The Bioarchaeology of War

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The Bioarchaeology of War

Abstract
The following is a report on the perimortem cranial traumas observed at the Hasanlu archaeological site with the sole purpose of relating these traumas to their causative implements. Nineteen of 187 skulls from Hasanlu were selected for extended analysis based on the clarity of their perimortem wounds; a sample of all weapon types recovered from the site was also analyzed. Sixty-three definite or very likely perimortem primary points of impact were identifiable on the 19 skulls, corresponding to both blunt and sharp force trauma. Evidence was found for cranial trauma induced by falls, maceheads, swords, daggers, and possibly spears. As a whole, the association of the cranial traumas with causative weapons suggests something previously unknown about the battle at Hasanlu: that combat took place at very close range. Thus, this novel association of trauma with weapons may enhance our understanding of a single devastating day 2200 years ago, ancient Near Eastern warfare as a whole, and ultimately, the history of human violence.

Disciplines
Anthropology

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THE BIOARCHAEOLOGY OF WAR

By

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In

Anthropology

Submitted to the
Department of Anthropology
University of Pennsylvania

Thesis Advisor: Dr. Janet Monge

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ABSTRACT

The following is a report on the perimortem cranial traumas observed at the Hasanlu archaeological site with the sole purpose of relating these traumas to their causative implements. Nineteen of 187 skulls from Hasanlu were selected for extended analysis based on the clarity of their perimortem wounds; a sample of all weapon types recovered from the site was also analyzed. Sixty-three definite or very likely perimortem primary points of impact were identifiable on the 19 skulls, corresponding to both blunt and sharp force trauma. Evidence was found for cranial trauma induced by falls, maceheads, swords, daggers, and possibly spears. As a whole, the association of the cranial traumas with causative weapons suggests something previously unknown about the battle at Hasanlu: that combat took place at very close range. Thus, this novel association of trauma with weapons may enhance our understanding of a single devastating day 2200 years ago, ancient Near Eastern warfare as a whole, and ultimately, the history of human violence.
INTRODUCTION

The cranial traumas in the Hasanlu Skeletal Collection have been studied numerous times in the past. Most recently, Monge and McCarthy (2011) assessed the differing prevalence and nature of cranial fracture between men and women and concluded that women at Hasanlu may have regularly been subjected to domestic violence. Similarly, many have analyzed the weapons recovered from Hasanlu, held within the Hasanlu Cultural Collection. Only last year, Thornton and Pigott (2011) systematically classified the various sharp weapons found at the site. Although a few authors have made unsupported speculations regarding the instruments responsible for the cranial traumas at Hasanlu, no one has yet made a serious attempt to associate the cranial traumas with the implements that may have caused them. This is especially surprising given the rarity of such an opportunity to look at a wide variety of traumas and weapons side by side. The following study is therefore a report on the perimortem cranial traumas observed at Hasanlu with the sole purpose of relating these traumas to their causative implements. A more exact knowledge of the weapons used in this battle may enhance our understanding of a single devastating day 2200 years ago, ancient Near Eastern warfare as a whole, and ultimately, the history of human violence.
BACKGROUND

The archaeological site at Hasanlu

Hananlu is an early Iron Age archaeological site located in the Gadar River Valley of northwestern Iran. Radiocarbon dating suggests that the city was occupied between the second half of the second millennium BC and roughly 800 BC. At this time, it was located at the junction of several trade routes and was likely a region of great cultural and material interaction (Dyson, 1989).

Excavations at Hasanlu began in 1957 and continued through 1977 under the sponsorship of the University of Pennsylvania Museum of Archaeology and Anthropology, the Metropolitan Museum of Art of New York, and the Archaeological Service of Iran (Dyson, 1989). Today, the site consists of two mounds: the Low Mound, which served as a cemetery during the Iron Age, and the High Mound, the once-inhabited city. Excavation of the High Mound commenced in 1958, leading to the discovery of the burned and thoroughly devastated remnants of an ancient battle. This archaeological level, and the associated period of Hasanlu prehistory, is now known as Hasanlu IVB (Dyson, 1989). It is clear that the city and its populace did not survive the violent attack. Reminiscent of Pompeii, skeletons lay strewn across the site, caught in the moment of death. The identity of their attacker remains unknown.

Warfare was a common facet of ancient Near Eastern life and was certainly an institution familiar to the people of Hasanlu. Early texts celebrate the slaughter of enemy civilians. They describe mutilations and massacres; they detail the extermination of foreign populaces. The Old Testament is particularly vehement in its insistence that no conquered man be allowed to survive
his defeat. Archaeological evidence, such as decorative reliefs depicting battle scenes, provides further support that war in this region was both frequent and vicious.

At Hasanlu, archaeologists found large weapon stores (evidently never accessed during the final battle) and numerous additional armaments discarded during the resistance. Also amongst the recovered artifacts are examples of protective metal armor employed by the people at Hasanlu, including helmets, shields, and shoulder guards. This is consistent with decorative imagery found at the site, which suggests that Hasanlu infantrymen traditionally wielded spears, swords, and small shields; cavalrymen carried spears. Although numerous maces, axes, and daggers littered the battle scene, these weapons are not depicted in the ancient illustrations (Muscarella, 1989).

The skeletons of 246 men, women, and children were discovered amongst the remains of Hasanlu IVB. Of these individuals, 157 perished inside burning buildings when the structures gave way. The 89 others were slaughtered in open areas. Eleven adults and five subadults were discovered in close proximity just outside of Burned Building XI. Six of the adult skulls in this skeleton cluster reportedly exhibit violent perimortem traumas. A second cluster of nine individuals, six adults and three subadults, was unearthed near the Upper Court Gate (Muscarella, 1989) and near 24 iron arrowheads and nine iron spearheads (Thornton and Pigott, 2011). One of these adults reportedly sustained perimortem cranial trauma (Muscarella, 1989). A group of 16 adults and 11 subadults was also found inside Burned Building IV (Muscarella, 1989); two iron spearheads and a sword were discovered in the same room (Thornton and Pigott, 2011). Four of these individuals have perimortem cranial traumas (Muscarella, 1989). Muscarella (1989) suggests that these four people were killed with a mace. Is his interpretation correct? How did the others die?
Hasanlu preserves a moment in time. It thus provides a rare glimpse into the past and an uncommon opportunity for investigation. In general, as Walker (2001) notes, skeletal remains provide direct evidence of violence in past societies free from the many interpretive difficulties posed by literary sources. But the deceased at Hasanlu have particularly potent analytic potential in that they have not been altered or prepared by unknown cultural traditions nor have they been torn from the contexts surrounding their manner and cause of death. It may therefore be possible to positively associate the skeletons found at Hasanlu with the implements responsible for their demise. This involves thorough cranial fracture analysis and detailed description of the cranial traumas encountered at the site.

**Cranial trauma analysis**

Fractures refer to “any break in the continuity of bone” and may result from direct trauma, indirect trauma, stress and/or pathology. Cranial fractures tend to be direct traumas to the vault and have a high specificity for assault (Lovell, 1997). Analysis of cranial fractures can be complicated and difficult. As severity of trauma increases, it becomes increasingly difficult to identify the point of impact and to associate it with related fractures (Lovell, 1997). Further, fractures caused by the same mechanism may vary in appearance, and fractures caused by differing mechanisms may be similar in appearance (Lovell, 1997). This variation is due to a number of extrinsic and intrinsic factors effecting fracture likelihood, extent, and characteristics/pattern. Extrinsic factors include the magnitude, duration, and direction of force, and the rate at which the bone sustains that force; intrinsic factors include the bone’s capacity to absorb energy and its elasticity/stiffness, density, and strength (Harkness et al., 1984; Berryman
and Haun, 1996; Berryman and Symes, 1998). Because individual skulls vary in their robusticity and elasticity, they display differential susceptibility to various fracture patterns.

It is also important to note that trauma to the cranium produces opposing forces on the inner and outer tables of the vault. When pressure is exerted against the skull from without, the local ectocranium inbends and the outer table compresses; the opposing inner table, however, is under tension. When pressure is exerted against the skull from within (usually a response to inbending of the cranium elsewhere), the ectocranium outbends and the outer table tenses; the opposing inner table is under compression. Because bone is twice as strong under compression as it is under tension and will therefore fracture first under tension (Berryman and Haun, 1996), this phenomenon of opposing stress is useful in determining the origin of fracture producing forces.

Cranial traumas are distinguished and categorized by the nature of the forces that produce them. Thus, they may be designated as blunt force traumas, sharp force traumas, or projectile traumas (Galloway et al., 1999). Despite the independence implied by their names, the delimitations of these categories are often unclear. Single weapons may simultaneously or sequentially impart multiple forces upon the cranium.

Blunt force is defined as a relatively low-velocity force applied over a relatively large surface area (Galloway et al., 1999). It may result from compression or from either direct or indirect impact (Galloway, 1999a). In turn, impact may involve either an acceleration injury, in which the head is static and struck by a dynamic object, or a deceleration injury, in which the head is dynamic and strikes a static object (Lovell, 1997). The severity and gross characteristics of blunt force traumas can vary greatly (Berryman and Symes, 1998). The most common cranial
lesions produced by blunt force are linear fractures and depressed fractures, which often co-occur (Kaufman et al. 1997; Lovell 1997).

Linear vault fractures normally result from a direct very low-velocity blow to the cranium by an object of large mass and may appear directly at the site of impact or at a more distant area of impact-related outbending (Galloway, 1999b). They may affect both tables of the skull or may be limited to either the inner or outer table. Most, however, initiate on the outer table as a corollary to tension produced by cranial outbending (Gurdjian et al., 1950). Linear fractures are therefore less common in subadult skulls due to the greater elasticity and flexibility of juvenile bone (Galloway, 1999a). In adults, linear fractures tend to progress quickly and to follow the path of least resistance by diverting around bony buttresses and often towards sutural lines and other linear fractures where bone is already weak (Galloway, 1999a). That the energy from a second impact will dissipate into fractures produced by a prior impact and will not cross them allows multiple traumas to be sequenced when they intersect (Berryman and Symes, 1998).

When a linear fracture is diverted into a suture, it is deemed diastatic (Galloway, 1999a). Stellate fractures are formed when multiple linear fractures radiate from a single point of impact (Lovell, 1997; Galloway, 1999a). If more than two cranial fragments are created, the fracture area is said to be comminuted (Galloway, 1999b). Stellate and comminuted fractures are indicative of greater force than are simple linear fractures (Lovell, 1997).

Slightly higher velocity low-velocity impacts with objects of smaller size result in depressed cranial fractures. Within this category, relatively low force and/or relatively large surface area will create a localized lesion of crushed outer table; slightly higher force/smaller surface area will result in inward displacement of the lesion; still higher force/smaller surface area will produce a completely detached depressed fracture that closely resembles a penetrating
injury (Lovell, 1997). In the last case, the local endocranial damage is frequently greater than the ectocranial damage (Courville, 1962; Galloway, 1999b). Thus, the degree of attachment is indicative of the degree of force used.

Because depressed fractures are localized to the point of impact, it may be possible to approximate the size and shape of the causative implement from the size and shape of the depression. It is important to note that the fracture area is often slightly larger than the striking surface of the tool that created it (Galloway, 1999a).

Unlike simple linear vault fractures, depressed fractures are primarily a consequence of compressive forces and inbending of the outer table (Galloway, 1999a). However, linear fractures may form around the depressed fracture in areas of concomitant outbending (Berryman and Symes, 1998). Such fractures are usually radiating or concentric in nature. That is, they either extend out from or circumscribe the primary fracture margins. Because concentric fractures associated with blunt force trauma initiate under tension on the outer table and progress to the inner table, they bevel internally (Berryman and Symes, 1998).

Cranial plastic deformation is also characteristic to blunt force. In general, loads applied to the skull cause bone to bend. When the load is removed quickly, the bone is able to return to its normal shape. However, if the load is applied with very low velocity, the bone may permanently deform (Berryman and Haun, 1996).

Blunt force injuries to a single individual usually involve only one weapon (Ambade and Godbole, 2006), though this weapon may be used to impart multiple blows. Once the skull has sustained a single fracture and thereby lost its structural integrity, complete destruction can be induced with little additional force (Gurdjian et al., 1950). Multiple blunt force traumas to a single skull also have the potential to create knapped and flaked fracture margins as “repeated
blows to an area of [already] shattered bone may force bone shards together” (Berryman and Symes, 1998, 341).

Falls are a source of non-weapon-related blunt force trauma. They result in comminuted or linear fractures below an imaginary line parallel to the Frankfort horizontal plane and passing through glabella (Kremer and Sauvageau, 2009; Guyomarc’h et al., 2010). Ring fractures, in which “the skull base separates with the rim of the foramen magnum and detaches from the vault,” can result when an individual lands on his feet or butt (Galloway, 1999a, 71) and as the vertebral column is forced upward against the cranium.

