particularly if the trauma is more prevalent on the left side of the cranium, or, that females are the more likely recipients of violent acts, particularly if the trauma is randomly dispersed throughout the face and cranium.

Summary

The studies referenced in this chapter present data on trauma typical of interpersonal violence in California prehistory. Recent archaeological research has encouraged a re-evaluation of intergroup relations in prehistoric California, which show some of the highest prevalence rates for projectile point injuries in the New World (Jurmain 2001). The pervasiveness of such injuries among prehistoric hunter-gatherers may have been the result of multiple processes such as increased sedentism, population increase, the introduction of hierarchical societies, increased territorial defense, resource depletion, and climatic fluctuations (Walker and Lambert 1989, Lambert and Walker 1991, Ferguson 1997, Broughton 2001, Walker 2001, Rosenthal et al. 2007). Thus, competition for resources, which took the form of direct interpersonal conflict, increased.
CHAPTER IV

MATERIALS AND METHODS

Introduction

The methods used to collect and analyze data for the present study are discussed in the following chapter. Sex and age estimation methods are presented first using both cranial and postcranial elements. Next, a description of the techniques used to identify craniofacial trauma is presented, followed by a discussion of the documentation of craniofacial trauma within the sample. Consideration of the chronology used for temporal analyses and the statistical methods appropriate for this study are also discussed. The chapter closes with a summary of each of the archaeological sites from which the craniofacial remains used in this study are associated.

Data Collection Methodology

The prevalence of interpersonal violence is analyzed through the examination of craniofacial trauma among males and females through time using 212 adult individuals from the six late Holocene sites in the Central Valley. The skeletal collections associated with each site are currently housed at the Phoebe A. Hearst Museum of Anthropology at the University of California at Berkeley. Osteological analyses of all skeletal remains were conducted on site between March and June 2009. Additional access to the skeletal remains of specific individuals for radiography transpired in June 2010.
Previous analyses by Bartelink (2006) provided information on the age, sex, and chronology for the majority of the individuals within this sample. The temporal placement of each burial was based on seriation notes of the late James A. Bennyhoff. The analysis of individuals not included in the sample used by Bartelink (2006), sex and age determinations were assessed using the cranial indicators discussed below.

**Sex Estimation**

For the prevalence of craniofacial trauma between males and females, only adult individuals of known sex are assessed. In this portion of the analysis, 97.2 percent (206/212) of the sample was sexed using established osteological standards. Of these individuals, 41.5 percent (88/212) were males and 55.7 percent (118/212) were females.

The majority of the sample, 80.2 percent (170/212), was sexed and aged by Bartelink (2006) using methods outlined in Buikstra and Ubelaker (1994). More accurate sex estimation methods include examination of sexually dimorphic traits of the pelvis: the greater sciatic notch, preauricular sulcus, and subpubic region (e.g., ventral arc, subpubic concavity, and ischiopubic ramus ridge) (Phenice 1969; Buisktra and Ubelaker 1994). Bartelink (2006) scored sexually dimorphic traits of the cranium (e.g., nuchal crest, mastoid process, supraorbital margin, glabella, and mental eminence) using methods derived from Ascádi and Nemeskéri (1970) and Buikstra and Ubelaker (1994). In the absence of pelvic or cranial remains, Bartelink (2006) measured femoral and humeral dimensions as outlined by Dittrick and Suchey (1986). For the 19.8 percent (42/212) of individuals not analyzed by Bartelink (2006), the aforementioned cranial indicators were used by the author to estimate sex.
As patterns of behavior differ between males and females, accurate estimation of sex is critical in the assessment of interpersonal violence. As previously mentioned, males are more likely to take risks and resort to physical force as a means of conflict resolution (Standen and Arriaza 2000). Though female involvement in warfare has been recorded in prehistoric and historic populations in Asia and the Americas (Thorpe 2003), females are far less likely than males to participate (Lambert 1997). It is therefore expected that this research will show a marked difference in the prevalence of craniofacial trauma between males and females, with males exhibiting higher levels of trauma sustained to the left side of the skull. The observed pattern of left cranial injury prevalence is consistent with instances of hand-to-hand combat as humans are predominantly right-handed (Kremer et al. 2008).

**Age Estimation**

Though excluded from the assessment of interpersonal violence by sex, 2.8 percent (6/212) of adult individuals whose sex is indeterminate were included in the assessment of interpersonal violence through time. While not limited to any particular demographic, interpersonal violence is more commonly observed in adult individuals (Jurmain et al. 2009), therefore only adult (18 years of age or older) crania were included in the present study.

Methods of adult age estimation using the male and female pubic symphysis as described by Katz and Suchey (1986), Brooks and Suchey (1990), and Buikstra and Ubelaker (1994) were used by Bartelink (2006) to assess 80.1 percent (170/212) of the sample. Techniques described by Lovejoy et al. (1985) and Buikstra and Ubelaker (1994) were also used by Bartelink (2006) to assess age-related degeneration of the auricular
surface of the ilium. In addition, Bartelink (2006) estimated age through ectocranial suture closure as outlined by Lovejoy et al. (1985) and Buikstra and Ubelaker (1994).

As this study does not assess interpersonal violence within specific age categories among the broader categorization of adult, age estimation for the remaining 19.8 percent of the sample not analyzed by Bartelink (2006) was determined primarily through dental formation and eruption patterns as outlined by Ubelaker (1989) and Buikstra and Ubelaker (1994), which indicate full eruption of permanent dentition by age 21. Though highly variable between human populations, dental attrition of occlusal surfaces was also considered since significant wear is more likely to be observed among adult individuals (Larsen 1997).

Craniofacial Trauma Identification

Depressed cranial fractures were identified by their varying degree of sunken or concave appearance, the majority of which were circular or ovoid in shape and presented pronounced margins. All of the cranial vault depressions observed were recorded as having occurred antemortem due to the degree of bone remodeling present.

Facial fractures were identified by irregularities in the external surface of bone or asymmetry of paired bones. Facial trauma was primarily identified as antemortem nasal fractures with obvious signs of remodeling and displacement that would have required a significant amount of time. Fractured teeth may also indicate trauma, but were not recorded in this study as much of the sample exhibited significant wear or were edentulous.

Antemortem injury is identified by evidence of remodeling as observed in the immediate outgrowth and eventual resorption of bone at the trauma site; the degree to
which this remodeling occurs is dependent upon the severity and location of the injury. Antemortem is differentiated from perimortem injury, trauma that occurs at or near the time of death, as the latter lacks significant signs of remodeling. Perimortem trauma can be distinguished from postmortem damage in that living bone is more capable of bending or splintering if fractured. After death, bone collagen deteriorates leaving the bone brittle and vulnerable to shattering. Fractures occurring perimortem may be identified by the continuity of the coloring of bone as the damaged area is more uniformly exposed to taphonomic processes. Alternatively, postmortem damage often results in the inconsistent coloring of the bone; the fracture site itself tends to be whiter in color as it had been more protected from taphonomic processes by the external aspects of the bone.

Included in the normal range of human variation are epigenetic traits, which may manifest as bilateral irregularities in bone such as the depressed appearance of congenital parietal thinning and can be misidentified as antemortem trauma. For this study, crania exhibiting an abnormality not readily identified as trauma were examined bilaterally whenever possible. Similarly, disease processes may result in the remodeling of bone similar to that observed after injury, though conversely, substantial bony responses may be indicative of infection incurred post traumatic injury (Ortner 2008).

Craniofacial Trauma Documentation and Analysis

Macroscopic observation of exterior indications of antemortem and perimortem cranial vault and facial injuries were recorded with skeletal inventory forms and cranial diagrams. For a more comprehensive analysis of trauma prevalence, cranial vault and facial trauma were recorded separately. This may also provide increased
understanding of the behaviors associated with the cause of each injury type (Walker 1997). Notation of the orientation and location of each injury in relation to known anatomical features and landmarks was also noted along with a description of the type of fracture resultant of the force, sharp or blunt.

Noteworthy traumatic injuries were documented through precise measurement using Cen-Tech® 6” digital calipers and their location recorded in relation to major landmarks of the face and cranium. Canon PowerShot S200 Digital ELPH and Canon PowerShot SD1200 IS Digital ELPH cameras were used to capture initial images in 2009 and secondary images in 2010. Anterior-posterior radiographs taken by staff at the UC Berkeley Orthopaedic Biomechanics Laboratory from a Hewlett-Packard Faxitron x-ray machine of each individual exhibiting craniofacial trauma were used to further assess injury severity.

Reconstructions of fractured bones, whenever possible, provide a more complete assessment of traumatic injury. Reconstructions with adhesive were not permitted by the Phoebe A. Hearst Museum of Anthropology, therefore significantly fractured crania which were not previously reassembled were excluded from this study. Similarly, to minimize bias due to preservation, only relatively complete (>70%) skulls of adult individuals were included in this research.

Statistical analyses include the chi-square test to compare craniofacial trauma prevalence through time, between each side of the cranium, and by sex. When results yielded expected counts less than five for two by two comparisons, a violation of chi-square, Fisher’s exact test was used. Statistical significance was set to an alpha level of
Where chi-square or Fisher’s exact test were not appropriate, simple prevalence comparisons were made.

Chronology

The five chronological periods developed for central California and used to seriate the present sample shown in Table 1 are consolidated into three broader periods: Early Period (ca. 4950-2150 B.P.), Middle Period (ca. 2150-1050 B.P.), and Late Period (ca. 1050-200 B.P.). Therefore, individuals falling within intermediate time period categories were classified with the later of the two time periods, i.e., an individual from the Middle/Late Period was grouped with the Late Period. This consolidation is also expected to simplify temporal analyses and better identify temporal trends.

Fifteen individuals (7.1% of the total sample) of unknown temporal association were noted in the study. These individuals were therefore excluded from temporal analysis, but were considered in the sex analysis.