Projectile trauma, often referred to as gunshot trauma despite a variety of causative implements, is created by high velocity forces applied over small areas (Galloway et al., 1999). This leads to penetration of the skull, often with associated radiating fractures, and to a subsequent rapid increase in intracranial pressure that can elevate plates of bone out of the vault and form heaving concentric fractures (Berryman and Haun, 1996; Berryman and Symes, 1998). The size of this penetration depends on the size of the projectile, the velocity of the projectile, and the distance traveled by the projectile (Lovell, 1997). The margins of entrance wounds bevel internally while those of exit wounds bevel externally (Berryman and Haun, 1996). Because the concentric fractures associated with projectile trauma initiate under tensile forces on the inner table, in contrast to blunt force concentric fractures, they bevel externally (Berryman and Symes, 1998). If the magnitude of the force is great enough, the bone will react as a brittle material and exhibit little to no plastic deformation (Berryman and Haun, 1996; Berryman and Symes, 1998); fracturing will likely be extensive and explosive (Berryman and Haun, 1996).

Sharp force trauma “involves forces directed along a very narrow surface with the discontinuities produced by physical interruption of the skeletal tissue by a foreign object”
If the length of the resulting discontinuity is greater than its depth, it is deemed an incised wound; if its length is less than its depth, it is a stab wound (Symes et al., 2002). Yet, knife wounds and other sharp force traumas that involve relatively slow velocities may be best described as blunt force traumas with sharp objects. Indeed, sharp objects are truly just “blunt” objects with sharp edges. Although the sharp edges ensure that the initial impact creates an incision in the bone surface, most subsequent force serves not to further slice the bone but rather to push a widening object through it. In consequence sharp weapons can exert blunt force against bone and can create the tension/compression fractures characteristic of traditional blunt force trauma (Symes et al., 2002). This is especially true when their cutting edge has dulled. Most pertinently, “[h]eavy cutting-edged weapons that are used in a chopping manner will produce crush [depressed] injuries in addition to penetration” (Lovell, 1997, 156). There is no set lesion size at which one can distinctly separate blunt trauma from sharp trauma (Galloway, 1999b).

Skeletal traumas are also classified by the period in which they occurred relative to the death of an individual: antemortem, perimortem, or postmortem.

Antemortem fractures are those that occur before the time of death. Gross signs of osteological repair or response to infection indicate that a trauma was sustained at least one week prior to death and can be used to distinguish antemortem fractures from peri- or postmortem fractures: dead bone does not react to insult. Although bone initiates the healing process immediately following fracture, repair will not be evident to the unaided eye for one to two weeks subsequent (Lovell, 1997). Woven bone callus formation suggests that a fracture occurred relatively shortly before death, while sclerotic bone callus formation indicates an older antemortem trauma (Buikstra and Ubelaker, 1994). It is important to remember that the exact
length of time required for visible signs of healing varies with the location of the injury and with the age and health of the individual who sustained it (Sauer, 1998). If there is no evidence of osteological response, the investigator must then concentrate on distinguishing perimortem trauma from postmortem damage. Fracture patterning becomes extremely important (Sauer, 1998).

Perimortem trauma refers to injuries sustained at the time of death and directly associated with the manner, though not necessarily the cause, of death (Sauer, 1998). The characteristics that distinguish perimortem trauma from postmortem trauma derive from the freshness of the bone at time of fracture. “Fresh bone that contains fluid-filled vessels, grease, and collagen fibers is significantly more pliable and has more tensile strength than dried bone” (Sauer, 1998, 325) and is more resistant to failure. The loss of collagen, however, is gradual and the period of elasticity therefore variable with environmental conditions. In hot, dry climates, as might be expected to characterize Hasanlu, the moisture content of bone is rapidly depleted (Galloway et al., 1999). Yet, in ancient archaeological contexts, perimortem fractures and fractures occurring very early in the postmortem period may be very difficult to differentiate (Walker, 2001). In general, perimortem cranial trauma is described by a lack of osseous response, uniform coloration of broken and intact bone surfaces, the presence of depressed fractures, concentric fractures, radiating fractures, and/or stellate fractures, adherent bone spurs or splintering, and beveled/oblique fracture margins (Lovell, 1997; Sauer, 1998; Galloway et al., 1999).

As previously stated, the loss of collagen after death greatly lowers bone elasticity and increases bone brittleness. Additionally, loss of soft tissue decreases the head’s ability to disperse force. A dry skull may fracture at one-tenth the force of a fresh head (Galloway et al., 1999). As a result postmortem fractures are characterized by smaller, more numerous fragments, right-
angled/squared fracture margins, absence of identifiable fracture patterns (depressed, radiating, concentric, and/or stellate fractures), absence of adherent bone spurs or splintering, and, if the trauma occurred relatively recently within the postmortem period, coloration differences between fracture margins and adjacent intact bone (Kaufman et al., 1997; Lovell, 1997; Galloway et al., 1999; Sauer, 1998). In addition to creating postmortem fractures, taphonomic processes may obscure perimortem fractures by destroying cortical bone and scalloping margins at impact sites (Calce and Rogers, 2007).

MATERIALS AND METHODS

Materials for the present study were provided by the Physical Anthropology Collections and Near Eastern Collections at the University of Pennsylvania Museum of Archaeology and Anthropology in Philadelphia.

The author analyzed 187 skulls in the Hasanlu Skeletal Collection for signs of trauma. The collection identification numbers, location codes, age, and sex were recorded when available. If age and sex were not provided, they were determined following White’s (1991, 310, Figure 16.2, as based on Gustafson and Koch, 1974, and Anderson et al., 1976) guidelines of dental development and Ascadi and Nemeskeri’s (1970; as presented in Buikstra and Ubelaker’s Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at the Field Museum of Natural History, 1994) guides of cranial sexual dimorphism. No innominate were analyzed; thus, to reduce error, individuals with third molar development (or in the absence of dentition, with full-sized skulls) were recorded simply as “adults,” and adults determined to be weak “likely males” or weak “likely females” were simply marked as adults of indeterminate sex.
Percentage completion of all cranial bones, general condition of the skull, degree of articulation, and whether articulation was artificial or natural were recorded. Cranial pathologies and variations with the potential to affect fracture patterning, including extra-sutural bones, foramen, tori, and cranial suture obliteration, were likewise noted.

Antemortem trauma was determined on the basis of osseous response, either (1) evidence of healing or (2) evidence of infection. A determination of perimortem trauma was made when more than one of the following was present: beveled margins, non-discolored margins, attached depressed fractures, concentric fractures, radiating fractures, stellate fractures, splintered/hinged bone, extensive endocranial or ectocranial flaking, and/or fractures associated with plastic deformation. Discolored margins, right-angled margins, regular edges, absence of recognizable fracture patterns, and a lack of beveling or flaking helped to determine post-mortem damage.

Traumatic lesions were measured using 150 mm stainless steel sliding calipers marked to the nearest millimeter. A layer of masking tape was used to “pad” the sharp metal outside jaws of the calipers to prevent damage to the bone. Although this may have slightly compromised the accuracy of the measurements, because the same pair of taped calipers was used to take all cranial measurements (and all weapon measurements not exceeding 150 mm), precision was maintained.

An attempt was made to locate all lesions in relation to distinct cranial points. The given distances represent the shortest linear distance between a given cranial point and a fracture’s closest margin to that point. Fracture size was measured at the longest/widest perpendicular axes. Attached fractures and linear fractures were typically measured using the outside jaws while detached fractures were more often measured with the inside jaws of the calipers. The depth probe was used to measure the depth of attached depressed fractures.
All fractures, whether antemortem, perimortem, or postmortem in origin, were drawn onto diagrams of the skull, taken from Buikstra and Ubelaker’s *Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at the Field Museum of Natural History* (1994). Solid colored areas indicate regions of missing bone. The letter “B” designates external beveling, “D” discoloration, “F” flaking, “S” shaving, “H” hinging, and “C” other cancellous bone exposure. All fractures were arbitrarily assigned numbers. Fracture numbers are not in any way suggestive of the chronological order in which fractures were sustained. Each radiating fracture associated with a given fracture is labeled with the main fracture number, followed by the letter “R” and another arbitrary number representing only the order in which that radiating fracture is described. For example, the third radiating fracture described in association with fracture #6 is labeled 6R3. Concentric fractures are similarly named, simply with a “C” instead of an “R” in the middle position. Sutures that have been forcibly “popped” open due to various cranial pressures are cross-hatched on the diagrams and labeled with the word “pop”. These drawings are provided in the Appendix as Figures 1 through 17.

Weapons were selected from the Hasanlu Cultural Collection’s archives based on archival description. Depending on the number of each weapon type present within the collection, either all or a representative sample of each weapon type was requested for study. Measures were taken with the same set of taped calipers described above when measurements were 150 mm or under; larger measurements were taken with a retractable tape measure. Object size, material, and general condition were also noted. Each object was hand-drawn by the author for her records.

After the skulls and weapons were analyzed independently, a selection of skulls and a selection of weapons were viewed side by side for more direct comparison.
RESULTS

The cranial trauma

Although Monge and McCarthy (2011) report that 40% of the Hasanlu skulls show signs of violent trauma, the present author found only 19 skulls in the Hasanlu collection exhibiting perimortem cranial traumas associable with a causative weapon. This subset is comprised of 13 adult males, three adults of indeterminate sex, and three subadults (including one female adolescent). All fractures, antemortem, perimortem, or postmortem, sustained by these individuals are described below.

Hasanlu 61-5-340 is an adult male. The lateral and basilar portions of the occipital are absent, as are the left temporal, left zygomatic, vomer, ethmoid, inferior nasal conchae, lacrimals, and all but the right greater wing of the sphenoid. The remaining bones are articulated. There are multiple wormians in the lambdoidal and sagittal sutures (Figure 1).

Fracture #1 is a sharp force wound of the right mandibular body. The bone is divided into two pieces between the RM₁ and RM₂. Just below RC, the compact bone appears shaved and smoothed. This gives rise to a large, more lateral area of cancellous exposure, roughly 4.2 cm by 2.6 cm in size. A pointed projection of compact bone overhangs the damaged region.

Fracture #2 is an oblong detached fracture area (a large region of comminution or absent bone) of the frontal, 6.2 cm from nasion and 12.5 cm from the right external auditory meatus. Its margins include a conspicuously smooth and regular curve that may represent a blunt force blow resulting in a detached depressed fracture. Fracture #2 ends posteriorly at the coronal suture, where it overlaps fracture #3. Its margins bevel internally but there is no delamination of the
diploe. Two radiating fractures and a concentric fracture are present. **2R1** runs anteriorly 5.3 cm to the left orbit, passes just medially to the supraorbital foramen, and continues onto the orbital plate. **2R2** runs to the left for 2.0 cm before terminating at the anterior most projection of fracture area #3. **2C1** runs from the mid-lateral lesion margin to the coronal suture, leaving a hinged fragment with a slight linear indentation across the midline; it affects both tables.

**Fracture #3** is also an irregularly shaped region of detached bone, rather than a distinct fracture, spanning an area of 8.0 cm by 9.8 cm located 5.6 cm from lambda and 12.1 cm from the right external auditory meatus; it includes bregma. Two distinctive curves contribute to its margins, one at the sagittal suture and one extending from 3C1 to the left coronal suture. Both of these curves are essentially identical in contour to the curved margin of fracture #2 when all three margins are superimposed. **3R1** radiates 5.0 cm to the right and branches mid-parietal. One branched tract runs anteriorly to pterion. The second moves posteriorly and terminates at the lambdoidal suture. It is possible that two additional fractures radiate from fracture #3 as well. **3R2** appears to form the more posterior margin of the anterior projection of fracture #3 and **3R3**, the more anterior margin. **3C1** parallels the left posterior wound margin and affects only the outer table.

**Fracture #4** is actually a missing wormian bone in the left lambdoidal suture, 1.9 cm left of lambda. Endocranially, the defect does not follow the wormian’s fingered margins - internal beveling is notable as is delamination of the diploe. This endocranial presentation is consistent with penetrating trauma in which bone is forcibly dislocated into the cranium. It is possible that this defect is the result of plastic deformation pressures created by a primary blow elsewhere on the cranium. **4R1** runs from the missing wormian to fracture area #5.
Fracture #5 is a fracture area affecting the left temporal, zygomatic, sphenoid, and lateral and basilar portions of the occipital. It is likely the result of postmortem damage, but a ring fracture, indicative of a fall, cannot be excluded.

In sum, Hasanlu 61-5-340 endured at least four direct perimortem applications of force to the cranium. These include three blunt force impacts resulting in two fracture regions with curved margins, summarized here as fractures #2 and #3. When superimposed, the contours of all three curves align, suggesting that a single implement is responsible for all three. This individual also sustained a direct sharp force trauma to the mandible. This was possibly caused by a short, sharp bladed implement.

Hasanlu 63-5-308 is an adult male. Sixty-percent of the right lateral portion and the entire left lateral and basilar portions of the occipital are absent. The petrous portion and zygomatic process of the left temporal, the body, pterygoid plates and 35% of the left wing of the sphenoid, the vomer, inferior nasal conchae, ethmoid, lacrimals, and 55% of the left palatine are likewise missing. The remaining bones are both naturally and artificially articulated. Four wormians are present in the lambdoidal suture, including two substantially-sized wormians at lambda (Figure 2).

Fracture #1 is a narrow elliptical attached depressed fracture located 8.8 cm from bregma and 10.0 cm from lambda on the left parietal. It is 2.4 cm by 0.7 cm in size, with a depth of 0.3 cm. Both cranial tables are affected. The outer table is lightly crushed. Endocranially, the inner table is uplifted and tented.