Archaeological Site Summaries

Human skeletal remains from archaeological sites of the lower Sacramento Valley (CA-SAC-006, CA-SAC-043, and CA-SAC-060) and the upper San Joaquin Valley (CA-SJO-068, CA-SJO-142, and CA-SJO-154) provide data for this study (Figure 1). Despite the close proximity of these six sites, their occupation over a variable expanse of time suggests likely association with different prehistoric cultural groups that resided in California’s Central Valley. CA-SAC-006, CA-SJO-068, and CA-SJO-142 are sites located within the known ethnographic boundaries of the Plains Miwok. CA-SAC-043, the northernmost site in this study, is situated within the region known to have been once
occupied by the Nisenan, or Southern Maidu, though occupation by Plains Miwok is also possible. CA-SJO-154, the southernmost site, lies within reported Northern Yokuts territory. However, the boundaries between various cultural groups were not impenetrable and any of the previously mentioned groups, as well as others not mentioned, may have occupied these areas at any given time prehistorically.
Archaeological Sites of the Sacramento Valley CA-SAC-006

Located along the Cosumnes River, CA-SAC-006 (Johnson Mound), a Late Period site long known to pothunters, had been largely picked over prior to systematic excavation (Heizer and Cook 1949). A small number of Spanish beads recovered from burials within this mound suggests the Cosumnes, a Plains Miwok group that resisted Spanish missionization in the early nineteenth century, resided there (Heizer and Cook 1949; Bennyhoff 1977). As there is little variability in burial depth, Heizer and Cook (1949) suggest the mound was inhabited by 500 B.P., and perhaps earlier.

CA-SAC-043

CA-SAC-043 (Brazil Mound), the northernmost site in this study, is located southeast of the divergence of the Sacramento River from the American River. Named for the farmer, Manuel Brazil, who in 1924 uncovered the large prehistoric village while digging a residential foundation on his property, the Brazil Mound contained human remains of multiple adults and children (Ehrenreich 2010). Upon notifying archaeologists at Sacramento Junior College, the mound was excavated and ultimately estimated to have been continuously occupied for nearly 2,000 years (Ehrenreich 2010). Charcoal samples provided a range of occupancy from approximately 2450 B.P. to 650 B.P., at which time a substantial drought likely led to the site’s abandonment (Ehrenreich 2010).

CA-SAC-060

CA-SAC-060 (Hicks I Mound) has a history of undocumented amateur excavations prior to its systematic excavation in 1934 by Sacramento Junior College, which uncovered 12 burials and two cremations (Lillard et al. 1939). A second
archaeological excavation spanning nearly four months in 1938 brought the total to 92 burials (Lillard et al. 1939).

An oval mound situated along the west shore of a slough, Hicks I Mound covers an area 140 feet by 75 feet (Lillard et al. 1939). The height of the mound, only detectable from a western orientation, rises approximately 20 inches above ground and reaches depths of 64 inches (Lillard et al. 1939). The majority of the 73 burials have been assigned to the Middle Period as they were recovered from the mound’s lowest depths in tightly flexed positions with no particular orientation, though three burials displayed the more typical Early Period interment style of ventral extension with heads directed to the west (Lillard et al. 1939). Associated artifacts included beads and ornaments of abalone and olive shell, quartz, charmstones, worked animal bones, and obsidian projectile points, though with minimal frequency (Lillard et al. 1939). The remaining 19 burials, interred 41 inches below the topsoil, were associated with Late Period occupation after abandonment by Middle Period inhabitants (Lillard et al. 1939). Variation of associated artifacts from earlier occupants further suggests cultural change as items such as baked clay ball sinkers, netting, and wooden fishhooks were recovered from Late Period burials (Lillard et al. 1939).

Archaeological Sites of the San Joaquin Valley CA-SJO-068

CA-SJO-068 (Blossom Mound) had originally been described as the oldest “pure-culture site” of the Early Period Windmiller sites (Ragir, 1972; Heizer 1976:7). Initially excavated by Elmer J. Dawson in 1921, Blossom Mound is located 1.5 miles northwest of Thornton and 1.2 miles south of the Mokelumne River (Heizer 1976).
Described as a midden of calcareous hardpan, refuse, and human skeletal remains by Heizer (1976), this evaluation was later challenged based on the number of burials in close proximity to one another and the dearth of evidence such as floral and faunal remains and discarded stone tool fragments that would signify a domestic habitation, and instead it was proposed to be an “artificial burial mound” created not by burying, but by covering the dead with soil from river beds and village refuse deposits, therefore contradicting the claim CA-SJO-068 was one of few type sites defining central California in the Early Period (Meighan 1987:34).

Dawson uncovered between 75 to 80 burials interred from six to 66 inches below the surface in an extended position with the head directed to the west (Heizer 1976). Forty of these burials included at least two types of grave goods such as Haliotis or Olivella shell beads, unworked animal bone, baked clay balls, charmstones, and quartz (Lillard et al. 1939). In 1938, the University of California removed another 17 extended burials with heads directed to the west, four interred dorsally and 13 ventrally (Heizer 1976). An additional 76 adult and eight infant burials and five cremations were recovered in 1947, the majority of which were in an extended ventral position with the head facing to the west (Heizer 1976).

Measuring 93 by 68 feet, the burial mass reached a depth of 5.5 feet and an above ground level height of two feet (Lillard et al. 1939). The location of CA-SJO-068 presently constitutes unfavorable conditions for prehistoric settlement due to its distance from freshwater resources (located 1.2 miles from the Mokelumne River) and its propensity toward flooding (Lillard et al. 1939; Heizer 1976). However, a large depression approximately 20 feet east of the mound may be a remnant of a prehistoric
waterway, suggesting the natural course of water changed significantly in the area since prehistoric occupation (Lillard et al. 1939).

CA-SJO-142

An Early Period burial mound, CA-SJO-142 (McGillivray Mound), was located by H. McGillivray, a farmer, while digging an irrigation trench through his property (Heizer 1976). This mound is situated one mile south of the Mokelumne River and immediately southeast of the tule-filled depression known as Fogg Lake, which likely served as the main channel for the Mokelumne River prehistorically (Lillard et al. 1939; Heizer 1976). CA-SJO-142 lies east of two additional sites, CA-SJO-143 and CA-SJO-144 at 100 yards and 150 yards away, respectively, which are also situated along the south rim of Fogg Lake (Heizer 1976). As CA-SJO-142 is slightly elevated from the surrounding land (12 inches marks the highest point), Heizer (1976) suggests this site, as well as CA-SJO-143 and CA-SJO-144, may have achieved greater elevations prehistorically so as to avoid submersion in moderate flooding, indicating these areas as preferred locations for burials of earlier inhabitants.

Between 1937 and 1938, the University of California removed 44 burials oriented to the west, two of these were in an extended dorsal position and five were flexed intrusive burials from the Middle Period (Heizer 1976). Additional evidence of a more recent presence includes five Middle Period cremations excavated in the area and noted variation in associated artifacts (Lillard et al. 1939; Heizer 1976).

McGillivray Mound is characterized by six inches of loose topsoil above ten inches of hardened gray stratum; the next 30 inches of brownish red soil contained minimal amounts of charred clay, charcoal, stone fragments, and animal bone, while
human skeletal remains were deposited as deep as 40 inches (Lillard et al. 1939; Heizer 1976). Layers of hardpan and variation in soil color well below ground level indicate some disturbance, but the lack of animal bones, ash pits, and charcoal concentrations provide little indication of regular occupation of this area (Lillard et al. 1939).

Similar to CA-SJO-068, the minimal presence of refuse material such as burned clay, charcoal, and animal bone in the disturbed soil of CA-SJO-142 is inconsistent with long-term, intensive habitation, and instead suggests this site was a burial knoll with occupation on a temporary basis (Heizer 1976). Lillard et al. (1939) also support the prehistoric “campsite” usage of this area and note the northern migration of the Mokelumne River and the accumulation of alluvium.

**CA-SJO-154**

In January 1976, human remains from multiple burials were recovered after a construction crew in downtown Stockton uncovered a prehistoric settlement (Hoffman 1987). Under the direction of Richard Hughes, then graduate student in archaeology at the University of California, Berkeley, and Dr. James Bennyhoff of Sonoma State University, the “salvage” excavation of the Cardinal site, named for the street on which the site was located, removed over a period of 12 days the remains of 34 burials and one cremation (Hoffman 1987). Many of the skeletal elements were significantly fragmented; once sorted, the remains identified 60 individuals, mostly of indeterminate sex, between birth and 59 years of age (Hoffman 1987).

Though interment position and orientation was highly variable, individuals were most commonly placed in either a tightly or semi-flexed position (Hoffman 1987). Based on the clustering of burials and the recovery of items found in association with
many of the burials, Hoffman (1987) suggests the site represents two groups of individuals. One group is classified by the presence of saddle-shaped *Olivella* beads recovered from several interments, an artifact associated with the late Middle Period, and centrally perforated, rectangular *Olivella* beads associated with the second group place it within the Early Phase I of the Late Period (Moratto 1984; Hoffman 1987).