Fracture #2 lies 8.3 cm from bregma and 5.1 cm from the left external auditory meatus. It is an irregular, arrow-shaped fracture on the left parietal and near the squamosal suture. The
entire arrow spans 2.6 cm by 2.0 cm. The superior arm of the arrow resembles a narrow ellipse, measures 2.5 cm by 0.7 cm, and may represent a direct impact site. The inferior arm may be formed by radiating fractures associated with such an impact. The inferior margin of fracture #2 is externally beveled, while margins associated with the superior ellipse are internally beveled. 

2R1 runs 6.0 cm posterolaterally to the mastoid corner of the parietal and to the occipitomastoid suture. 2R2 extends anteriorly 2.3 cm to fracture #4 (and may contribute to the damage at fracture #4). 2R3 runs inferiorly to the squamosal suture, a distance of 1.0 cm.

**Fracture #3** is a fracture area on the frontal that covers a 5.3 cm by 5.1 cm region. The margins here are discolored and exhibit external beveling. There is also web-like cracking of the outer table. This appears to be the result of postmortem damage.

**Fracture #4** is a fracture area continuous with both fracture areas #2 and #6. It primarily affects the left frontal, left side of the sphenoid, and the left zygomatic arch. This is a 6.7 cm by 6.2 cm region. Its margins are dry and flaky and discolored. Internal beveling haphazardly mixes with external beveling. This fracture area likely results from a combination of postmortem damage and comminution from fracture #2.

**Fracture #5** is a linear fracture on the left mandibular ramus that cuts from LM₃ to the neck of the mandibular condyle. It is 5.5 cm in length. Its origins may be peri- or postmortem.

**Fracture #6** is a large fracture area implicating the majority of the basicranium. The lateral and basilar portions of the occipital, the sphenoid body, and the right petrous portion are absent. The margins are not discolored or sharp. A ring fracture is possible.

In sum, Hasanlu 63-5-308 received at least one direct blow to the cranium during the perimortem interval, resulting in fracture #1 (2.4 cm by 0.7 cm). This was likely caused by a dull ed sharp implement used in a hacking/chopping manner to inflict blunt force trauma.
Additionally, a second direct blow may be represented by fracture #2 (2.5 cm by 0.7 cm). Characteristics of fracture #2 are likewise consistent with perimortem trauma induced by a small sharp weapon.

**Hasanlu 63-5-311** is an adult male. His skull is incomplete, currently comprised of the left maxilla, the left zygomatic, the frontal, the left parietal, an incomplete right parietal (~65% complete), the mastoid and zygomatic process of the left temporal, the squamous portion of the occipital, and less than half of the mandible. The facial bones are not articulated with the bones of the cranial vault. All cranial bones are very dry and brittle and exhibit some degree of postmortem damage. Nonetheless, several traumas are apparent. Exactly how the post- and perimortem damage interact is unclear (Figure 3).

**Fracture #1** is best described as a large chip disrupting the continuity of the outer table of the external occipital protuberance. It is characterized by extreme discoloration and is consistent with sharp trauma sustained during the postmortem interval, possibly during excavation. It is also possible that this is an area of perimortem trauma that was rendered particularly vulnerable to postmortem flaking of the outer table due to loss of structural integrity. It measures 2.4 by 0.8 cm and lies 5.0 cm from lambda and 10.9 cm from the left external auditory meatus, just inferolateral to fracture #2.

**Fracture #2** is located 3.3 cm below lambda and 10.7 cm from the left external auditory meatus on the central occipital. It is an attached ellipse-shaped depressed fracture that measures 2.5 cm by 1.0 cm and is limited to the outer cranial table. As is consistent with the attached fractures sustained by other individuals at Hasanlu, it is associated with a sharp indent along its midline and two radiating fractures. **2R1** extends laterally from the superior left corner of the
wound, crosses the lambdoidal suture without redirection, and terminates 10.2 cm from its origin at fracture #5 (alternatively, it originates at fracture #5 and terminates at fracture #2. However, the greater comminution associated with fracture #5 suggests that the bone in that region was weakened prior to that blow, as would be the case in the former scenario). 2R2 runs laterally (right) from the mid-right wound margin, crosses the lambdoidal suture without redirection and terminates at the large fracture area on the right parietal. It is about 8.4 cm in total length.

**Fracture #3** is a detached depressed fracture located 8.2 cm from bregma and 8.0 cm from lambda on the right parietal boss. Wound margins bevel internally, though there is no flaking or delamination of the inner table. The inferior corner is continuous with the large fracture area on the right side of the cranium, and therefore the size of the wound is only known to be at least 2.7 cm by 1.4 cm. The elliptical shape of the trauma, assuming relative symmetry – a feature of the other elliptically-shaped cranial traumas at Hasanlu – is suggestive of an overall wound 3.1 cm by 1.4 cm in size. At least two, and possibly five, fractures radiate from the visible margin. 3R1 extends superiorly, crosses the sagittal suture, redirects anteriorly and slightly inferiorly at the left parietal boss, and terminates at the coronal suture. 3R2 runs anteriorly from the wound and terminates at fracture #4 (alternatively 3R2 continues to the coronal suture at 4R2, but is interrupted by a subsequent blow - #4-, or 3R2 actually radiates from fracture #4 and terminates at fracture #3). It is 2.2 cm long. 3R3 runs posteroinferiorly to 2R2. 3R4 is a possible radiating fracture that parallels 3R3 and drastically redirects to terminate at 3R3. 3R5 is a possible radiating fracture that extends inferiorly to the mastoid notch.

**Fracture #4** is likewise an elliptical detached depressed fracture that extends into the large right-side fracture area. The entirety of its anterior margin, however, is accounted for and yields a measurable wound size of 4.3 cm by 2.0 cm. It lies 6.1 cm from bregma and 10.6 cm
from lambda, just posterior to the coronal suture. A sharp midline indent can be seen at the superior corner. There is internal beveling at the margins, but no flaking or delamination endocranially. It may be associated with four radiating fractures, though the actual causation/origin of the fractures described below is unclear. **4R1** runs anteroinferiorly to the facial skeleton, **4R2** is the same as 3R2, and **4R3** may be a continuation of 3R2. 4R3 may also be described as a short 0.6 cm fracture that runs from the anterior margin to the coronal suture. **4R4** is slightly longer, measuring 1.1 cm in length, but is limited to the inner table. It runs superiorly from the wounds superior margin.

**Fracture #5** appears to be an ellipse-shaped trauma that is only partially detached. It is at least 2.2 cm, and likely about 3.0 cm, long, and at least 0.9 cm, likely 1.1 cm, wide. Ectocranially, it is marked by a hinged attached fracture piece containing a sharp midline depression; however, it shows no clear perimortem damage markers endocranially. The portion of 2R1 located on the right parietal may actually be **5R1**.

**Fracture #6** is an irregular fracture, and possibly a fracture area, on the left side of the frontal 9.2 cm from nasion and 10.5 cm from the left external auditory meatus. Its size can be roughly summarized as 4.2 cm by 2.6 cm. The bone bound by the fracture margin and the coronal suture is missing. These margins are not smoothed and a small area along the anterolateral margin appears to have been scraped. Endocranially, there is delamination of the anterior diploe and the left coronal suture is open. The posterior margin is intersected by fracture #7.

**Fracture #7** intersects the coronal suture at fracture #6. It is located 2.1 cm from bregma, 10.6 cm from the left external auditory meatus, and 11.9 cm from lambda on the left parietal and frontal bones. The parietal portion, also the posterior half, lacks both outer table and diploe,
though the inner table is still present; the frontal piece (the anterior half) is detached entirely and included in fracture #6. The margins are externally beveled and not discolored, though the external surface of the inner table upon which the fracture sits is discolored. In its entirety, the wound is at least 2.0 cm by 1.1 cm, and probably about 2.3 by 1.1 cm.

In sum, there are signs of at least five separate direct impacts to the skull of Hasanlu 63-5-311. All of these blows resulted in elliptical shaped traumas summarized here as fractures #2, #3, #4, #5, and #7. These fractures measure 2.5 by 1.0 cm, at least 2.7 cm (likely 3.1 cm) by 1.4 cm, 4.3 cm by 2.0 cm, at least 2.2 cm by 0.9 cm (likely 3.0 cm by 1.1 cm), and at least 2.0 cm (likely 2.3 cm) by 1.1 cm, respectfully. Characteristics of all five fractures are suggestive of a dull sharp object used in a chopping fashion to inflict blunt force upon the cranium. Slight variations in the size of these traumas could stem from different causative instruments, or more likely, variations in strength and direction of blow inflicted by a single implement. The fragmentary and brittle nature of the skull renders fracture analysis difficult and error prone.

**Hasanlu 63-5-314** is an adult male. His skull is largely complete, though there is a large area of missing bone encompassing the right temporal squamous and zygomatic process and most of the right parietal; the sphenoid is severely damaged. The small facial bones are absent. The remaining bones are naturally articulated. There are several wormian bones along the lambdoidal suture, which, along with the sagittal suture, is largely obliterated (Figure 4).

**Fracture #1** appears to be the result of sharp force to the occipital. It is a 2.2 cm by 0.1 cm small linear defect located 2.4 cm from lambda and 7.7 cm from basion. The wound is externally beveled and is associated with endocranial delamination of the diploe. Two fractures radiate from its margins. **1R1** runs inferiorly around the external occipital protuberance to the
left and terminates after 7.7 cm at a small region of detached bone at the occipitomastoid suture. 1R2, 6.5 cm in length, moves superiorly through the right parietal foramen and terminates at the sagittal suture.

**Fracture #2**, a partially attached depressed fracture, overlaps the damaged region on the right parietal, 6.7 cm from lambda. The wound, at least 2.3 cm by 1.6 cm (and likely 3.0 cm by 1.6 cm), is elliptical in shape. Beveling of margins is internally directed; there is endocranial delamination of the diploe. 2R1 extends posteriorly to 1R2.

**Fracture #3** is the smoothly curved and internally beveled superior margin of the right-sided fracture area that runs between the coronal suture and fracture #2, a distance of 7.4 cm. 3R1 radiates from its anterior edge (at the coronal suture) and terminates mid-frontal (alternatively both #3 and 3R1 radiate from fracture #2). This fracture is 5.3 cm long, though it becomes unusually wide as it approaches the coronal suture and therefore may be associated with plastic deformation. Fracture #3 itself may be a concentric fracture related to a massive blunt force trauma of the right side of the skull resulting in severe comminution, and subsequently, loss of bone.

**Fracture #4** is a linear fracture extending between the left external auditory meatus and the squamosal suture on the left temporal. Remodeling suggests that this is an antemortem wound.

In sum, Hasanlu 63-5-314 sustained at least two direct perimortem impacts to the cranium, likely with multiple weapons. Fracture #1 represents a direct blow with a sharp object used in a stabbing manner and fracture #2, a direct blow with a dull sharp object used in a chopping/hacking manner. Fracture #3 represents a probable third direct blow, caused by a broad, blunt weapon with a large striking surface.
Hasanlu 65-31-760 is a female subadult, 14 to 16 years in age. Her vault is present in two pieces: one fragment with part of the frontal, part of the left parietal, part of the right temporal, the right parietal, and part of the occipital, both naturally and artificially articulated, and the other with part of the frontal, part of the left parietal, and part of the left parietal articulated. Overall, about 10% of the occipital, 90% of the right parietal, 80% of the left parietal, 10% of both temporal squamae, and 70% of the frontal are present. In addition, the mandible is complete. There is marked taphonomic damage and plastic deformation of unknown origin (Figure 5).

Fracture #1 is a 3.1 cm by 1.6 cm detached depressed fracture. It is elliptical in shape and located 8.4 cm from lambda and 7.5 cm from bregma. The superior margin is beveled internally and the inferior margin is beveled externally, suggesting an upward force. Some margins are discolored and lightly spiky. Five fractures radiate from this wound, though many seem more consistent with postmortem linear fracturing. 1R1 radiates superiorly and terminates at the sagittal suture, 1R2 radiates inferoposteriorly and terminates at the lambdoidal suture, 1R3 radiates anteriorly and terminates at the coronal suture, 1R4 radiates posteroinferiorly and terminates at the posterior squamosal suture, and 1R5 radiates inferiorly onto the temporal squama. Overall, this fracture has several postmortem qualities. However, given the brittle nature of the skull, if fracture #1 was inflicted recently, the entire skull would likely have fractured more extensively and without preserving elliptical margins. Further, the lesion is of similar size and shape to lesions observed on other crania at Hasanlu that were clearly sustained during the perimortem interval. It is likely that fracture #1 was initially sustained during the perimortem interval and later became subject to additional postmortem destructive processes.
**Fracture #2** is a well-delineated curve at the posterior-most edge of the left vault fragment. At 3.1 cm long, it is nearly identical to the superior curve of fracture #1 when the two are superimposed. Fracture #2’s width is unknown. It is accompanied by extensive delamination of the diploe.

In sum, Hasanlu 65-31-760 sustained two direct blunt force blows resulting in two ellipsoid fractures during the perimortem interval. These are described above as fractures #1 and #2. They measure 3.1 cm by 1.6 cm and 3.1 cm by ? cm respectfully. Characteristics of both fractures are consistent with a dull sharp object used in a chopping manner to inflict blunt force against the cranium.