Summary

This study uses cranial remains of 212 individuals from six archaeological sites in central California collectively occupied from the Early, Middle, and Late Periods to assess the prevalence of prehistoric interpersonal violence between males and females over time through craniofacial trauma analysis. Sex and age estimation, when not previously recorded, was determined through standard methods; individuals of indeterminate sex were included in temporal comparisons of craniofacial trauma, but omitted from comparisons based on sex. Likewise, individuals of unknown temporal association were omitted from temporal analysis, but included in the analysis by sex. Documentation of antemortem and perimortem trauma in the form of depressed and linear fractures included a count of individuals as well as elements affected. The results of chi-square and Fisher’s exact tests are expected to address the research expectations of this study and make inferences about interpersonal violence in prehistoric central California from patterns of craniofacial trauma.
CHAPTER V

RESULTS

Introduction

Discussions thus far include a review of some of the theoretical perspectives for the presence of violence among prehistoric hunter-gatherers. The perspective anticipated to have influenced violent behavior within the Central Valley is based on resource competition as a result of rapid population expansion and subsequent resource depression, which is believed to have been exacerbated by significant climatic fluctuations during the Middle and Late Periods. Similar studies within central and southern California found moderate to high levels of skeletal trauma indicative of interpersonal violence and warfare, some of which also suggested environmental and demographic pressures as major contributing factors.

The following chapter reports the results of basic descriptive statistics comparing trauma prevalence by archaeological site, period, and sex. A description of the observed craniofacial trauma organized by element is discussed next with specific detail given to more significant injuries. The focus of this chapter then turns to the three research expectations introduced in Chapter I. The expectation of a temporal increase in craniofacial trauma through time will be addressed through a comparison of the prevalence of craniofacial injury from the Early Period through the Late Period. Results include a separate review of craniofacial, cranial vault, and facial trauma for the male and
female samples. The expectation of a greater prevalence of craniofacial trauma on the left side of the skull will be explored through a comparison of the prevalence of craniofacial injuries by anatomical location. A comparison of the prevalence of craniofacial trauma among males and females will address the final research expectation that males will exhibit a higher rate of craniofacial trauma than females. This analysis also looks at the prevalence of craniofacial, cranial vault, and facial trauma separately as well as the frequency of trauma observed within each element in anticipation of additional insight into the expected variance between male and female trauma prevalence.

Skeletal Sample

The skeletal sample consists of 212 individuals, of which 88 (41.5%) are male, 118 (55.7%) are female, and six (2.8%) are of indeterminate sex. The sex distribution within each site is fairly consistent with the exception of CA-SAC-006, in which females outnumber males four to one resulting in an overrepresentation of females in the total sample. The distribution of individuals by site is less consistent with the largest sample, CA-SJO-068, totaling 60 individuals and the smallest sample, CA-SJO-154, totaling just 14 individuals. This discrepancy is not expected to negatively impact results as this study is more concerned with temporal trends of interpersonal violence as opposed to regional trends.

The sites that exhibited the lowest frequency of injured individuals were CA-SAC-006, CA-SJO-142, and CA-SJO-154 with a combined total of five injured individuals (Table 2). Coincidentally, these same sites presented the three smallest sample sizes. The greatest prevalence of injury was observed in CA-SAC-060 with 17.5
TABLE 2. Descriptive statistics for individuals sampled by site and sex.

<table>
<thead>
<tr>
<th>Site</th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
<th>Indeterminate</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
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<tbody>
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<td>n</td>
<td>%</td>
<td>N</td>
<td>n</td>
<td>%</td>
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<td>n</td>
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<td>1</td>
<td>0</td>
</tr>
<tr>
<td>CA-SJO-154</td>
<td>5</td>
<td>1</td>
<td>20.0</td>
<td>7</td>
<td>1</td>
<td>14.3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>18</td>
<td>20.5</td>
<td>118</td>
<td>11</td>
<td>9.3</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

N=number of individuals per site; %=N/total number of individuals for sex class x 100.

percent of the sample affected. CA-SAC-043 followed with 15.7 percent and CA-SJO-068, with the largest sample size, showed the third highest frequency of individuals with craniofacial trauma.

The largest number of individuals, 82 (38.7%), is associated with the Early Period, 62 individuals (29.2%) represent the Middle Period, and the Late Period is represented by still fewer individuals at 53 (25.0%). An additional 15 individuals (7.0%) whose temporal association is unknown will be included in overall trauma prevalence analyses, but will be excluded from the temporal analyses. Figure 2 shows the number of individuals of each sex in each time period.

Cranial Trauma Descriptions

Of the 212 individuals in the sample, 29 (13.7%) show evidence of at least one instance of craniofacial trauma. Of these 29 individuals, 18 (62.1%) were male and 11 (37.9%) were female. No individuals of indeterminate sex exhibited craniofacial trauma. Ten individuals (34.5%) exhibited evidence of more than one craniofacial trauma, mostly in the form of depressed or linear fractures, for a total of 44 affected
elements. Craniofacial elements with observed signs of trauma include the frontal, parietal, temporal, zygomatic, maxilla, and nasal bones (Figure 3). With the exception of the frontal, each of these elements is a paired bone meaning the single element is represented by two mirrored bones located on each side of the skull. To accurately assess the prevalence of craniofacial trauma, the frontal is also treated as a paired bone.

Sixteen of the 29 injured individuals (55.2%) exhibited trauma to the cranial vault only, including 11 males (37.9%) and five females (17.2%). Injuries isolated to facial bones occurred in nine individuals (31.0%), five males (17.2%) and four females (13.8%). Another four individuals (13.8%), two males (6.9%) and two females (6.9%), exhibited injuries on the vault and facial bones.
Of the 44 craniofacial injuries identified, a total of 23 traumatic injuries (52.3%) were observed on the right side of the skull, including three frontal, nine parietal, two temporal, one zygomatic, one maxilla, and seven nasal bones. The left side presented 21 injuries (47.7% of overall injuries), including seven frontal, eight parietal, two zygomatic, and four nasal bones. Males exhibited nine injuries (20.5%) on the right side of the skull and 15 (34.1%) on the left. The opposite trend was observed in females as 14 injuries (31.8%) were observed on the right side of the skull and six (13.6%) were observed on the left.
In terms of the anatomical location of trauma, 29 of 44 injured craniofacial elements (65.9%) were located on the cranial vault, 14 on the right side (31.8%) and 15 on the left (34.9%). Males sustained 15 cranial vault injuries (34.9%) and 14 (31.8%) were observed in females. Fifteen injured elements observed on the face (34.1%) were identified in nine males (20.5%) and five females (11.4%); nine on the right (20.5%) and six on the left side of the cranium (13.6%). Males exhibited a larger number of frontal and nasal injuries than females at eight each (33.3% and 33.3%, respectively, of total injuries among males). Conversely, females presented more parietal, zygomatic, and maxilla trauma at 11, one, and three, respectively (55.0%, 15.0%, and 20.0% of total injuries among females). See Table 3 for a complete list of craniofacial trauma observed within the sample.

Frontal

Among 206 individuals of known sex, eight frontal injuries (3.9%) were observed in males and one female (0.1%) exhibited two injuries to the frontal. Two of the eight frontal injuries in males were located on the right side of the skull and six were on the left. Two males from CA-SJO-068 displayed right frontal trauma, one in the form of a smooth, bony growth superior to the zygomaticofrontal suture. Flattening of the bone along the zygomaticofrontal suture was also present and extended slightly onto the frontal process of the right zygomatic. The second male displayed a shallow, amorphous indentation along the lateral border of the supraorbital ridge. One male from CA-SAC-006 displayed a circular depression approximately 14 millimeters in diameter on the left frontal near the anatomical landmark bregma. Two other males from CA-SAC-043 displayed left frontal injuries; one with a deep, triangular depression along the lateral
### TABLE 3. Craniofacial trauma inventory.

<table>
<thead>
<tr>
<th>Site</th>
<th>Period</th>
<th>Sex</th>
<th>Number of Injuries</th>
<th>Injured Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-SAC-006</td>
<td>Late</td>
<td>Male</td>
<td>1</td>
<td>Left frontal</td>
</tr>
<tr>
<td>CA-SAC-006</td>
<td>Late</td>
<td>Male</td>
<td>1</td>
<td>Left parietal</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Late</td>
<td>Female</td>
<td>5</td>
<td>Right frontal, right parietal (2), left frontal, left parietal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Right parietal, right temporal, left zygomatic</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Middle</td>
<td>Female</td>
<td>3</td>
<td>Right nasal</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left parietal</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left nasal</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Middle</td>
<td>Female</td>
<td>1</td>
<td>Left zygomatic</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left frontal</td>
</tr>
<tr>
<td>CA-SAC-043</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left frontal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Unknown</td>
<td>Male</td>
<td>2</td>
<td>Right nasal, left frontal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Unknown</td>
<td>Female</td>
<td>1</td>
<td>Left parietal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left frontal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left nasal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Late</td>
<td>Female</td>
<td>2</td>
<td>Right maxilla, right nasal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Late</td>
<td>Male</td>
<td>2</td>
<td>Right nasal, left nasal</td>
</tr>
<tr>
<td>CA-SAC-060</td>
<td>Unknown</td>
<td>Female</td>
<td>3</td>
<td>Right parietal</td>
</tr>
<tr>
<td>CA-SJO-068</td>
<td>Early</td>
<td>Male</td>
<td>2</td>
<td>Right frontal, right zygomatic</td>
</tr>
<tr>
<td>CA-SJO-068</td>
<td>Early</td>
<td>Female</td>
<td>1</td>
<td>Right parietal</td>
</tr>
<tr>
<td>CA-SJO-068</td>
<td>Early</td>
<td>Male</td>
<td>2</td>
<td>Left frontal, left parietal</td>
</tr>
<tr>
<td>CA-SJO-068</td>
<td>Early</td>
<td>Female</td>
<td>1</td>
<td>Right parietal</td>
</tr>
<tr>
<td>CA-SJO-068</td>
<td>Early</td>
<td>Male</td>
<td>1</td>
<td>Right temporal</td>
</tr>
<tr>
<td>CA-SJO-068</td>
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<td>Male</td>
<td>1</td>
<td>Right frontal</td>
</tr>
<tr>
<td>CA-SJO-142</td>
<td>Early</td>
<td>Male</td>
<td>2</td>
<td>Right parietal, left parietal</td>
</tr>
<tr>
<td>CA-SJO-154</td>
<td>Late</td>
<td>Female</td>
<td>1</td>
<td>Left parietal</td>
</tr>
<tr>
<td>CA-SJO-154</td>
<td>Middle</td>
<td>Male</td>
<td>1</td>
<td>Left parietal</td>
</tr>
</tbody>
</table>

( ) indicates number of distinct injuries on single craniofacial element.
border of the supraorbital ridge, the other a shallow, ovate depression on the frontal squama approximately one inch above the landmark nasion. Two more shallow depressions similarly located were observed in two males from CA-SAC-060. A sixth left frontal injury from CA-SJO-068 was observed in another male midway between the landmarks bregma and pterion along the coronal suture, noteworthy for its diameter measurement of approximately two centimeters. This injury also extended into the left parietal.

Though few frontal injuries were recorded in females, one notable example is from CA-SAC-043. This individual exhibited flattening of the vault at bregma approximately four centimeters in diameter and extended into both parietals and either side of the frontal.

Parietal

A total of 17 parietal injuries (38.6%) were observed in the sample. Males presented six (15.4%) healed injuries whereas 11 (25.0%) were observed in females. One male CA-SJO-142 exhibited a healed depression on the right side of the skull with an anterior-posterior measurement of approximately 3.5 centimeters. This same male displayed a smaller depression on the left parietal measuring 11 millimeters in diameter. Three more healed depressions on the left side of the skull were observed in males from CA-SAC-006, CA-SAC-043, and CA-SJO-068, none of which were extraordinary. Of particular interest was a fifth male from CA-SJO-154 with evidence of left parietal plastic deformation indicating the injury occurred at or near the time of death, the only evidence of perimortem injury observed in the sample.
Among females, one parietal injury in the form of an asymmetrical puncture wound and seven parietal depressions were observed on the right side of the skull. Of three additional depressions on the left, two were unremarkable and one formed a slight indentation two centimeters in diameter and posterior to the coronal suture at the midpoint between bregma and pterion in a female from CA-SJO-154.

**Temporal**

Temporal injuries were less commonly observed in the sample, affecting only two individuals (4.5%), one male and one female. In the male from CA-SJO-068, a spiculate projection of bone on the inferior margin of the root of the right zygomatic process was present. The female from CA-SAC-043, noted above for her right parietal puncture wound, also exhibited a similar wound to the right temporal.

**Zygomatic**

Three injuries (6.8%) were observed on zygomatic bones in one male and two females, respectively. The male from CA-SJO-068, also noted in the section above on frontal injuries, displayed right zygomatic flattening on the superior aspect of the frontal process inferior to a round, bony projection on the frontal. Projections of bone were also noted on two females from CA-SAC-043, one located inferior to the zygomaticofacial foramen and protruding approximately 4.4 millimeters from the surface of the left zygomatic. This female also displayed right parietal and right temporal puncture wounds as previously mentioned. The second female presented with a spiculate protuberance on the temporal process of the left zygomatic.
Maxilla

The maxilla was the least traumatized element in the sample with only one injury (2.2%) on the right side in a female from CA-SAC-060. Displaying a square depression measuring 6.5 millimeters by 7.9 millimeters, this injury also extended into the right nasal.

Nasal

The second most frequent element affected was the nasal bone with 11 occurrences (25.0%). More fractures were observed on the right side of the skull in both sexes, though two males from CA-SAC-060 and CA-SJO-068 displayed fractures to both nasal bones. Observed in males more often than females at eight and three, respectively, the vast majority of nasal trauma took the form of linear fractures as evident by the slightly misshapen appearance of the nasal bones after healing. One right nasal injury in a female from CA-SAC-060 was a healed depression that is evident in the right maxilla, as stated in the section above.

Total Trauma Prevalence

The craniofacial trauma prevalence of the 212 individuals sampled as observed through injuries in 18 males and 11 females is 13.7 percent. If the six individuals of indeterminate sex who did not show evidence of trauma were removed from the total sample, the craniofacial trauma prevalence increases to 14.1 percent. Removing the 15 individuals of unknown temporal association, including three individuals (one male and two females) with evidence of injury, results in a craniofacial trauma prevalence of 13.2 percent, a value commensurate to that for the entire sample.
Research Expectation One: Increase in Craniofacial Trauma Prevalence Through Time

A total of 197 individuals were analyzed for the prevalence of craniofacial, cranial vault, and facial trauma through time. Fifteen individuals were excluded from analysis due to their unknown temporal association, of which three individuals exhibited craniofacial trauma. The following section examines temporal trends through the comparison of craniofacial, cranial vault, and facial trauma prevalence between time periods and within the male and female sample.

Total Trauma Prevalence through Time

The Early and Middle Periods are each represented by ten individuals (5.1% of overall sample, respectively) with craniofacial trauma; only six individuals (3.0% of the overall sample) were identified in the Late Period. Though the sample size for each time period decreases from the Early through the Late Periods, ten individuals with craniofacial trauma were observed in the Early and Middle Periods each, resulting in a 3.9 percent increase in craniofacial trauma from the Early Period (12.2% within time period) through the Middle Period (16.1%). Of 144 individuals within these periods, 20 individuals (13.9%) showed evidence of craniofacial trauma. Despite this and the sample sizes between the periods differing by 20 individuals, there is no significant difference in trauma prevalence between these time periods ($\chi^2=4.57, df=1, p=.499$).

Unlike the Early and Middle Period craniofacial trauma prevalence comparison, a 0.9 percent decrease was observed between the Early and Late Periods. Six traumatic injuries among 53 individuals in the Late Period resulted in an 11.3 percent trauma prevalence compared to the Early Period’s previously noted 12.2 percent affected.
Within these periods, 16 of 135 individuals (11.9%) displayed craniofacial trauma. Like the Early and Middle Periods, there is no statistically significant difference in craniofacial trauma prevalence between the Early and Late Periods ($\chi^2 = .024, df = 1, p = .878$).

The craniofacial trauma prevalence between the Middle and Late Periods also declined, this time by 4.8 percent from the Middle Period’s 16.1 percent trauma prevalence to the Late Period’s 11.3 percent prevalence. Of 116 total individuals within these periods, 16, or 13.9 percent, showed evidence of trauma. Following the other comparisons, the difference in the trauma prevalence between Middle and Late Periods is not statistically significant ($\chi^2 = .552, df = 1, p = .458$).

Cranial vault trauma was observed among seven of 82 individuals (8.5% within time period) in the Early Period versus six of 62 individuals (9.7% within time period) in the Middle Period. Of the 144 total individuals within these periods, 13 (9.0%) exhibited cranial vault trauma. Though a slight increase is observed, no significant difference in vault injuries is present between the Early and Middle Periods ($\chi^2 = .056, df = 1, p = .813$).

The cranial vault trauma prevalence in the Early Period is one percent greater than the 7.5 percent prevalence observed in the Late Period. With 11 of 135 individuals displaying cranial vault trauma, the total prevalence within the two periods is 8.1 percent. Again, no significant difference in cranial vault trauma is observed between the Early and Late Periods (Fisher’s Exact $p = 1.000$).

A comparison between the Middle and Late Periods reveals a 2.2 percent decrease through time in cranial vault trauma. Ten injured individuals from a combined total of 115 equates to a cranial vault trauma prevalence of 8.7 percent in these periods,
which is also not statistically significant (Fisher’s Exact $p = .751$). As described, the increasing trend of cranial vault trauma prevalence observed between the Early and Middle Periods followed by a decreased prevalence from the Middle through the Late Periods closely resembles that described for craniofacial trauma prevalence.

Facial trauma prevalence from the Early through Late Periods is not also statistically significant. An increase of 3.2 percent is observed between the Early and Middle Periods, which have a facial trauma prevalence of 4.9 percent and 8.1 percent, respectively (Fisher’s Exact $p = .499$). Another increase of 0.8 percent is noted between the Early and Late Periods, though this increase is also not statistically significant (Fisher’s Exact $p = 1.000$). Between the Middle and Late Periods is a 2.4 percent decrease in facial trauma as the Late Period is represented by three injured individuals out of 53 (5.7% within time period), which is also not a significant difference (Fisher’s Exact $p = .724$).

Male Trauma Prevalence through Time

A comparison of craniofacial injury among males only in each time period reveals a different trend (Figure 4). Of 36 males in the Early Period, seven (19.4%) exhibited trauma compared to the Middle Period in which seven of 32 males (21.9%) showed signs of injury. The Late Period continued to show an increase in craniofacial trauma prevalence with three of 13 males (23.1%) affected. In this comparison, an increase in craniofacial trauma prevalence of 2.5 percent is observed between the Early and Middle Periods and a 1.2 percent increase is observed between the Middle and Late Periods. The total increase among males through time is 3.7 percent. In considering the time periods in pairs, there is no significant difference in craniofacial trauma prevalence
through time. Of seven males of unknown temporal association, one (14.3%) exhibited craniofacial injury. If this one individual had been associated with the Early or Middle Periods, the prevalence of craniofacial trauma among males still would not have consistently increased through time.

Cranial vault injuries were observed in five of 36 males (13.9%) in the Early Period compared to five of 32 males (15.6%) in the Middle Period (Figure 5). A 0.2 percent decrease is observed from the Middle Period to the Late Period where two (15.4%) of 13 males displayed vault injuries.

Facial injuries among males were observed in 3 of 36 individuals (8.3%) in the Early Period (Figure 6). The Middle Period showed a 2.1 percent decrease in facial

**FIGURE 4.** Craniofacial trauma prevalence by period and sex.
injuries with two of 32 males (6.2%) affected, followed by an unexpected increase of 9.2 percent due to two of 13 injured males (15.4%) in the Late Period.