**Hasanlu 65-31-781** is a 10 to 12 year-old subadult. The skull lacks the left zygomatic, vomer, ethmoid, nasals, inferior nasal conchae and lacrimals. The facial skeleton is articulated separately from the cranial vault. A metopic suture is present (Figure 6).

**Fracture #1** is a roughly elliptical attached depressed fracture on the left parietal, located 5.8 cm from bregma, 9.9 cm from the left external auditory meatus, and 7.6 cm from lambda. The 2.1 cm by 1.1 cm and 0.3 cm deep defect has a sharp midline depression. There is delamination of the diploe endocranially. There are two radiating fractures associated with this wound. **1R1** extends posteroinferiorly for 4.9 cm and terminates mid-left parietal. **1R2** runs anteromedially for 3.7 cm and terminates at the coronal suture.

**Fracture #2** is a 3.0 cm by 0.7 cm detachment located 7.4 cm from the right external auditory meatus and 4.8 cm from bregma along the coronal suture. It affects only the frontal ectocranially and only the right parietal endocranially, with internal to external beveling and
some delamination of the parietal diploe. The coronal suture has popped open between fracture #2 and 1R2.

**Fracture #3** is a 1.2 cm by 1.4 cm defect on the frontal, located 4.3 cm from bregma. It is discolored and brittle. Though two fractures radiate from it, they too are cracked and peeling in appearance. 3R1 extends posterolaterally to the left for a distance of 5.6 cm and terminates at the coronal. 3R2 runs 5.6 cm to the right. Fracture #3 is likely the result of postmortem damage.

**Fracture #4** is a small region (1.2 cm by 0.8 cm) of lightly chipped and smoothly depressed outer table with minor exposure of the underlying diploe on the left parietal. It lies 5.0 cm from lambda and 8.3 cm from the left external auditory meatus.

**Fracture #5** is represented by the absence of much of the left face and orbit. Whether this is related to trauma or is simply damage is difficult to determine.

**Fractures #6, #7, and #8** are all linear fractures that appear as simple and light cracking of the skull. They seem to have occurred postmortem.

In sum, Hasanlu 65-31-781 sustained at least two direct perimortem blows to the cranium, described above as fractures #1 and #2, which measure 2.1 cm by 1.1 cm and 3.0 cm by 0.7 cm respectfully. The first is consistent with a direct blow by a dull sharp object used in a hacking or chopping manner to inflict blunt force trauma on the cranium. The second appears to be a more piercing trauma and may be associated with an instrument with a sharper edge and flatter profile.

**Hasanlu 66-23-405** is an adult male. The cranial bones, which are not articulated, include the squamous portion of the occipital, the majority of the left and right parietals, the mastoid process of the right temporal, the left temporal, the right zygomatic, 75% of the frontal, 75% of the right maxilla, the left maxillary alveolus, part of the left palatine, and the mandibular body.
At least seven wormians lie in the lambdoidal suture and there is some degree of suture obliteration. The bone is quite brittle (Figure 7).

**Fracture #1** mars the left frontal and includes the orbit. It is located 8.0 cm from bregma. It is an irregularly shaped region of detachment with a wedge-like superior margin. The traumatized region measures 3.8 cm by 4.3 cm. The bone in this area is very dry, brittle, and cracked, however, only some of the fracture margins are discolored. **1R1** radiates posteriorly for 8.0 cm and terminates at bregma. **1R2** extends 3.5 cm to the right and terminates superior to the right orbit.

**Fracture #2** is 9.5 cm from lambda and 8.4 cm from bregma on the right parietal. It is an ellipse-shaped detached depressed fracture measuring 3.3 cm by 1.7 cm; its margins are discolored. Its inferior margin is externally beveled and its superior margin internally beveled. It is therefore likely that the causative implement entered the individual’s skull from below. The inferior corner of the trauma opens into and is continuous with a larger region of detachment. **2R1** radiates medially to the sagittal suture, a distance of 8.2 cm, appears to cross this suture with minimal redirection, and continues 4.8 cm onto the left parietal.

**Fracture #3** is an elliptical fracture on the left parietal, 7.8 cm from bregma and 9.4 cm from lambda. It is part of a larger fracture area, but is at least 4.1 cm by 1.7 cm in size. Its margins bevel internally and are discolored.

In sum, the skull of Hasanlu 66-23-405 may have sustained two direct perimortem blunt force impacts resulting in two ellipse-shaped traumas summarized here as fractures #2 and #3. These fractures measure 3.3 cm by 1.7 cm and 4.1 cm by 1.7 cm, respectfully. Some characteristics of the two fractures are suggestive of a dull sharp object used in a chopping fashion that inflicted blunt force upon the cranium. However, other characteristics are more
suggestive of postmortem trauma. A combination of these two destructive mechanisms may be responsible.

Hasanlu 71-23-504 is an adult of indeterminate sex. The cranial bones are not articulated. The basilar portion of the occipital, parietals, temporals, sphenoid, right zygomatic, maxillae, mandible, left palatine, and less than half of the frontal are present. Postmortem damage is extensive; fragment margins are dry, discolored, and brittle with peeling layers of cortex.

Fracture #1 is an attached depressed fracture on the right parietal 5.5 cm from lambda and 6.5 cm from bregma. This 2.2 cm by 0.8 cm elliptical defect appears as a small area of light crushing on the outer table, but is more noteworthy in its endocranial presentation; the inner table is fractured into a “Y,” uplifted, and tented.

Fracture #2 is also an ellipse-shaped attached depressed fracture on the right parietal. It lies 11.8 cm from bregma and 3.8 cm from lambda and measures 2.3 cm by 0.9 cm with a depth of 0.6 cm. Its margins bevel internally. Endocranially, it appears as a roughly circular and internally displaced fracture of the inner table with uplifting and tenting. Two radiating fractures extend from its margins. 2R1 moves anteriorly from the anterior margin to an area of postmortem fracturing, a distance of 9.5 cm. 2R2 runs posteriorly from the posterior margin to the mid-right lambdoidal suture, a distance of 1.7 cm.

Fracture #3 is a linear fracture mirroring 2R1 on the left parietal. It is at least 7.4 cm in length and may be due to either peri- or postmortem trauma.

In sum, the skull of Hasanlu 71-23-504 endured at least two direct perimortem blunt force impacts resulting in two elliptical traumas summarized here as fractures #1 and #2. These fractures measure 2.2 cm by 0.8 cm and 2.3 cm by 0.9 cm (0.6 cm deep) respectfully.
Characteristics of both fractures are suggestive of a dull sharp object used in a chopping fashion to inflict blunt force upon the cranium. Slight variations in size of these traumas could stem from different causative instruments, or more likely, variations in strength and direction of blow inflicted by a single implement. That the depth of the attached fractures is positively correlated with the length of the fracture supports the latter notion that the elliptical wounds sustained by the individual were caused by a common weapon using differing degrees of force.

**Hasanlu 71-23-526** is an adult male. His skull is missing the nasals, vomer, ethmoid, inferior nasal conchae, and lacrimals. The facial bones are articulated separately from the calvarium. This individual has a metopic suture, unusually flattened supraorbital tori, a hooked occipital protuberance, and at least seven large wormians in the lambdoidal suture (Figure 8).

**Fracture #1** is a linear fracture of the mandibular body and runs parallel to the symphysis. It may be peri- or postmortem in origin.

**Fracture #2** is a detached half-ellipse roughly perpendicular to the left temporal ridge of the frontal. It lies 7.4 cm from bregma and 6.5 cm from nasion. It measures 2.3 cm by 1.7 cm, though its posterior corner opens up into a larger area of absent bone on the left parietal (fracture area #4). Margins are internally beveled. One radiating fracture (**2R1**) runs anteroinferiorly from the wound’s inferior margin to the orbital margin, where it crosses the orbital plate along the coronal plane.

**Fracture #3** also opens into the larger left-side fracture area (#4), but takes the form of a full ellipse, 3.7 cm by 1.3 cm in size. It is a detached depressed fracture located 6.1 cm from bregma, 8.1 cm from the right external auditory meatus, and 8.9 cm from lambda on the left parietal. Its margins bevel internally. **3R1** runs posteriorly from the wound’s posterior margin to
Fracture #5, for a total length of 1.1 cm. 3R2 and 3R3 may also extend from fracture #3, forming the margins of fracture area #4. The first runs to the squamosal suture; the second extends to fracture #2 (alternatively, this fracture may be continuous with 2R1 and form the inferior border of fracture #2).

**Fracture #4** is a fracture area on the left side of the cranium. Only the margins associated with fractures #2 and #3 are beveled, suggesting that the detachment of this fracture is due to comminution of these two blows and not necessarily to an independent blow.

**Fracture #5** is a roughly trapezoidal region of missing bone bounded, and likely created, by the sagittal suture, lambdoidal suture, fracture 3R1 and a fracture continuous with 6R1 on the left parietal. It is 4.2 to 6.7 cm by 5.7 cm in total size. Only the lateral margin shows internal beveling and flaking.

**Fracture #6** is an irregular and somewhat keyhole-shaped fracture on the right parietal, 8.3 cm from lambda, 6.6 cm from bregma, and 6.7 cm from the right external auditory meatus. It is a 3.0 cm by 3.6 cm detached fracture with internal beveling on the anteroinferior margin only. There are three radiating fractures associated with this fracture. 6R1 runs posteromedially from the posteromedial corner to the sagittal suture, intersecting it at the same point as the anterior margin of fracture #5. 6R2 extends inferiorly from the wound’s inferior corner to fracture #7 and may actually be continuous with 6R1. 6R3 radiates anteriorly from the anteroinferior corner to the coronal suture. Sutural fingers are missing between where it intersects and where 8R1 intersects the coronal suture (6R3 and 8R2 may actually be the same fracture).

**Fracture #7** affects the mastoid angle of the right parietal and the right temporal squama. Posteriorly it manifests as a 2.7 to 2.9 cm by 1.7 cm anvil-shape and anteriorly as a 4.3 cm by 1.1
cm oblong shape. It is likely the result of 6R2 and the natural parietal margin in conjunction with postmortem damage to the thin squama.

**Fracture #8** is a detached depressed fracture located 8.0 cm from bregma and 3.5 cm from nasion on the frontal. The wound is elliptical in shape, though its length cannot be accurately measured because it occurs at the edge of the right supraorbital torus; it is 1.2 cm wide. The margins are internally beveled, and the facial skeleton detaches from the calvarium directly below this fracture. **8R1** runs posteriorly from the wound’s superior corner to the coronal suture, a distance of 4.1 cm. The nearby sphenosquamosal suture has “popped” open.

**Fracture #9** breaks the right greater wing of the sphenoid into three pieces at the cranial base. This may be a result of indirect force originating from the “popping” of the sphenosquamosal suture or the result of poor reconstruction.

**Fracture #10** occurs at the jugular process of the occipital. The process itself is broken and a linear fracture extends from the break to a more posterior point on the right lateral part of the occipital, curving around the foramen magnum. A similarly curved fracture mirrors this fracture to the right of the foramen magnum, originating where the temporal petrous pyramid is broken. This may indicate a ring fracture, which is suggestive of a fall, or may simply be postmortem damage.

In sum, the skull of Hasanlu 71-23-526 endured at least two direct perimortem blunt force impacts resulting in two elliptical traumas summarized here as fractures #3 and #8. These fractures measure 3.7 cm by 1.3 cm and approximately 3.3 cm by 1.2 cm. Characteristics of both fractures are suggestive of a dull sharp object used in a chopping fashion to inflict blunt force upon the cranium. Slight variations in size of these traumas could stem from different causative instruments, or more likely, variations in strength and direction of blow inflicted by a single
implement. Two other fractures on the individual’s skull may represent two additional direct, independent, perimortem blunt force impacts. These, as described above, are fractures # 2 and #6. The former may represent a blow by the same implement responsible for fractures #3 and #8, yielded at a novel angle, a blow by a second weapon, or damage secondary to blunt force applied elsewhere on the skull.

*Hasanlu 75-29-501* is an adult male with a complete skull (only the left inferior nasal concha is unaccounted for) (Figure 9).

**Fracture #1** is an elliptical detached depressed fracture on the posterior right parietal 3.1 cm from lambda, 9.5 cm from bregma, and 9.1 cm from the right external auditory meatus. It is 3.0 cm by 1.2 cm in size. **1R1** runs anterolaterally from the middle of the wound’s superior margin to fracture #5. This linear fracture expands in breadth as it nears fracture #5 due to plastic deformation of the vault. There is also a light concentric fracture, **1C1**, which both originates and terminates along the anterior margin.

**Fracture #2** mars the left parietal at lambda, 10.7 cm from the left external auditory meatus. The lambdoidal suture comprises both the inferomedial margin and the medial corner of the wound, while the right branch of the lambdoidal suture is open. This is a 3.7 cm by 1.5 cm detached depressed fracture with internal beveling and one radiating fracture, **2R1**, which extends anterolaterally from its superomedial corner to the superomedial corner of fracture #1.

**Fracture #3** is a fracture area with internal beveling on the right occipital and the mastoid angle of the right parietal. It is roughly 6.0 cm by 6.2 cm, despite its irregular shape. There are two notable projections; one more posteriorly located and rounded in shape and the other inferiorly located and elliptical in shape. The former projection is associated with internal
flaking of the inner table along the superior margin and plastic deformation of the adjacent lambdoidal suture. **3R1** runs leftward from this projection to the left lambdoidal suture, where it moves through a missing wormian and continues as a hairline fracture on the left parietal. **3R2** extends anteroinferiorly from the other projection, terminating at fracture #10.

**Fracture #4** is a fracture area that contains a 2.9 cm by 1.4 cm defect located just posteromedial to the left mastoid process on the occipital. It is associated with severe comminution, including several linear fractures, splintering of the outer table, and possible diastatic fractures.

**Fracture #5** is a fracture area located at the right pterion, 8.1 cm from bregma and 6.9 cm from nasion. It affects the right temporal, parietal, and greater wing of the sphenoid. The right mandibular condyle is crushed. Overall, this fracture appears to be an area of severe crushing with several fragments of bone missing (forming a 4.0 cm by 6.4 cm irregularly shaped open defect). A concentric fracture, **5C1**, curves from fracture #3 at the left external auditory meatus to the coronal suture along a trajectory roughly parallel to the squamosal suture. Nearby, the coronal, zygomaticofrontal, and the frontonasal sutures have opened. This is most consistent with blunt force trauma due to a blow by an object with a relatively large striking surface.

**Fracture #6** is a linear fracture that extends from bregma to the mid-frontal, sweeping lightly to the left as it descends. A second branch runs from nasion to just above glabella and also sweeps to the left. The frontal angle of the right parietal is elevated and the right coronal suture is open. This is consistent with perimortem fracturing resulting from indirect forces and plastic deformation, likely created by a primary blow elsewhere on the cranium.

**Fractures #7** and **#8** are also both linear fractures that may have resulted secondarily to other blows due to indirect forces acting on the cranium. The first extends posterolaterally from
the mid-sagittal suture across the left parietal boss until it terminates mid-bone. The second 
radiates anterosuperiorly from a missing wormian bone just superior to fracture #4 and forks 1 
cm away. One branch extends to the left coronal suture while the other transverses more laterally 
and terminates near the left parietal boss.

**Fracture #9** is a linear fracture to the mandibular body and affects the anterior alveolus 
only. It may have occurred in either the perimortem or postmortem intervals.

**Fracture #10** is a fracture area that manifests as the absence of the basilar and right 
lateral portions of the occipital. This damage likely occurred postmortem, but this is difficult to 
determine due to the degraded condition and the thin nature of the remaining margins.

In sum, the skull of Hasanlu 75-29-501 endured at least two direct perimortem blunt 
force impacts resulting in two elliptical traumas summarized here as fractures #1 and #2. These 
fractures measure 3.0 cm by 1.2 cm and 3.7 cm by 1.5 cm respectfully. Characteristics of both 
fractures are suggestive of a dull sharp object used in a chopping fashion that inflicted blunt 
force upon the cranium. Slight variations in size of these traumas could stem from different 
causative instruments, or more likely, variations in strength and direction of blow inflicted by a 
single implement. Another likely area of direct impact, possibly created by the application of 
blunt force applied over a greater surface area (either by a weapon with a broader striking surface 
or by the ground after a fall) is represented by fracture area #5.

**Hasanlu 75-29-503** is an adult of indeterminate sex and without a facial skeleton. The 
squamous and basilar portions of the occipital are complete, though the lateral portions are both 
fractured: the right side is 50% present and the left side is 30% present. The squamous portion of 
the right temporal is missing, as is 80% of the squamous portion of the left temporal. The left
wing and pterygoid pates of the sphenoid are likewise absent. The frontal is mostly (85%) complete. Small portions of both nasals remain (Figure 10).

**Fracture #1** is a stellate fracture with its center of impact 3.4 cm from bregma, 12.2 cm from nasion, and 10.7 cm from the external auditory meatus. It is located at the frontal angle of the right parietal. The crushed region, bounded by a concentric fracture (1C1), spans 4.6 cm at its greatest sagittal length. 1C1 is three-sided and circumscribes the point of impact posteriorly, medially, and posterolaterally. It runs to the coronal suture; the coronal suture is popped open between the point where the concentric fracture intersects and fracture #2. Four fractures also radiate from the point of impact. 1R1 runs posterolaterally and terminates at 1C1 2.2 cm away. 1R2 extends medially, crosses 1C1, and runs to fracture #12, possibly forming this fracture’s posterior margin. In total, it spans 9.6 cm. 1R3 runs anteriorly 6.8 cm to fracture #2. 1R4 radiates laterally to fracture #5, a distance of 3.3 cm. 1R5 is a 9.0 cm long fracture extending from 1C1 across the right parietal to lambda. This pattern is most consistent with a direct blunt force blow to the right parietal delivered by a heavy object with a sizable striking surface.

**Fracture #2** is a fracture area located 5.5 cm from bregma and 5.4 cm from nasion on the right frontal. It is roughly trapezoidal in shape, with a width ranging from 6.7 cm to 2.4 cm and an approximate height of 4.7 cm. The fracture area is detached, likely due to extensive comminution, and exhibits external beveling. There are three radiating fractures associated with this fracture. 2R1 radiates from the anteromedial corner of the traumatic area inferomedially for 3.4 cm to the mid frontal and terminates above glabella. 2R2 runs posteriorly from the posterior wound corner to fracture #5, a distance of 2.7 cm, and may continue as the superior margin of fracture #5 and 5R2.
**Fracture #3** is a detached fracture that lies 5.6 cm from bregma and 5.7 cm from nasion on the left side of the frontal. It measures 3.4 cm by 0.9 cm and forms a narrow backwards “D”. A 1 cm wide rim of internal beveling surrounds the entirety of the fracture on the endocranial surface. Four fractures radiate from these margins. **3R1** runs posteromedially from the posterior corner 5.6 cm to bregma. **3R2** runs medially from the posterior margin to fracture #2. It is 6.2 cm long. **3R3** extends inferomedially from the posterolateral margin to the supraorbital notch, and **3R4** radiates posteriorly from the posterolateral margin, crosses the coronal suture, forms the superior margin of fracture #10, and terminates at 1R2.

**Fracture #4** is a fracture area marked by the absent right temporal squamous, which appears to have fractured away without concomitant damage to the underlying parietal. Both fracture #2 and lines radiating from fracture #5 lead into fracture #4, suggesting that it is the result of extensive comminution from other blows, possibly supplemented by postmortem damage.

**Fracture #5** is a 2.6 cm by 0.7 cm oblong area of detachment located 6.3 cm from bregma, 8.6 cm from the right external auditory meatus, and 7.8 cm from lambda on the right parietal. Endocranially, there is flaking of the inner table. In particular, a large, roughly rectangular flake of bone is missing directly posterior to the wound. The defect as a whole may have been created by a direct blow or, alternatively, as a result of fractures radiating from other areas of impact. Indeed, 1R4 is continuous with both its inferior margin and **5R1**, and 2R2 is continuous with both its superior margin and **5R2**, suggesting that the intersection of 1R4 and 2R2 may have produced the detachment. In fact, if #5 does represent an independent blow, the local fracture order is muddled. 1R4 ends at #5, suggesting #5 came before #1, yet 5R1 ends at 1R5, suggesting that #1 came before #5.
Fracture #6 is a fracture area that lies on the left parietal 2.6 cm from lambda and 2.7 cm from the left external auditory meatus. Like fracture #5, this is an irregularly shaped area likely resulting from comminution of other primary traumas. The most posterior projection of the bony detachment, however, shows slight external to internal beveling and may be related to an oblique penetrating wound. Overall, the detachment spans 9.7 cm by 4.1 cm.

Fracture #7 is a 5.0 cm long linear fracture on the right occipital. It runs from the mid right lambdoidal suture to the inferior right lambdoidal suture, just medial to the occipitomastoid margin.

Fracture #8 is a 2.0 cm by 2.1 cm area of detachment on the left lateral portion of the occipital. Fracture #9 is a similar fracture, 3.4 cm by 2.3 cm in size, on the right lateral portion of the occipital. 9R1 follows the curve of the foramen magnum for 2.1 cm. Fracture #11 is a 2.3 cm linear fracture that transverses the basilar at an angle. It is more pronounced endocranially, where it is also more horizontally oriented. It may be related to the impact that caused fracture #4. Together, these three fractures suggest a possible ring fracture of the basicranium.

Fracture #10 is a roughly triangular fracture with external beveling. It seems to be the result of fractures radiating from other areas of trauma, including 3R4 and 1R2. It measures 1.4 cm by 1.5 cm and lies 6.6 cm from bregma, 9.5 cm from nasion, and 6.3 cm from the left external auditory meatus on the left parietal.

In sum, the skull of Hasanlu 75-29-503 endured at least one direct perimortem impact resulting in a narrow oblong trauma summarized here as fracture #3. This fracture measures 3.4 cm by 0.9 cm. One other such fracture on the individual’s skull may represent an additional direct, independent, perimortem blunt force impact. This fracture is described above as fracture #5 and measures 2.6 cm by 0.7 cm. Characteristics of both fractures are suggestive of a small,
dulled sharp object used in a chopping fashion to inflict relatively blunt force upon the cranium.
In addition, this individual received at least one other blunt force impact to the cranium with a
larger blunt object. The resulting lesion is described above as fracture #1.

Hasanlu 75-29-504 is an adult male with calvarium independent of the facial skeleton.
The occipital, left and right parietals, and left temporal are complete; the right temporal is
missing the zygomatic process and roughly one-third of the squama. The frontal and mandible
are likewise nearly complete. The left wing of the sphenoid is intact. Roughly half of both
maxillae are present. The zygomatics, nasals, inferior nasal conchae, lacrimals, palatines, vomer,
and ethmoid are absent. The calvarium exhibits extensive ectocranial closure of the sagittal and
lambdoidal sutures and complete endocranial closure of the sagittal, lambdoidal, and coronal
sutures (Figure 11).

Fracture #1 is a region of extensive web-like cracking extending from a small, triangular,
and discolored chip on the frontal. Both the cracking and the chip appear to have occurred
postmortem.

Fracture #2 is a linear fracture of the mandibular body, extending from the right incisor
laterally to the left. The fracture margin is less splintered on the posterior surface than on the
anterior surface. The resulting separate mandibular halves differ from each other in overall color,
suggesting that the trauma occurred either during the perimortem interval or very early in the
postmortem interval.

A second mandibular fracture, fracture #3, runs posteroinferiorly from the left ramus to
the mandibular angle. The posterior articular surface of the left mandibular condyle is crushed;
the coronoid process is cracked and missing its anterior surface. This is consistent with
perimortem trauma, possibly associated with fracture #4, but may also be the result of postmortem damage.

**Fracture #4** is a stellate fracture located 10.0 cm from lambda and 9.2 cm from bregma on the left parietal vault. It appears to be the point of impact of a blunt force blow and manifests as the junction of four radiating fractures without comminution. The margins are not discolored but do occur at right angles to the bone surface. **4R1** runs superomedially from the juncture and terminates 6.7 cm away on the parietal. **4R2** runs posteriorly for 3.5 cm and terminates on the parietal as well. **4R3** runs inferiorly, affecting both the temporal squama and the underlying parietal. **4R4** runs anteriorly and terminates at the zygomatic process of the frontal.

**Fracture #5** lies 7.6 cm from lambda and 11.0 cm from bregma at the mastoid angle of the right parietal. It is an irregularly shaped detached fracture area roughly 7.1 cm by 3.8 cm in size (although it has been partially reconstructed). Fracture margins are not discolored, but occur at right angles to the bone surface. Two radiating fractures are associated with fracture #5. **5R1** runs posteromedially to the sagittal suture for a length of 7.9 cm. It begins as a wide gap and narrows to a thin line as it approaches the suture (alternatively this fracture is not the result of fracture #5, but of plastic deformation resulting from fracture #4 at the time of impact). **5R2** extends laterally from the inferior corner of the wound for 3.9 cm to the foramen magnum and appears to have occurred in the postmortem interval. As a whole, fracture #5 results from interaction between peri- and postmortem damage.

**Fracture #6** is a detached fracture area. It lies 8.4 cm from bregma and 12.1 cm from lambda and affects the right parietal, temporal, and sphenoid. It is composed of a large rounded square anteriorly and a small circle posteriorly and measures 6.9 cm by at least 4.3 cm. There is a
slight internal bevel along the anterior margin. It is likely the result of comminution, but whether this comminution occurred in the peri- or postmortem interval is unclear.

In sum, the skull of Hasanlu 75-29-504 endured at least one direct perimortem blunt force impact, resulting in a non-comminuted stellate fracture described here as fracture #4. This type of fracture is suggestive of impact of the cranium with a broad flat surface and may have resulted from forcible contact of the cranium with a wall or the ground. The bifurcation of the mandible may be an indirect consequence of the same force.

**Hasanlu 75-29-510** is an adult male. The cranium is articulated and lacking only the left zygomatic process and half of the left zygomatic in addition to portions of the frontal and right lateral occipital absent due to fracturing (Figure 12).