Female Trauma Prevalence through Time

Females showed a slightly different trend in craniofacial trauma prevalence through time (Figure 4). Three of 43 females (7.0%) in the Early Period showed evidence of craniofacial injury. An increase of 3.3 percent was observed in the Middle Period with three of 29 females (10.3%) affected. The trauma prevalence then decreases into the Late Period with three of 39 females (7.7%) affected. Though a 2.6 percent decrease is observed between the Middle and Late Periods, the Late Period prevalence is still larger than the Early Period by 0.7 percent. This is an important observation as the total number

**FIGURE 5.** Cranial vault trauma prevalence by period and sex.
of females in each period fluctuated by as many as 14 individuals, yet each period consistently observed the same number of injured females and an increase in trauma prevalence. However, unlike males, if the two of seven females (28.6%) of unknown temporal association with craniofacial injuries were found to be associated with the Early or Middle Periods, the prevalence trend in females would be significantly altered.

Cranial vault injuries were observed in two of 43 females (4.7%) in the Early Period and one of 29 females (3.4%) in the Middle Period (Figure 5). The Late Period saw an increase to 5.1 percent as two of 39 females exhibited cranial vault injuries.

FIGURE 6. Facial trauma prevalence by period and sex.
Females with facial injuries in the Early Period totaled one of 43, or 2.3 percent (Figure 6). This was followed by a notable eight percent increase in the Middle Period to 10.3 percent with three of 29 females injured. Facial trauma prevalence in females returned to 2.6 percent in the Late Period with one of 39 individuals injured, a 7.7 percent decrease from the Middle Period. The unexpected spike in the Middle Period is more than three times the prevalence of facial injuries in the Early and Late Periods.

Results of temporal analyses indicate the prevalence of craniofacial trauma, either observed on the cranial vault or facial elements, among individuals of known temporal association does reveal a consistent spike during the Middle Period, but that trend does not continue through the Late Period as hypothesized. Therefore, the expectation of a consistent temporal increase in craniofacial trauma prevalence is rejected.

Research Expectation Two: Greater Prevalence of Craniofacial Trauma on the Left Side of the Skull

Of 212 individuals, ten (4.7%) presented craniofacial trauma exclusively on the right side of the skull and 13 individuals (6.1%) showed signs of trauma only on the left side (Figure 7). These results appear to indicate left craniofacial injuries were more prevalent, however, another six individuals (2.8%) showed evidence of craniofacial trauma on both sides of the cranium, which affected the overall trauma prevalence for each side of the skull.

Of 44 elements that sustained craniofacial injuries, 23 (52.3%) were observed on the right side of the skull and 21 (47.7%) were on the left side. The most frequently
injured element on the right side of the skull was the parietal with nine injuries (39.1% of total injuries on the right) followed by the nasal with seven (30.4%), the frontal with three (13.0%), the temporal with two (8.7%), and the zygomatic and maxilla each with one injury (4.3%). The left side of the skull showed a slightly different pattern. Eight injuries (38.1% of total injuries on the left) were noted on the parietal, but the frontal was the next most frequently injured element with seven occurrences (33.3%), followed by the nasal with four (19.0%), the zygomatic with two (9.5%), and no temporal or maxilla injuries. Considering the total number of injuries observed in the sample, the right side of the cranium exhibited a greater prevalence of trauma, therefore, research expectation two is also not supported.

FIGURE 7. Trauma prevalence by element affected and side.
Research Expectation Three: Greater Prevalence of Craniofacial Trauma in Males

A total of 206 individuals were examined in the analysis of craniofacial trauma prevalence in males and females. Six individuals of indeterminate sex were not included. Craniofacial trauma was observed in 29 individuals, 18 males (20.5% of the male sample) and 11 females (9.3% of the female sample). Though females were the more represented sex in the total sample, a larger number of males exhibited craniofacial trauma. The difference in craniofacial trauma prevalence between males and females is statistically significant, supporting the third research expectation that males exhibit more injuries ($\chi^2 = 5.165$, $df = 1$, $p = .023$).

Males also exhibited a higher frequency of cranial vault injuries than females at 11 and five individuals, respectively, for a cranial vault injury prevalence of 12.5 percent among the total male sample and 4.2 percent among the total female sample. This difference between males and females is statistically significant ($\chi^2 = 4.494$, $df = 2$, $p = .034$) (Table 4). Facial injuries were also more commonly observed in males with a total of five individuals (5.7% of the male sample) versus four females (3.4% of the female sample). Unlike cranial vault injury prevalence, the difference between male and female facial injury prevalence was not statistically significant ($\chi^2 = 1.270$, $df = 2$, $p = .260$). Two males (2.3% of the male sample) and two females (1.7% of the female sample) exhibited injuries to both cranial vault and facial elements.

Males presented injuries to all craniofacial elements included in the study with the exception of the maxilla for a total of 15 cranial vault (62.5% of observed trauma in males) and nine facial injuries (37.5%) (Figure 8). Females presented injuries to all
TABLE 4. Chi-square results comparing sex by trauma location and period.

<table>
<thead>
<tr>
<th>Sex</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial vault</td>
<td>4.494</td>
<td>1</td>
<td>0.034*</td>
</tr>
<tr>
<td>Cranial vault and period</td>
<td>6.168</td>
<td>1</td>
<td>0.013*</td>
</tr>
<tr>
<td>Facial</td>
<td>1.270</td>
<td>1</td>
<td>0.260</td>
</tr>
<tr>
<td>Facial and period</td>
<td>1.368</td>
<td>1</td>
<td>0.242</td>
</tr>
</tbody>
</table>

*Significant at $p < .05$.

![FIGURE 8. Prevalence of affected elements by sex and side.](image-url)
craniofacial elements for a total of 14 cranial vault (70.0% of observed trauma in females) and six facial injuries (30.0%). The most commonly affected elements of the cranial vault among males were the frontal and parietal at eight (53.3%) and six (40.0%), respectively. Females exhibited 11 parietal injuries (78.6%), far more than any other element of the cranial vault. Facial injuries were also more commonly observed in males. Of the nine facial bone injuries (37.5%) observed in males, the most commonly affected element was the nasal at 88.9 percent, or eight incidences. The nasal bone was also the most commonly affected facial element among females with three injuries (50.0%).

Within Period Comparisons

Removing the individuals of unknown temporal association left 197 individuals; 81 were male, 111 were female, and five were of indeterminate sex. Males, therefore, comprised 41.1 percent of this sample and females represented 56.3 percent. The individuals whose sex cannot be determined made up 2.5 percent of the sample, and also did not exhibit evidence of trauma; therefore, these individuals are removed from further comparisons in this section.

Among 81 males, 17 (20.1%) showed signs of craniofacial injury compared to nine (8.1%) of 111 females. Of 17 males of known temporal association, 12 (70.6%) exhibited cranial vault injuries and six (41.2%) exhibited facial trauma. One male exhibited both a cranial vault and facial injury and is therefore counted in each category. Five injuries each (55.6%) were observed on cranial vault and facial bones in nine females. Like the male sample, a single female displayed both a cranial vault and facial injury.
Of ten injured individuals within the Early Period, seven males (70.0%) and three females (30.0%) were affected. Seven of these ten individuals (70%) exhibited vault trauma, five males (71.4%) and two females (28.6%). Four of the ten individuals (40%) exhibited facial trauma, three males (75%) and one female (25%). It should be noted one of the three males with facial trauma also displayed a cranial vault injury.

Similar to the Early Period, ten injured individuals are present in the Middle Period, seven (70.0%) males and three (30.0%) females. Cranial vault injuries were more common with six occurrences versus five occurrences of facial trauma. Five males (71.4%) and one female (14.3%) showed evidence of cranial vault trauma while two males (40.0%) and three females (60.0%) displayed facial trauma. Cranial vault and facial trauma was observed in one female.

In the Late Period, the number of injuries was split equally between the sexes. A total of six craniofacial injuries in the Late Period included three males (50.0%) and three females (50.0%). Of these, four injuries (66.7%) were observed on the cranial vault and two (33.3%) were on facial elements. More specifically, two males and two females each displayed cranial vault injuries and one male and one female showed evidence of an injury to the face.

An alternate comparison of total sample size per period by craniofacial trauma prevalence indicated stasis from the Early through Middle Periods (38.5% each) and a decrease through the Late Period (23.1%). Even if the three injured individuals of unknown temporal association were in fact associated with the Late Period, bringing the total craniofacial injury prevalence for that period to nine (31.0%), a decrease in trauma prevalence would still be observed.
To summarize the temporal analysis between males and females, greater trauma prevalence was observed among males in all trauma categories and time periods with the exception of 10.3 percent of females exhibiting facial injuries in the Middle Period (Table 5). Though no significant difference in trauma prevalence between males and females within each time period is observed (Table 6), an assessment of the three periods combined reveals a statistically significant difference in craniofacial trauma prevalence in the male sample ($\chi^2=6.635, df = 1, p = .010$) (Table 7).

**TABLE 5.** Descriptive statistics for individuals with craniofacial trauma sampled by period and sex.

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
<th>Indeterminate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$N$</td>
<td>%</td>
<td>$n$</td>
</tr>
<tr>
<td>Early</td>
<td>7</td>
<td>36</td>
<td>19.4</td>
<td>3</td>
</tr>
<tr>
<td>Middle</td>
<td>7</td>
<td>32</td>
<td>21.9</td>
<td>3</td>
</tr>
<tr>
<td>Late</td>
<td>3</td>
<td>13</td>
<td>23.1</td>
<td>3</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>7</td>
<td>14.3</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>88</td>
<td>20.5</td>
<td>11</td>
</tr>
</tbody>
</table>

$n=$number of individuals with craniofacial trauma per site; $N=$number of individuals per site; $\%=$N/number of individuals per sex class x 100.