**Fracture #1** is a roughly 3.0 cm by 0.6 cm rectangular region of detachment 4.3 cm from the external auditory meatus, 6.1 cm from nasion, and 8.5 cm from bregma. It includes the right sphenosquamosal margin. There is smooth, evenly sloped external beveling on the posterior margin and similar internal beveling on the anterior margin, suggestive of a sharp force moving in an anterior to posterior direction. Two fractures radiate from this wound. **1R1** moves posteriorly across the length of the squama from the posteroinferior corner of the trauma and terminates after a length of 6.0 cm at the posterior squamosal suture of the right temporal. **1R2** runs anteroinferiorly across the right greater wing of the sphenoid; it is 1.4 cm long.

**Fracture #2** is a narrow (3.1 cm by 0.8 cm) nearly elliptical detachment on the right parietal, 8.7 cm from the right external auditory meatus, 12.2 cm from nasion, and 3.5 cm from bregma. Its margins are internally beveled. A hairline concentric fracture (**2C1**) lies near the posterior margin; three fractures radiate from the wound. **2R1** is 3.2 cm long and extends
medially to the sagittal suture; it terminates just posterior of bregma. It cuts through the diploe and inner table at a smooth, sharp right angle to the bone. The fracture to the outer table cuts slightly anterior to that of the inner table, creating a thin, somewhat jagged overhang. \(2R2\) runs anteromedially from the wound’s medial corner to the sagittal suture, a distance of 2.6 cm. In conjunction with the \(2R1\), the coronal suture and the sagittal suture, it delineates a second area of detached bone just medial to fracture #2. \(2R3\) runs 2.3 cm anteroinferiorly from fracture #2’s lateral corner to the first radiating fracture associated with facture #3; a small portion of the outer table is missing at their intersection.

**Fracture #3** is a detached fracture located 5.1 cm from bregma, 1.5 cm from nasion, and 9.3 cm from the right external auditory meatus, just above the right orbit. It is a narrow ellipse with internally beveled margins and is continuous with a larger and more irregularly shaped fracture area with external beveling that cuts into the frontal sinus. The elliptical area measures 3.1 cm by 0.7 cm; the entire area of detachment is 6.5 cm by 2.7 cm. Three fractures radiate from the wound margins. \(3R1\) radiates posterolaterally from mid-ellipse to \(2R1\) on the posterior right parietal, where it sharply redirects anteroinferiorly. \(3R2\) runs posteromedially from the posterior of the ellipse to the coronal suture, a total distance of 3.7 cm. \(3R3\) extends inferomedially to \(4R2\) from the lesion’s medial margin; \(3R4\) does the same from the lesion’s lateral margin.

**Fracture #4** is located primarily on the left side of the frontal, 5.4 cm from nasion, 3.2 cm from bregma, and 4.7 cm from the left external auditory meatus. It is a large, irregularly shaped detached fracture area, roughly 7.0 cm by 5.5 cm in size. It is likely associated with multiple impacts and concomitant radiating lines. There is also a conspicuous, smoothly curved and 2.6 cm long margin at this fracture area’s most medial extent. A large flake in the outer table mars the fracture’s posterior margin, the coronal suture. Internal flaking is present along the
anterior fracture area margin. 4R1 runs posteromedially from a rounded region of the fracture on the superior frontal to the detached area associated with fracture #2, a length of 3.3 cm. 4R2 moves anteromedially from the inferior side of this rounded region to either 3R3 or the orbit, a distance of 2.7 cm. 4R3 runs laterally to an area just superior to pterion. The combination of 4R3 and the coronal suture seems to create the majority of detachment associated with fracture #4.

Fracture #5 is marked by the absence of 50% of the left zygomatic. Margins are not discolored. A sharp and straight-edged piece of the left orbital margin is absent, and just lateral to this, in line with the zygomatic break, a triangular piece of the frontal is missing below the temporal ridge. The missing piece may represent an application of direct force against the cranium in the perimortem interval as it is very similar in size and shape to fracture #2 and the blows at fracture #6. The irregularity of this fracture makes its size difficult to ascertain.

Fracture #6 is a large fracture area that lies 6.4 cm from lambda, 3.0 cm from the left external auditory meatus, and 7.1 cm from bregma. It is a roughly 3.8 cm by 11.0 cm region of detachment. Although it is primarily located on the posterior left parietal, it extends to the cranial base, affecting the right lateral portion of the occipital. The overall shape is irregular and appears to have been created by at least two direct blows: a superior blow measuring 3.2 cm by 0.7 cm, and an inferior blow, measuring 3.2 cm by ? cm. The inner table along the margins implicated in the two direct blows are beveled and much more extensively so than the other margins forming the fracture area. The lambdoidal suture constitutes the posteroinferior fracture margin. The fracture narrows as it runs behind the mastoid and onto the occipital. The margins along the occipital portion of the fracture are discolored and sharp and may represent post-mortem damage. 6R1 radiates anteromedially from the most superior blow and runs 5.2 cm to the coronal suture.
6R2 extends medially, also from the most superior blow, for a distance of 3.2 cm before terminating on the left parietal. 6R3 runs anteriorly and ends mid-temporal.

Fracture #7 cuts the mandible in half at the symphysis and may represent either peri- or postmortem trauma.

In sum, the skull of Hasanlu 75-29-510 endured at least four direct perimortem sharp/blunt force impacts resulting in four narrow ellipse shaped traumas summarized here as fracture #2, fracture #3, and the two blows at fracture #6. These fractures measure 3.1 cm by 0.8 cm, 3.1 cm by 0.7 cm, 3.2 cm by 0.7 cm, and 3.2 cm by ? cm respectfully. Three other narrow ellipsoid fractures on the individual’s skull may represent additional direct, independent, perimortem impacts. These fractures are described above as fractures #1 and #5, and less likely as an impact site, fracture #4. Fracture #1 measures 3.0 cm by 0.6 cm; fracture #5 is not measurable. Fracture #4 is 2.6 cm by ? cm. Characteristics of these fractures (with some exception in the case of #4) are suggestive of a small, somewhat sharp object used in a chopping fashion to inflict blunt, penetrating force upon the cranium. Slight variations in the size of these traumas could stem from different causative instruments or variations in strength and direction of blow inflicted by a single implement. A large amount of ectocranial flaking along fracture margins suggests a moderate amount of perimortem comminution and movement of fractured pieces over one another.

Hasanlu 75-29-518 is an adult of indeterminate sex. The cranium consists only of several right parietal fragments (~20%), several left parietal fragments (~20%), and a very small piece of occipital squama (~5%). These bones are burned, which in combination with the high degree of fragmentation, makes fracture analysis difficult.
**Fracture #1** represents a series of sharp force traumas with straight and polished edges cut at externally beveled oblique angles. These are located on a fragment containing the right parietal lambdoidal suture, on a second parietal fragment near the lambdoidal suture, on a parietal fragment near the sagittal suture, at the edge of a fourth parietal fragment, and on the left inferior parietal margin. On two fragments, the fracture cuts through both the inner and outer tables. On the remaining three pieces, just the outer table and diploe are affected.

**Fracture #2** represents a series of small regions with skimmed/chiseled cortex that come to right-angled edges. All are roughly rectangular with slight tapering. Two are 1.4 cm wide and one only 1.0 cm wide. All lengths are unknown as all occur at fragment margins. Two fractures are also slightly discolored; the other is not.

In sum, Hasanlu 75-29-518 seems to have sustained at least one, and possibly multiple, cranial traumas due to direct application of sharp force upon the skull. Though these lesions appear to date to the perimortem interval, due to the present condition of the bones, the timing of the wounds remains is a matter of supposition.

**Hasanlu 75-29-531A** is an adult male. His skull lacks the left zygomatic, left and right nasals, vomer, ethmoid, left and right inferior nasal conchae, left and right lacrimals, and left palatine. The remaining bones, including extrasutural bones at the left and right pterion, are articulated. The sagittal suture is obliterated (Figure 13).

**Fracture #1** is 4.4 cm from the left external auditory meatus and 9.6 cm from lambda on the left parietal. It is a 3.1 cm by 1.1 cm depressed fracture that affects both tables of the skull. The majority of the traumatic lesion is still attached with only a strip at the midline open to the endocranium.
**Fracture #2** is also an attached depressed fracture with only the thin strip of the midline open to the endocranium. It is located on the left parietal 7.1 cm from the external auditory meatus and 7.0 cm from lambda and is 2.6 cm by 1.0 cm in size. 2R1 extends 3.7 cm posteriorly from the mid-lateral wound margin to the mid-lambdoidal suture, and 2R2 extends to fracture #1. A very light concentric circle, 2C1, is visible at fracture #2’s inferior corner.

**Fracture #3** is a detached depressed fracture of the occipital (just right of lambda). It measures 3.5 cm by 1.4 cm in size and is roughly elliptical in shape. Its margins bevel internally and are flaked. 3R1 runs from the wound’s inferior corner to fracture #6 for a length of 5.5 cm. The superior wound corner overlaps with fracture #4.

**Fracture #4** lies superior to fracture #3 on the right parietal. It is also a roughly elliptical detached depressed fracture, 3.5 cm by 1.4 cm in size, with internal beveling and flaking of the wound margins. 4R1 runs 4.8 cm anteriorly to fracture 5R1, where it terminates at a right angle. Together, fractures #3 and #4 are associated with three hinged pieces of bone.

**Fracture #5** is an unusual defect on the frontal located 3.2 cm from bregma and 7.5 cm from nasion. It manifests as a roughly circular region of missing outer table (1.7 cm by 1.5 cm) surrounded by a halo of discoloration (2.3 cm by 2.3 cm). More extensive fracturing is visible endocranially. 5R1 runs posteriorly to the coronal suture and redirects posterolaterally. 5R2 runs posterolaterally for 3.0 cm. 5R3 moves anteriorly. 3.8 cm above nasion it forks to create fracture #7. Overall, this fracture is most suggestive of postmortem damage, perhaps sustained by the cranium during excavation.

**Fracture #6** runs around the foramen magnum from the mastoid margin on the right, up to the external occipital protuberance, and back down to the mastoid margin on the left. 6R1 runs anterolaterally to the mastoid margin on the right. 6R2 extends anterolaterally to the mastoid
margin on the left, terminating at fracture #10. A second fracture (#9) and a secondary partial fracture (#8) curve around the anterior of the foramen magnum on the basilar portion of the bone. Together, these fractures may indicate a ring fracture, suggestive of a fall, or may be the result of postmortem damage. The bone here is very thin; only outer table remains.

Fracture #7 is a wedged shaped area of missing bone at glabella. It has been “reconstructed” with putty, making analysis difficult. It does not likely represent a direct impact and may be the result of postmortem damage, perhaps associated with 5R3 and fracture #5.

Fracture #8 is a linear fracture located mid occipital basilar on the left side. As previously mentioned, it may contribute to a ring fracture.

Similarly, fracture #9 is located at the sphenobasilar synchondrosis with damage to the body of the sphenoid and the pterygoid plates. Again, it may be related to a possible ring fracture and/or damage to the left maxilla, left orbit, and left and right zygomatic bones. It may also be the result of postmortem damage.

Fracture #10 separates the left occipital condyle from the bone posterolateral to it. The margins are not discolored.

Fracture #11 is marked by the absence of the left zygomatic and damage sustained by the left greater wing of the sphenoid.

Fracture #12 is marked by the absence of the right zygomatic and mandibular condyle and damage to the right maxilla.

In sum, the skull of Hasanlu 75-29-531A endured at least four direct perimortem blunt force impacts resulting in four elliptical traumas summarized here as fractures #1, #2, #3, and #4. These fractures measure 3.1 cm by 1.1 cm, 2.6 cm by 1.0 cm, 3.5 cm by 1.4 cm, and 3.5 cm by 1.4 cm, respectfully. Characteristics of all four fractures are suggestive of a dull sharp object.
used in a chopping fashion to inflict blunt force upon the cranium. Slight variations in size of these traumas could stem from different causative instruments, or more likely, variations in strength and direction of blow inflicted by a single implement. That degree of attachment is positively correlated with the length of the fracture supports the latter notion that the elliptical wounds sustained by the individual were caused by a common weapon using differing degrees of force.

**Hasanlu 75-29-531B** is an adult male. The cranium is largely present, lacking only the left temporal, vomer, nasal conchae, and right lacrimal. There is no mandible (Figure 14).

**Fracture #1** is a 2.5 cm by 1.0 cm elliptical wound located 3.7 cm from lambda, 9.3 cm from bregma, and 11.0 cm from the right external auditory meatus on the posterior right parietal. Although it affects both tables, the fracture is attached. A linear indentation is present along the midline. Endocranially, the inner table is splintered in a Y-shaped pattern.

**Fracture #2** is also an attached depressed fracture elliptical in shape. It measures 3.3 cm by 1.3 cm with a depth of 0.4 cm and is located in the middle of the right branch of the lambdoidal suture. Only the occipital half of the wound is depressed upon ectocranial inspection, although a midline fracture/indentation is continuous across the sutural line. The trauma margins on the parietal are beveled internally. Endocranially, the trauma presents as a roughly circular area of delamination with a small protrusion of bone at its center. **2R1** runs anterosuperiorly from the wound’s superior corner to fracture #1, a distance of 1.4 cm. **2R2** runs medially from the same corner to the lambdoidal suture, which has popped open.

**Fracture #3** lies 5.4 cm from bregma, 8.6 cm from lambda, and 9.3 cm from the right external auditory meatus on the right parietal boss. It is 3.2 cm by 1.1 cm and 0.6 cm deep and
elliptical in shape. Both tables are affected by this depressed fracture, but the wound is still attached to the cranium. Endocranially, the lesion manifests as a circular region lacking inner table with an elliptical protrusion at its center.

**Fracture #4** is a detached depressed fracture of the left parietal, just overlapping the lambdoidal suture lateral to lambda. It is 2.6 cm from lambda and 11.5 cm from bregma. It is a 3.5 cm by 1.2 cm elliptical wound with internally beveled edges. It overlaps with fracture #5 to form a V-shaped defect.

**Fracture #5** is the same size (3.5 cm by 1.2 cm) and roughly the same shape as fracture #4 and likewise appears to be a detached depressed fracture of the left parietal with internally beveled margins. The two fractures share an inferior corner. However, a slight bony projection into the inferior wound margin calls the true nature of this fracture and its legitimacy as a unique impact into question. Fracture #5 is also associated with a possible concentric fracture, 5C1, which curves laterally from the anterior corner of the wound and terminates at the lambdoidal suture. 5R1 runs anterosuperiorly and may actually be a continuation of 8R2.

**Fracture #6** is an elliptical detached depressed fracture 3.2 cm by 1.1 cm in size. It is located on the left parietal 7.8 cm from bregma and 3.1 cm from the left pterion. The causal instrument appears to have entered the cranium at an angle from below, resulting in an externally beveled inferior margin and an internally beveled superior margin. It is highly comminuted, associated with many radiating fractures. The comminution renders interpretation/directionality of these radiating fractures exceedingly difficult. Fractures likely radiating from #6 include 6R1, which extends anteriorly and terminates mid left parietal, and 6R2, which runs superiorly and terminates at 5R1; 6R3 runs posterosuperiorly from the superior corner and terminates mid left parietal at a small area of missing bone; 6R4 extends posterosuperiorly from the inferior corner,
terminating at 5R1; 6R5 extends inferior and is interrupted by fracture #7; and 6R6 extends inferiorly into the larger fracture area #12.

**Fracture #7** is 11.8 cm from bregma and 4.8 cm from pterion on the left parietal/temporal. It is an elliptical detached depressed fracture 1.2 cm wide and of unknown length that disappears into a large highly comminuted region of missing bone on the left side of the cranium (fracture area #12). The visible margins are beveled externally; there are no additional internal markers of perimortem trauma. 7R1 extends posterosuperiorly and terminates at 5C1.

**Fracture #8** is a 3.6 cm by 1.3 cm detached elliptical wound of the frontal, just superior to the right orbit, where it opens the frontal sinus. More precisely, it lies 2.4 cm from nasion, 9.0 cm from bregma, and 5.1 cm from the right pterion. Internal flaking and beveling is present along the left margin. There are five radiating fractures associated with this blow. 8R1 runs laterally from the right corner, crosses the temporal line, and terminates at the sphenoid. 8R2 runs posteriorly from the mid-superior margin to bregma. 8R3 extends to the left from the left lateral corner and terminates 2.0 cm away on the mid-frontal. This fracture is very light (hairline). 8R4 runs inferiorly for a length of 1.6 cm, and 8R5 extends inferolaterally to the supraorbital notch and crosses the orbital roof.

**Fracture #9** is a linear fracture of the right maxilla. It runs from the zygomaticomaxillary suture at the orbit, down and medially around the infraorbital foramen, laterally around the alveolus, and onto the posterior maxilla. It may be a continuation of 8R5.

**Fracture #10** is a roughly circular, partially detached fracture of the posterior skull base on the right occipital. It measures 3.0 cm by 4.3 cm. The posterosuperior half of the fracture is hinged endocranially, suggestive of perimortem trauma.
Fracture #11 is postmortem damage resulting in the loss of the occipital condyles and external cortex of the lateral portions of the occipital. The bone here is sharp and discolored.

Fracture #12 is a fracture area that implicates the left temporal region of the cranium. Several margins, including those near the zygomatic, are sharp and discolored, suggesting that this region was created by the combined forces of fractures #5, #6, and #7 and by postmortem damage.

In sum, the skull of Hasanlu 75-29-531B endured at least six direct perimortem blunt force impacts resulting in six elliptical traumas summarized here as fractures #1, #2, #3, #4, #6 and #8. These fractures measure 2.5 cm by 1.0 cm, 3.3 cm by 1.3 cm (0.4 cm deep), 3.2 cm by 1.1 cm (0.6 cm deep), 3.5 cm by 1.2 cm, 3.2 cm by 1.1 cm, and 3.6 cm by 1.3 cm respectfully. Two other elliptical fractures on the individual’s skull may represent two additional direct, independent, perimortem blunt force impacts. These, as described above, are fractures # 5 and #7, which measure 3.5 cm by 1.2 cm and ? cm by 1.2 cm respectfully. Characteristics of all eight fractures are suggestive of a dull sharp object used in a chopping fashion to inflict blunt force on the cranium. Slight variations in size of these traumas could stem from different causative instruments, or more likely, variations in strength and direction of blow inflicted by a single implement. That the depth/ degree of detachment of the fractures are relatively consistent with the length of the fracture supports the latter notion that the elliptical wounds sustained by the individual were caused by a common weapon using differing degrees of force. Fracture #10 may also reflect a direct blunt impact to the back of the skull, but the causation of this is less clear.

Hasanlu 75-29-532 is a subadult approximately two years in age. The skull is comprised of the occipital squamous portion, both parietals, the right temporal, the mastoid and petrous
portions of the left temporal, the right zygomatic, the frontal, and both maxillae, and is not articulated. Multiple wormians, severe postmortem fracturing, and plastic deformation render reconstruction and fracture analysis difficult (Figure 15).

**Fracture #1** is an irregularly shaped detached depressed fracture with an elliptically shaped anterior tip. The anterior margins show marked internal beveling and light red staining. This 4.4 cm by 2.8 cm defect is located on the sagittal suture and affects both the left and right parietals. **1R1** runs anterolaterally to the right coronal suture, a distance of 3.6 cm, and has a remarkably straight edge. Two other fractures extend from the wound and may be postmortem in nature.

**Fracture #2** is an equally irregular detached depressed fracture on the left side of the frontal, 5.0 cm from nasion. Overall, it measures 6.1 cm by 2.5 cm. Its margins include several distinct curves. Internal beveling, however, is especially notable at the elliptically shaped posterior corner. When superimposed, this corner’s contour almost exactly matches that of the anterior corner of fracture #1. This suggests that the same instrument was used to create both defects. There are also several possible radiating fractures associated with this lesion, including **2R1**, which runs from the right margin to the coronal suture and, like 1R1, is unusually straight.

In sum, the skull of Hasanlu 75-29-532 endured at least one direct perimortem blunt force impact resulting in an elliptical trauma. This is part of fracture #1. A second direct impact is likely implicated in fracture #2. Characteristics of both fractures are suggestive of a dull sharp object used in a chopping fashion to inflict blunt force upon the cranium.

**Hasanlu 75-29-534** is an adult male with a largely complete cranium. Only the vomer, lacrimals, and half of the frontal are missing. The remaining bones are articulated (Figure 16).
**Fracture #1** is a sharp force trauma on the occipital near lambda. More precisely, it is located 2.6 cm from lambda, 8.9 cm from the right external auditory meatus, 7.0 cm from the foramen magnum, and 9.9 cm from the left external auditory meatus. It is a 6 cm by 0.1 cm inferiorly directed chop. Directionality can be determined by the sloping of its margins. Internal beveling is present on the inferior surface, suggesting a blow from above. There are two radiating fractures. **1R1** runs inferolaterally to the left from the left edge of the wound to the foramen magnum. **1R2** is best understood when viewed endocranially; it extends inferolaterally to the right, curves upward, moves through the squamosal suture, continues onto the sphenoid angle of the parietal, crosses the coronal, and runs onto the frontal.

**Fracture #2** is a large (15.2 cm by 7.0 cm) fracture area on top of the vault and primarily involves the frontal and left parietal. Its margins are both discolored and externally beveled; they are dry and brittle. Two fractures radiate from its margins. **2R1** runs posteriorly across the left parietal and **2R2** moves laterally onto the right parietal. Overall, this fracture area appears to have been created by postmortem damage, although one can not exclude the possibility that a perimortem trauma at its center is responsible for weakening the bone and rendering it particularly susceptible to taphonomic peril.

**Fracture #3** is a postmortem fracture of the right zygomatic. Fracture margins are discolored and spiky.

In sum, Hasanlu 75-29-534 received at least one direct sharp force blow to the cranium. Characteristics of the resulting lesion, fracture #1, suggest that a long, sharp blade used in a chopping or slashing manner was the causative weapon.
Hasanlu 75-29-542 is an adult male. His skull is complete, missing only the left inferior nasal concha and small fracture fragments. The majority of the missing bone appears to be associated with perimortem trauma (Figure 17).

Fracture #1 is a depressed fracture located 2.0 cm right of the sagittal suture, directly lateral to the right parietal foramen, and 4.0 cm superior to the lambdoidal suture. Both the inner (endocranial) and outer (ectocranial) tables are affected, but the crushed region is still attached to the skull. It forms an ellipse approximately 1.9 by 0.8 cm on the outer table with a sharp depression along the midline. The inner table is splintered, with bone protruding endocranially in a tented fashion. A small hairline concentric fracture (1C1) parallels the posterolateral wound margin, to which a small spur adheres, but does not affect the inner table. One radiating fracture (1R1) runs anteriorly from the medial corner and similarly only affects the outer table of the skull.

Fracture #2 is likewise an attached depressed fracture, elliptical in shape. It is located 2.4 cm anterolateral to the fracture previously described, 6 cm from the sagittal suture, and 5.2 cm from the lambdoidal suture. Measuring 2.4 cm by 1.2 cm, it is larger than fracture #1 and is dislocated more deeply into the endocranium (0.4 cm). Again, there is a sharp depression along the wound’s midline and the inner table is splintered in an uplifted tenting fashion. One radiating fracture (2R1), approximately 8.1 cm in length, runs posteromedially through both tables from the traumatic lesion, traversing the lambdoidal suture onto the os inca, where it forks. One end continues to move inferiorly and either terminates at the inferior os inca suture or crosses the suture, redirects slightly, and sweeps around the external occipital protuberance. The other fork terminates at fracture #10. 2R2 runs anteriorly from the wound’s lateral-most corner for a length
of 4.5 cm. 2R3 runs superiorly for a short distance. Neither of these latter two fractures affects the endocranial.

Fracture #3 is located on the frontal, 5.5 cm from bregma, 5.5 cm from nasion, and 7.0 cm from the right pterion. It is also an attached depressed fracture affecting both tables with a sharp depression along the midline, splintering of the inner table, and two radiating fractures. It is intermediate in size between the two previously described fractures, measuring 2.1 cm by 1.2 cm and extending 0.2 cm into the endocranium. 3R1 moves inferiorly to the right supraorbital torus and affects both the endo- and ectocranium. 3R2 radiates to fracture #4.

Elliptical fracture #4 is 2.1 cm superior to #3 and measures only 1.7 cm by 0.4 cm. It has no depth and affects only the outer table of the skull. 4R1 runs from the right lateral fracture corner to the coronal suture. Although ectocranially, 3R1, 3R2, and 4R1 do not form a continuous line, they do form a continuous line endocranially.

Fracture #5 is a hairline fracture that begins at the right supraorbital torus and extends inferiorly, almost parallel to 3R1, through the bone of the outer table. It runs through the supraorbital foramen and onto the orbital plate of the frontal. It may be an indirect fracture resulting from deformation of the bone associated with fracture #3.

Fracture #6 is a small detached area of bone near pterion, 3.0 cm by 1.4 cm. The shape, though nearly elliptical, is more jagged and irregular than the clearly delineated ellipses seen elsewhere on the cranium. In addition, it is not associated with any beveling, flaking, or delamination, though two fractures seem to radiate from its margins.

Fracture #7 is located 2.4 cm left of the sagittal suture and 5.3 cm posterior to the coronal suture on the left parietal. It is partially detached and partially attached (about 50/50, divided along the midline). The attached portion is marked by a line that affects only the
ectocranium. However, there is internal beveling of the margins as well as areas of missing inner table along the endocranial margins. The lateral corner is undefined (part of a larger detached fracture area); the wound is therefore at least 2.2 cm by 1.2 cm in size, but more exact measures cannot be made. One certain and two possible radiating fractures run from its margins. 7R1 runs from the superior corner of the traumatic lesion to the sagittal suture and affects both tables. The superior margins of fracture area #8 may represent 7R2 and 7R3.

Fracture # 8 is a fracture area affecting the left parietal. It covers a 7.3 cm by 3.2 cm region and is delineated by externally beveled margins that may have been formed by radiating fractures and comminution created by fractures #7 and #13. It is possible that an additional impact inflicted upon the region, but no longer visible due to the absence of bone, contributed to the formation of fracture #8 as well.

Fracture #9 is simply the loss of the left temporal squama. It may be a result of comminution or postmortem damage.