**Summary**

Several comparisons in this study required narrowing of the total sample size of 212 individuals, which resulted in some modest sample sizes that prohibited the use of a chi-square test. Chi-square is only valid when most expected values equal five or more. Consequently, results are primarily assessed by how they compare proportionately to one another.

The results of this study did not support the expectations that trauma prevalence increased through time or that more injuries were located on the left side of
### TABLE 6. Chi-square results comparing trauma by sex and period.

<table>
<thead>
<tr>
<th>Craniofacial trauma</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Period vs. Middle Period</td>
<td>4.289</td>
<td>1</td>
<td>0.038*</td>
</tr>
<tr>
<td>Early Period vs. Late Period</td>
<td>4.902</td>
<td>1</td>
<td>0.027*</td>
</tr>
<tr>
<td>Middle Period vs. Late Period</td>
<td>4.000</td>
<td>1</td>
<td>0.046*</td>
</tr>
<tr>
<td>Cranial vault</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Period vs. Middle Period</td>
<td>4.611</td>
<td>1</td>
<td>0.032*</td>
</tr>
<tr>
<td>Early Period vs. Late Period</td>
<td>F.E.</td>
<td></td>
<td>0.100</td>
</tr>
<tr>
<td>Middle Period vs. Late Period</td>
<td>F.E.</td>
<td></td>
<td>0.086</td>
</tr>
<tr>
<td>Facial trauma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Period vs. Middle Period</td>
<td>F.E.</td>
<td></td>
<td>0.740</td>
</tr>
<tr>
<td>Early Period vs. Late Period</td>
<td>F.E.</td>
<td></td>
<td>0.102</td>
</tr>
<tr>
<td>Middle Period vs. Late Period</td>
<td>F.E.</td>
<td></td>
<td>0.711</td>
</tr>
<tr>
<td>F.E. = Fisher's Exact</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
*Significant at $p < .05$

### TABLE 7. Chi-square results comparing craniofacial trauma by sex and period.

<table>
<thead>
<tr>
<th>Craniofacial Trauma</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>5.165</td>
<td>1</td>
<td>0.023*</td>
</tr>
<tr>
<td>Period</td>
<td>0.700</td>
<td>2</td>
<td>0.705</td>
</tr>
<tr>
<td>Sex and period</td>
<td>6.635</td>
<td>1</td>
<td>0.010*</td>
</tr>
</tbody>
</table>
*Significant at $p < .05$

the skull. However, the expectation that more males than females exhibited craniofacial injuries was supported, which is of particular interest given the greater representation of females in the sample. Though the results were not in full accordance with the research expectations, the data still provide valuable insight into the inference of interpersonal violence as observed through overall sample prevalence and patterns of craniofacial injury, which is the focus of the following chapter.
CHAPTER VI

DISCUSSION

Introduction

The previous chapter reviewed the results of statistical analyses and prevalence comparisons with particular consideration given to the research expectations of this study. Those results did not wholly support the research expectations as no consistent temporal increase was noted from the Early through Late Periods. Though a consistent increase was not observed through time, a notable increase was observed in the Middle Period, an observation generally unlike those of similar studies in prehistoric California and one that is further discussed in the present chapter. Additionally, there appears to be no predilection for one side of the skull sustaining more injuries than the other. Though this again means the rejection of a research expectation, an unexpected observation in trauma patterns between males and females is revealed, which may have implications for differential exposure to violent encounters, a subject further explored in the present chapter. Results of the third research expectation that more males display evidence of craniofacial trauma were supported as noted in the previous chapter, despite females representing the majority of the sample. The present chapter compares these results with those of similar studies, noting the possibility for an alternate explanation for trauma risk. Finally, the overall craniofacial trauma prevalence of 13.7 percent is
considered with respect to the prevalence rates observed in similar studies of prehistoric populations in California.

Interpretation of Craniofacial Trauma Analyses

Of the 212 individuals in this study, 44 craniofacial injuries were identified in 29 individuals, none of whom were of indeterminate sex. Ten individuals displayed more than one traumatic injury, the most commonly affected elements being the parietal, nasal, and frontal, respectively.

Research Expectation One

The expectation that craniofacial trauma prevalence would increase through time was based on the climatic changes and human population increases documented in prehistoric central California during the Middle Period, which are argued to have had an influence on resource intensification and competition. Craniofacial injuries may also be due to accidents such as trips or falls, but given the Central Valley landscape is characterized as a relatively flat basin with the most notable elevation being the Sutter Buttes located well north of the sites used in this study (Moratto 1984), the potential for accidental injury is minimized.

Hunter-gatherer groups of the Central Valley, such as the Plains Miwok, relied primarily on collecting plant resources, notably acorns (Mayer 1976; Bennyhoff 1977), a resource that has been argued as the stimulus for population growth due to its storability. To support the argument that the prolonged drought in the Middle and Late Periods associated with the Medieval Climatic Anomaly propelled humans toward violence, an increase in craniofacial trauma prevalence in these time periods is expected.
Schwitalla and Jones (2011) suggest the high rates of diseases such as cribra orbitalia and porotic hyperostosis, both associated with poor diet during childhood, meant the health of human populations in central California suffered to some degree during the Medieval Climatic Anomaly. Schwitalla and Jones (2011) go on to argue that droughts reduced animal populations, forcing humans to rely more heavily on cached acorns, a food product notably higher in carbohydrates than proteins and fats, which, despite their ability to support a large population, actually compromised human health levels. The present study saw increases in total craniofacial, cranial vault, and facial trauma prevalence during the Middle Period with declining rates into the Late Period (Figure 9); however,

![FIGURE 9. Trauma prevalence through time.](image-url)
none of the comparisons were statistically significant. An increase in acorn reliance and subsequent decline in health levels may have indeed occurred, but given the lack of a consistent temporal pattern of craniofacial trauma in this study, results do not support the research expectation of increased interpersonal violence in the Central Valley from the Early through Late Periods as a result of human population increases and climatic fluctuations.

Though not supported by this study, the Late Period is cited as a time of significant increases in skeletal trauma prevalence in other studies throughout prehistoric California. A temporal analysis of craniofacial and forearm fractures primarily from sites in the northern Sacramento Valley by Nelson (1997) provides an example. The sites, dating between 4000 and 250 B.P., were reorganized by Nelson (1997) into three periods, 4000 – 2500 B.P., 2500 – 1250 B.P., and 1250 – 250 B.P., which reasonably correspond with the Early, Middle, and Late Periods. Cranial vault injuries, approximately three times more common than facial and forearm fractures, primarily took the form of antemortem trauma. Nelson (1997) found a consistent increase in the prevalence of combined skeletal fractures through time, with the greatest ratio of affected individuals associated with the period from 1250 to 250 B.P., a time frame corresponding to the Late Period.

Temporal analyses from the San Francisco Bay Area tend to follow an earlier emergence of trauma prevalence increases. Bartelink et al. (2013) reported a statistically significant difference in cranial vault trauma and trophy-taking prevalence in the San Francisco Bay Area with a noticeable spike during the Early/Middle Period Transition. The Middle Period was noted for the highest levels of facial trauma, and projectile point
injuries dominated the Late Period, though the pattern was not statistically significant. The Early/Middle Transition Period was also noted by Andrushko et al. (2010) as a time of increased violence in the San Francisco Bay Area as evidenced by elevated rates of trophy-taking and dismemberment. Bartelink et al. (2013) and Andrushko et al. (2010) both reported variable temporal patterns with decreased evidence of trauma in the Late Period, and in the study by Andrushko et al. (2010), a total absence of trophy-taking and dismemberment in the Historic Period was noted. Explanations for these trends include the emergence of a move toward a hierarchical societal structure in the Middle Period that magnified social inequality and may be evidenced by a change in mortuary patterns and ethnohistoric accounts describing the prestige attributed to the collection of the body parts of enemies as trophies.

Trauma patterns in southern California appear to follow a temporal trend more consistent with that of the Central Valley. In a cemetery site north of Los Angeles along the Pacific Coast, Walker and Lambert (1989) attributed the high rate of skeletal trauma to population-induced resource scarcity during the Late Period, citing signs of declining health as evidenced by reduced stature and increased dental hypoplasias and treponemal dieases. Research by Walker (1989) in the Santa Barbara Channel Islands off the coast of southern California indicated an increase in craniofacial trauma prevalence on Santa Cruz Island, peaking during the Late Period, and greatly outnumbering injuries observed on the mainland. In a later study, Lambert and Walker (1991) corroborate the increased frequency of trauma within the Santa Barbara Channel Islands and identify the greater tendency of sublethal violence in island populations, but note the dramatic decrease in trauma levels in the Late Period perhaps due to political and economic stabilization in the
region. Continued research by Lambert (1997) supported the decrease in trauma at the outset of the Late Period in southern California, paralleling the results of the present study, and citing the development of trade networks during the violent late Middle Period as one of the more important economic and sociopolitical improvements.

**Research Expectation Two**

Statistical analysis indicated no significant difference in the number of traumatic injuries on either side of the cranium, resulting in the rejection of the research expectation that more traumatic injuries would be observed on the left side of the cranium. This hypothesis was based on the expectation that prehistoric examples of interpersonal violence were primarily dispensed in face-to-face encounters in which the participants were predominantly right-handed, inflicting blows to the left side of the opponent’s cranium. Despite the lack of evidence for this hypothesis, it is still possible violent encounters occurred while participants were in close proximity to one another.

Figure 10 shows the location of cranial vault depressions observed in males and females. In a similar figure by Nelson (1997), the distribution of trauma is more even throughout the cranial vault, however in this study, the majority of vault injuries recorded in males were concentrated on the anterior portion of the cranium, particularly the left side of the frontal, which does support the expectation of face-to-face fighting with a right-handed opponent. Lambert (1997) made a similar observation of nonlethal frontal injuries in males from the Santa Barbara Channel Islands and coastal mainland and, like Walker (1989), suggested their presence could be explained by socially prescribed hand-to-hand conflict resolution meant to settle a dispute through injury, but not death.
Figure 10. Location of cranial vault injuries in males and females.

Differing from the male pattern, injuries to the posterior portion of the cranium were more commonly observed in females. This pattern can still support the expectation of face-to-face fighting because there is no limit to the number of positions taken by participants in a violent encounter. A cluster of injuries on the right parietal,
though not expected in this study, can be explained by the likelihood of movement during a violent encounter. If an attack is anticipated, the recipient will instinctively attempt to avoid injury by ducking, dropping the chin to protect the face, or turning away to flee, which can result in different trauma patterns. For example, a victim struck from behind by a right-handed attacker would be more likely injured on the right side of the head and body, as we see in the female representation in Figure 10. Another explanation for the posterior concentration of vault injuries observed in females is the possibility the victims took a seated fetal position with knees drawn up to protect the face and hands wrapped around the back of the head. This position would leave the posterior portion of the parietals exposed and may explain the lower frequency of nasal injuries in females as detailed in Figure 11.

This scenario could be further supported by the presence of fractures to the middle or distal diaphysis of the radius or ulna (or both) of the forearm referred to as parry fractures as they are associated with attempts by the victim to deflect blows to the head. Though rare compared to the frequency of cranial trauma, parry fractures reported by Nelson (1997) were only observed in three of 205 individuals, all of whom were female. Willits (2010) reported three distal radius fractures in a sample of 270 individuals, two of which were female. Another ten of 270 ulnae displayed fractures, though the distribution between right and left sides and proximal and distal location varied. However, that 90 percent of these fractures were observed in females could lend support to the association of a specific behavioral response to a violent attack toward that sex, particularly if, as Lambert (1997) suggests, females were victims of spousal abuse and perhaps incurred these injuries as they attempted to protect themselves. In turn, the
Figure 11. Location of facial injuries in males and females.

fewer observances of parry fractures and greater prevalence of nasal fractures in males could further support a higher risk of participation in face-to-face fighting by that sex (Figure 11). It has been suggested the initial blow in a face-to-face encounter was directed at the face as a means of stunning the opponent and rendering him incapable of defending himself before sustaining more serious injuries to the head and body (Walker 1989).

Larsen (1997) argues the presence of cranial and forearm fractures are expected to occur simultaneously if forearm fractures are to be considered parry fractures. Because many of the same individuals were sampled in both the present study and Willits’ (2010) research, a comparison of trauma revealed three individuals within the shared sample exhibited both parry fractures and craniofacial trauma. One individual from CA-SAC-060, a male, suffered a right distal radius fracture and a left frontal
depression. Another individual, a female from CA-SAC-043, sustained a proximal left ulna and a right nasal fracture. A second female, also from CA-SAC-043, showed evidence of a distal right ulna fracture and a large, bony projection on the left zygomatic. All of these traumata were well-healed and serve as possible examples of face-to-face fighting, though it is not possible to determine if the pair of injuries in each individual were suffered at the same point in time, or if their presence is coincidental.

Figures 12 and 13 illustrate the injuries to either side of the skull in males and females, respectively, that are not illustrated in Figures 10 and 11. With only three zygomatic injuries and two temporal injuries, neither sex exhibited many injuries. So as not to create confusion, some injuries such as the well-healed vault depression at bregma in one female, are signified by a single circle though damage may have been noted on multiple elements. In the example of the trauma at bregma, the depression was scored as having affected the right and left parietals and the right and left frontals (the frontal was assigned this designation to aid in the analysis by side, though the true anatomical nature of this element is as a single bone).

**Research Expectation Three**

Though females displayed injuries to all craniofacial elements noted in this study, results indicated males, with 20.5 percent of the male sample affected, were significantly more likely than females to sustain craniofacial trauma through time. When separated by anatomical location, the prevalence of trauma between males and females did not differ through time. The exception to this was the prevalence of cranial vault trauma between the Early and Middle Periods when once again males were significantly favored over females to exhibit trauma.
Figure 12. Location of injuries on the right and left sides of the skull in males. These are injuries not illustrated in Figure 10. Note the presence of a single temporal injury on the right side and the absence of injuries on the left side.

Figure 13. Location of injuries on the right and left sides of the skull in females. These are injuries not illustrated in Figure 10.
Males have been cited in other studies as the more commonly affected sex when it comes to violent injuries (Andrushko et al. 2010; Jurmain et al. 2009; Lambert 1997; Standen and Arriaza 2000; Walker 1989) due to their more likely participation in violent or dangerous behaviors (Walker 2001). For example, 20.0 percent of males from the CA-ALA-329 site in the San Francisco Bay Area displayed craniofacial trauma while only 1.6 percent of females were affected (Jurmain et al. 2009). In a sample from the Santa Barbara Channel Islands and coastal mainland, Lambert (1997) reported males in all time periods were significantly more likely to carry scars of craniofacial injuries into old adulthood, whereas females were far more likely to sustain violent injuries as mature adults than as young or old adults, suggesting either a greater susceptibility to such trauma or a differential mortality rate associated with craniofacial trauma.

Though this sex difference is commonly observed in bioarchaeological studies, it is not universal. Nelson (1997) compared the size and depth of depressed cranial fractures between males and females in the northern Central Valley and reported the traumata observed in males were larger and deeper on average. Despite this, the trauma distribution between males and females was not significantly different. Similarly, Jurmain (2001) observed no sex differences in both cranial and long bone fractures of individuals from the south San Francisco Bay.

Discussion of the second research expectation addresses the distribution of craniofacial trauma in the sample and offers violent interactions as an explanation for their presence. The dissimilarity in trauma prevalence between males and females may also reflect aspects of the sexual division of labor. Among the Plains Miwok, tasks associated with males included securing geographic boundaries, hunting, fishing, and
baskery and weaving insofar as their use in making traps and nets, while females were primarily responsible for collecting food, including acorns, and manufacturing tools used in basketry (Bennyhoff 1977). However, within this group, sexually prescribed duties were somewhat flexible as males offered significant assistance in the acorn collecting process and other activities typically performed by females (Mayer 1976). Despite this ethnographic account, differential exposure to violence offers a more convincing explanation for the variable patterning observed in males and females in the sample.

Total Trauma Prevalence

This study’s total craniofacial trauma prevalence rate of 13.7 percent is notably high compared to other regions worldwide and particularly for central California. Though not the highest rate reported for central California (Nelson 1997), this result is larger than that of many other studies (Jurmain 2001; Andrushko et al. 2005; Andrushko et al. 2010; Jurmain 2009). However, skeletal trauma prevalence rates in central California, which include evidence of trophy taking and dismemberment, acts that require a particular level of violence and disregard for the enemy, typically trail those of southern California, even though trophy taking and dismemberment have not been observed there (Andrushko et al. 2010).

Nelson (1997) found 14.9 percent of his sample from central California exhibited cranial and forearm injuries. When separated by craniofacial trauma, 9.3 percent of the adult sample sustained facial injuries while a staggering 19 percent suffered from cranial vault trauma. These findings are exceptional, particularly when compared to the 4.8 percent prevalence from a sample including 30 archaeological sites
located throughout the San Francisco Bay Area (Bartelink et al. 2013). Additionally, Jurmain et al. (2009) found a cranial trauma prevalence of 9.0 percent in a sample from the south San Francisco Bay (Jurmain et al. 2009).

The variation in rates of violence within California, particularly between the Middle and Late Periods, has been explained by “differences in social geography” (Andrushko et al. 2010:92). Social organization of the Plains Miwok and Northern Valley Yokuts, groups that consisted of independent, chief-led tribelets (Levy 1978; Wallace 1978), participated in rituals involving dismembered remains including scalps (Andrushko et al. 2010). Prehistoric central California was populated by small, culturally distinct groups living in close proximity to one another whereas southern California, in contrast, comprised “multi-village polities” with a “collective Chumash identity” (Andrushko et al. 2010:92). The absence of a shared identity in central California likely suggests groups saw one another as outsiders and may explain the propensity toward the trophy-taking and dismemberment (Andrushko et al. 2010).

Walker and Lambert (1991) suggest the temporal increase of cranial trauma in archaeological populations from the Santa Barbara Channel was a symptom of greater environmental and social constraints (Walker and Lambert 1991). Throughout California, environmental factors like variations in precipitation and temperature affected the density of floral species, which is expected to have also affected the population levels and migration patterns of the faunal populations relying upon them (West et al. 2007). This was compounded with human populations that, according to Richerson et al. (2001), could have increased between 1 and 3 percent per year without interference such as death due to disease, natural disaster or warfare with the greatest population growth in the
Sacramento-San Joaquin Delta having occurred in the Middle Period (Basgall 1987). The pressures increasing human populations placed on already stressed resources would have resulted in their increased exploitation and depressed numbers, amplifying resource competition and the violence that ensued as a consequence.

Interpretation of Trauma

The most commonly observed injury classifications in this study were cranial vault depressions and nasal fractures, injury types that, among others, tend to occur under violent conditions (Lambert 2002) and represent the most often cited indicators of interpersonal violence (Jurmain et al. 2009). All but one of the injuries cited in this study was non-life threatening as evidenced by substantial healing prior to death. This pattern has also been observed within the Santa Barbara Channel Islands where approximately 19 percent of individuals sampled showed evidence of craniofacial trauma (Walker 1989). As most of these injuries were nonlethal, Walker (1989) proposed their presence may have been due to fighting as a form of conflict resolution with the goal being injury, but not death.

The majority of injuries noted in this study took the form of shallow, nonlethal circular or ovoid depressions of variable size and were primarily located on the frontal, parietal, and nasals. The shapes of these injuries suggest they were created by a club-like instrument that was also round, but given the lack of depth, they likely did not leave the victim with permanent disability (Lambert 1997). Standen and Arriaza (2000) report a similar trend in a study of trauma among the skeletal remains of the Chinchorro, a prehistoric hunter-gatherer group that inhabited the northwest coast of Chile, and suggest
the trauma pattern, in the absence of clubs, may have been caused by the use of cobblestones as weapons. Though the southeastern portion of the Sacramento Valley was said to have been void of stones (Bennyhoff 1977), the riparian nature of the Sacramento-San Joaquin Delta provided a source of river stones, which Kroeber (1925) describes as a weapon of convenience among central California inhabitants.

No evidence of warfare in the form of embedded projectile point injuries, scalping, or other forms of trophy taking of the skull were observed in the sample. However, Willits (2010) identified projectile point injuries in her study using skeletal remains from many of the same archaeological sites as the present study. One young male and one older male from the Early Period each presented an embedded projectile injury to the posterior side of the humerus. The injury in the young male was located in the olecranon fossa on the posterior side of the bone, suggesting the arm was flexed when struck, and the lack of a bony response likely indicates the injury occurred perimortem (Willits 2010).

An ethnographic account of the Plains Miwok by Bennyhoff (1977) suggests this group who inhabited the southeastern Sacramento Valley exhibited underdeveloped hunting skills despite the availability of a selection of arrows, more often preferring to chase down prey or steal horses from neighboring coastal tribes. The preference for other means of capturing prey may explain the absence of projectile point injuries in this sample, particularly in the Late Period with the development of the bow and arrow (Milliken et al. 2007).

To assess the probability for a projectile point to strike bone, Walker (2001:584) calculated the human “skeleton occupies about 60% of the target area a body
represents to an assailant” when observed from the front, meaning a projectile shot at a person at random would have a 40 percent chance of not striking bone, thus leaving no indication of cause of death from skeletal remains alone. Although both weapons were used for hunting, the replacement of the atlatl with the bow and arrow during the Late Period (Milliken et al. 2007) was likely due to its preference for reducing the risk of injury by avoiding face-to-face fighting and subduing an adversary from a greater distance (Bartelink et al. 2013). Such weapons are more likely to be directed at the body since the likelihood of making contact with the post-crania is greater, especially if tracking a moving target. Despite the widespread adoption of this technology in the Late Period, the decline in craniofacial trauma observed in the Late Period sample in the present study may be due to the exclusion of post-cranial analyses. In other words, if the bow and arrow became the predominant weapon, a shift from craniofacial trauma to post-cranial trauma is expected in the Late Period. However, in reviewing the results of postcranial trauma analyses by Willits (2010), which identified only two incidences of projectile point trauma, injury patterns were determined to have been less consistent with violence and more indicative of a sexual division of labor, further supporting a decrease in total trauma in the Late Period. It is important to note the elements of the axial skeleton were not included in Willits’ (2010) research; therefore, additional research may reveal an alternate temporal pattern.

Summary

Only one of the three research expectations of this study was supported, the expectation that craniofacial trauma would be more common within the male sample. But
failure to support the expectations of a temporal increase in craniofacial trauma concentrated on the left side of the skull does not discredit the likelihood that interpersonal violence was just another feature of the hunter-gatherer lifestyle within the Central Valley during the Holocene. The 13.7 percent prevalence of craniofacial trauma observed in the sample lends additional credence to this position. California has reported some of the highest rates of violence-induced skeletal trauma worldwide, though predominantly from the southern part of the state. The rate reported here suggests the Central Valley was not as serene an environment as once thought and may have in fact been rife with the threat of violence.
CHAPTER VII

CONCLUSION

This study analyzed the prevalence of craniofacial trauma in prehistoric human populations from the Central Valley in California in an attempt to identify temporal, physical, and sex-related patterns of interpersonal violence. Population expansion, climatic oscillations, and resource intensification during the late Holocene were explored as major contributing factors to the rates of craniofacial trauma.

The vast majority of identified injuries were antemortem cranial vault depressions and nasal fractures. No increase in injury prevalence through time was noted, rejecting the first research expectation. In this study, a notable increase in trauma prevalence was typically observed in the Middle Period, however, temporal analyses generally found a decrease in the Late Period, an unexpected pattern given the contemporaneous emergence of more advanced weaponry such as the bow and arrow.

The second research expectation was also not supported as craniofacial trauma prevalence was equally represented on both sides of the skull. However, an interesting cranial vault injury pattern emerged indicating males primarily sustained trauma to the anterior vault while females sustained more posterior injuries. As expected by this study, more males sustained traumatic injuries than females, further supporting the assumption that males would have been more likely to participate in violent encounters brought on by population increases and resource competition.
The most notable aspect of this study is the presence of craniofacial trauma in 13.7 percent of the sample, a larger result than what is generally reported within central California and is more in accordance with the trauma rates of southern California. This could be interpreted to mean the Central Valley was a more dangerous environment than other parts of central California including the San Francisco Bay Area. On the other hand, the nonlethal classification of nearly all of the identified injuries combined with the observation of a single craniofacial injury in most of the affected individuals suggest the violence inflicted upon Central Valley inhabitants was not meant to kill, but only to injure an opponent as a means of settling disputes, possibilities noted by Walker (1989) and supported by later research (Nelson 1997). However, it should be noted that most lethal injuries, such as those caused by projectile points, are typically restricted to the postcranial skeleton, therefore the present study with its limitation to cranial remains does not provide a complete picture of violence related skeletal trauma in prehistoric central California.

Limitations of Study

Because this study makes some interesting conclusions, the potential for research bias deserves mentioning. Sample sizes from a few archaeological sites, particularly CA-SJO-142 and CA-SJO-154, were comparatively smaller than others and may have distorted the data. This is compounded by the temporal analysis that included time periods several hundred years in length. In other words, it is questionable whether the skeletal remains of 15 or 20 individuals are representative of a larger population spanning a significant amount of time.
The sole presence of skeletal trauma in archaeological populations is inadequate support for violence just as the absence of trauma is not definitive evidence of a harmonious society (Lambert 2002) because the skeletal elements exposed to trauma may not have been preserved well enough for analysis, if at all. Due to the variable preservation of skeletal remains in the sample, the inclusion of crania no less than 70 percent complete was meant to minimize bias. Initial research methodology included only the examination of craniofacial trauma as a whole and not as trends separated between the cranial vault and facial elements. Examining isolated regions for traumatic injury such as the cranial vault or face offers additional insight into trauma patterns, particularly between males and females. However, some skulls with 70 percent cranial vault presence, but significant absence of the facial elements, and vice versa, were included in the study, creating an opportunity for skewed results. Rather than remove these skulls and risk additional bias due to a shrinking sample size, skulls with less than 70 percent presence of the cranial vault or face remained in the analysis after data collection.

The absence of injuries identified on one large craniofacial element, the occipital, may be the result of observer bias. While injuries to these elements have been reported in other craniofacial trauma research (Walker 1989), the lack of even a single fracture calls attention to the possibility the author unwittingly scrutinized the elements comprising the superior portion of the cranial vault and nasal region of the face more closely knowing these areas are more commonly affected in face to face violent encounters. It is conceivable no such injuries were in fact present within the sample, but given the number of skulls examined, the likelihood of this is drawn into question.
Implications for Future Research

Further craniofacial analysis could include comparisons designed to identify additional patterns of trauma. For example, trauma sustained to the anterior versus the posterior portions of the skull could identify variable patterns of trauma indicative of face-to-face encounters versus injuries inflicted during escape attempts by the victim or surprise attacks by the aggressor.

The results of multiple studies of prehistoric violence in California show young males were the more frequent victims of violent encounters than their older counterparts (Jurmain et al. 2009; Andrushko et al. 2005, 2010). The present study ignores trauma patterns differentiated by age, a factor that is of little consequence here due to the frequency of antemortem injury. However, in the event a skeletal sample consists of a larger representation of perimortem trauma, and to facilitate a broader understanding of demographic patterns of violence in central California, further analysis could include more narrowly defined age categories to allow for comparisons of perimortem craniofacial trauma prevalence between younger adults and older adults.

Finally, the inclusion of postcranial trauma assessment including evidence of trophy-taking and dismemberment evaluated in conjunction with craniofacial trauma would offer more comprehensive, definitive evidence of prehistoric violence, particularly warfare. Further inclusion of results from the research conducted by Willits (2010) coupled with an analysis of the axial skeleton would be particularly interesting as such comparisons are expected to afford a broader understanding of violence within the Central Valley.
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PHOTOGRAPHS OF OBSERVED TRAUMA

Superior view of individual 6699 from CA-SAC-043 showing antemortem cranial vault depression at bregma. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-6699).

Left anterolateral view of individual 6702 from CA-SAC-043 showing large bony projection to left zygomatic. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-6702).
Left lateral view of individual 6718 from CA-SAC-043 showing ovoid antemortem cranial vault depression near the sagittal suture. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-6718).

Superior view of left zygomatic arch of individual 6725 from CA-SAC-043 showing spiked projection of bone on the left zygomatic. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-6725).
View of antemortem trauma to the right nasal and maxilla in individual 6800 from CA-SAC-060. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-6800).
Antemortem cranial vault depressions of the right parietal in individual 7799 from CA-SAC-060. Note the surface wear throughout the cranium. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-7799).
Superior view of antemortem cranial vault depression on the left parietal and frontal in individual 7582 from CA-SJO-068. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-7582).
Lateral view of antemortem fracture to the right temporal in individual 7603 from CA-SJO-068. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-7603).

Antemortem cranial vault depression to the left parietal near the coronal suture in individual 11286 from CA-SJO-154. Courtesy of the Phoebe A. Hearst Museum of Anthropology and the Regents of the University of California. Photograph by Kristin Chelotti, (Catalogue No. 12-6699).