Fracture #10 is a fracture area. It covers a region roughly 9.6 cm by 6.9 cm in size spanning the os inca, left parietal, and the occipital. Its left lateral and inferior margins are described by the sutures of the os inca. This area is irregularly shaped and likely caused by comminution associated with fractures radiating from other areas of direct impact or by comminution from these in association with a direct impact to the fracture region no longer detectable due to the absence of the affected bone. Indeed, 10A is a detached fragment (now reconstructed) that was likely pushed into the skull during the perimortem period, possibly in consequence to a direct blow. The ectocranial aspect of the fragment is ovoid in shape and measures 2.1 cm by 1.0 cm; a much larger portion of inner table is detached from the diploe endocranially. The endocranial surface is also beveled along the medial margin. The sutures
from this point on the os inca through the sphenosquamosal suture are open with possible plastic deformation of the posterior right skull.

**Fractures #11 and #12** are linear fractures to the mandible that may have occurred peri- or postmortem.

**Fracture #13** is represented by a well delineated curve in the inferior margin of the superior left lateral projection of fracture #10 and is 2.1 cm long (width unknown). It is accompanied by extensive delamination of the diploe endocranially, very similar to that produced by detached fragment 10A. Possible radiating fractures include 13R1, 13R2, and 13R3. It is possible that the latter two radiating fractures and 2R1 combined to create the comminution responsible for the missing bone at fracture area #10.

In sum, the skull of Hasanlu 75-29-542 endured at least four direct perimortem blunt force impacts resulting in four elliptical traumas summarized here as fractures #1, #2, #3, and #4. These fractures measure 1.9 cm by 0.8 cm, 2.4 cm by 1.2 cm (0.4 cm deep), 2.1 cm by 1.2 cm (0.2 cm deep), and 1.7 cm by 0.4 cm respectfully. Three other fractures on the individual’s skull may represent three additional direct, independent, perimortem blunt force impacts. These, as described above, are fracture # 7, detached fragment 10A, and fracture #13, which measure at least 2.2 cm by 1.2 cm, 2.1 cm by 1.0 cm, and 2.1 cm by ? cm respectfully. Characteristics of all seven fractures are suggestive of a dull sharp object used in a chopping fashion to inflict blunt force upon the cranium. Slight variations in size of these traumas could stem from different causative instruments, or more likely, variations in strength and direction of blow inflicted by a single implement. That the depth of the attached fractures is positively correlated with the length of the fracture supports the latter notion that the elliptical wounds sustained by the individual were caused by a common weapon using differing degrees of force.
The weapons

Mace heads have been postulated as the cause of many of the cranial traumas at Hasanlu (Muscerella, 1989). The author of the present report examined 24 of the 37 mace heads recovered from Hasanlu and listed in the University of Pennsylvania Museum of Archaeology and Anthropology archives. It is reported elsewhere that a total of 76 mace heads exist from the site, 48 of which are stone and 28 metal (bronze and/or iron) (Muscerella, 1989). Although all are catalogued as mace heads, it is not clear that all were actually used by the people of Hasanlu as maces.

The analyzed mace heads vary drastically in size, shape, and degree of ornamentation. All are made of either stone (n = 15) or metal (n = 9). Most are more-or-less spherical in shape (n = 15); others are spiked (n = 2) or disc-like (n = 1). One takes the form of a flower, another resembles a stone hammer, and two are simply bulges marked with several smaller protrusions on a narrow shaft. A few have carved (n = 3) or gold-inlaid (n = 1) embellishments. Some possess a single neck (n = 11) and others two necks (n = 5); the remainder lack necks (n = 8). Striking surface heights range from 2.0 cm to 6.9 cm, with an average striking height of 4.5 cm. Striking diameters range from 4.3 cm to 7.8 cm, with an average striking diameter of 5.5 cm.

Seven celts are listed in the University Museum’s Hasanlu database; all seven were analyzed. Five are metal and two are stone. Heavy corrosion of all five metal celts makes accurate determination of size difficult; however, four of the metal celts are very similar in overall design and shape. The striking surfaces of the celts are as follows: 3.5 cm by 1.3 cm, 2.7 cm by 1.0 cm, 4.2 cm by 1.0 cm, 5.1 cm by 1.2 cm, 3.8 cm by 0.6 cm, and 4.0/5.5 cm by 1.3 cm (this last celt is double sided and has two striking surfaces). The seventh is too fragmentary to be measured.
Two axes are listed in the Museum archives, but both are still incased in excavating molds and can not be readily examined. A casting mold used by the people at Hasanlu to craft these axes, however, was examined. It would have produced an axe with a roughly 18.5 cm by 7.5 cm blade.

Seven relatively complete sword blades, including one complete sword, were examined. Reports as to the total number of swords recovered from the site vary, likely based on the criteria various authors and observers have used to differentiate sword blades from other types of blades. The total number of swords found at Hasanlu is therefore uncertain. Thornton and Pigott’s (2011) recent study, which defined sword blades as tanged blades greater than 30 cm in length, indicates that archaeologists recovered 22 swords from the site. Parts (blades, hilts, and pommels) derived from 20 swords are listed in the archives. Most are made of iron.

The complete sword housed by the University of Pennsylvania is 54 cm in total length; the blade alone is 37 cm long. The tip of the blade is 1.5 cm wide and the base of the blade is 5.4 cm wide. The blade cross section is narrow with a raised metal rib at the midpoint (t-shaped), representing one of two blade styles observed. The narrow aspect of this cross section is 0.8 cm thick; the midpoint rib is 1.2 cm to 1.9 cm thick, depending on where on the blade the cross section depth is measured. These cross sectional measures are relatively consistent for all observed mid-ribbed blades (n = 5); the others measured 0.8 cm to 1.9 cm, 0.7 cm to 1.7 cm, 1.0 cm to 1.4 cm, and 0.9 cm to 1.8 cm.

The other style of blade examined (represented by two specimens) has a smooth elliptical cross section that ranges from 2.2 cm to 3.4 cm in thickness depending on where on the blade the measurement is taken. The base of one such flat blade, which lacks a point, is 5.8 cm wide. The point of the other observed flat blade, which lacks a base, is 0.5 cm wide.
Thornton and Pigott (2011) noted three predominant styles of blade in their analysis: mid-ribbed (the first style described above), flat (the second style described above), and mid-ridged (not observed by the present author). They describe nearly all blades as triangular in shape. That is, they are widest at the hilt and taper evenly to a point.

Hasanlu dagger blades, defined as tanged blades less than 20 cm in length, and shortsword blades, those between 20 cm and 30 cm in length, are nearly identical in design and variety to the Hasanlu full-sized sword blades (Thornton and Pigott, 2011). Thornton and Pigott (2011) report 49 shortswords and daggers; 53 knives and daggers are listed in the museum archives.

Hasanlu arrowheads are defined by Thornton and Pigott (2011, 136) as “tanged blades of length less than 8-9 cm or socketed blades of similar length with a socket less than 1 cm in diameter.” Following this definition, 681 arrowheads were found at Hasanlu. Five-hundred-ninety-four of these are flat, non-barbed and non-winged leaf-shaped blades. The average width of these flat arrowheads, as analyzed by Thornton and Pigott (2011) is 1 to 3 cm, with a thickness of less than 0.5 cm. Overall blade length varies from between 3 to 5 cm, 5 to 7 cm, and 7 to 9 cm. The majority have a narrow elliptical cross section. Because the majority of these arrowheads were also forged from iron, no two are exactly alike (Thornton and Pigott, 2011).

Spearheads at Hasanlu are defined by Thornton and Pigott (2011, 136) as “socketed blades with a socket of greater than 1 cm in diameter,” a definition that includes pike weapons. Four-hundred-twenty such weapons were found at Hasanlu. Three-hundred-fifty-three flat-bladed and point-tapering spearheads were recovered and represent the most common handheld weapon used in the battle (Thornton and Pigott, 2011). Cross sections of these blades may be mid-ribbed (t-shaped), accounting for 40% of the spearheads, mid-ridged (diamond-shaped),
29%, or flat (ellipsoid), 16%. For these spearheads, blade length may be up to 36 cm. Thirty-seven additional spearheads have circular or square cross sections, 1 to 2 cm in diameter. Such weapons range in blade length from 10 cm to 46 cm and also taper to a point. Fifteen spearheads do not taper to a point, but rather have flat blades with rectangular ends quite similar to those of chisels (Thornton and Pigott, 2011).

Only one adze from Hasanlu is listed in the museum database. The adze was examined. It is a heavy, corroded metal tool with a blunt blade. Its striking surface measures 3.7 cm by 0.8 cm.

The author examined two “bars” that theoretically could have been wielded as bats. Both are highly fragmented and heavily corroded long metal shafts. One is completely flat while the other appears to be slightly rounded. The least corroded piece of the former comes to a tapered rounded point and measures 3.0 cm wide by 0.6 cm thick. This bar is at least 47 cm long when reconstructed. The least corroded piece of the second bar is 4.0 cm wide and 1.4 cm thick. This bar is at least 50 cm long and also appears to come to a tapered point.

One hammer in the collection was analyzed. It is a crude stone tool (rock) with one flattened, chipped, and circular surface. The hammering surface measures 4.0 cm by 4.0 cm.

The collection also contains seven chisels and 26 sickles, which have weapon potential. Given the plethora of other weapons available, the adze, bars, hammer, chisels, and sickles were not likely wielded as weapons in the final battle.
DISCUSSION

In sum, 63 definite or very likely perimortem primary points of impact are identifiable on the 19 skulls. This is an average of 3.3 impacts per skull, with a range of one to eight impacts, a median of three impacts, and a mode of two impacts. As Monge and McCarthy (2011, 183) observed, interpreting these traumas is extremely difficult as “there are no modern trauma patterns that could possibly be used to model violence patterns in the past.” Indeed, it is almost never possible to definitively attribute any trauma to a specific weapon - even within more modern contexts - due to the great number of variables affecting fracture patterning discussed above. However, the available evidence does allow hypotheses to be made. Hypotheses may be better assessed in the future with the help of carefully designed experimental archaeology tests.

Three examples of comminution associated with expansive concentric fractures are present on three skulls in the Hasanlu collection. These traumas are suggestive of blunt force trauma with a moderately sized and relatively round object. A spherical mace is the likely culprit. While two of these traumas (Fracture #3 on Hasanlu 63-5-314 and fracture #5 on Hasanlu 75-29-501) are too comminuted to estimate the size of the striking surface used to produce them, fracture #1 on Hasanlu 75-29-503 suggests a causative object roughly 4.6 cm in height; the average striking height of the observed maces is 4.5 cm. Although this evidence in-and-of-itself can not confirm that a mace is responsible for these lesions, it does rule out nearly every other weapon recovered from the battle scene, with the exception, perhaps, of the stone hammer. It is possible that several other examples of severe comminution and fragmentation on Hasanlu skulls result from mace blows as well, but without clear areas of impact, it is not possible to attribute
these traumas to a causative weapon with any degree of certitude, especially as it is known that many skulls were also crushed under buildings during the perimortem interval.

The stellate fracture lacking comminution on Hasanlu 75-29-504 is most consistent with blunt force via a broad and relatively flat surface, such as a wall, the ground, the non-cutting surface of a sword blade, or some other type of wide bat; it occurs within a cranial region diagnostic for both falls and blows.

Five (Hasanlu 61-5-340, Hasanlu 63-5-308, Hasanlu 71-23-526, Hasanlu 75-29-503, and Hasanlu 75-29-531A) of the 19 individuals analyzed here exhibit some degree of fracturing encircling the foramen magnum. These may be examples of ring fractures, though postmortem damage to the basicranium is not unlikely. Ring fractures are suggestive of falls or jumps from heights that force the vertebrae into the occipital. This would be expected at Hasanlu if individuals jumped from or were thrown from the second story of burning buildings and landed on their feet, buttock, or crowns.

There are also four examples of classic perimortem sharp force trauma in the collection: two incised wounds and two stabbing wound. The two sharp force traumas of measurable width (one incised wound and one stabbing wound) are both 0.1 cm wide. The incised wounds (fracture #1 on Hasanlu 75-29-518 and fracture #1 on Hasanlu 75-29-534) have straight, smooth, and polished edges that cut through the bone at oblique angles. A sword is the most likely causative implement; which style of sword blade was used cannot be deduced from the available evidence. The short size and apparent depth of fracture #1 on 63-5-314 and the direction of striations associated with fracture #1 on 61-5-340 suggest that they are dagger or shortsword stab wounds.
Most notably, there are 54 ellipsoid (or, if only partial margins remain, probable ellipsoid) depressed fractures present on 16 of the 19 skulls. That only three individuals do not have such lesions is largely a side affect of the author’s criteria for inclusion that all skulls exhibit perimortem trauma potentially associable with a causative weapon. Fourteen fractures are attached, four are partially attached, and 36 are entirely detached from the cranium. Attached fractures range in length from 1.7 cm to 3.3 cm and in width from 0.4 cm to 1.3 cm, with an average height of 2.5 cm and median height of 2.4 cm and an average and median width of 1.0 cm. Height to width ratios range from 1.75 to 4.25, with an average of 2.62 cm and a median of 2.55 cm. The depths of these fractures range from 0.0 cm to 0.6 cm, with an average of 0.2 cm and a median of 0.1 cm. When those with a depth of 0.0 cm are excluded, internal displacement ranges from 0.2 to 0.6 cm with an average and median of 0.4 cm. The measures for all partially attached fractures are tentative and therefore not further analyzed. For ellipsoid detached depressed fractures, heights range from 2.1 cm to 4.1 cm and widths from 0.6 cm to 1.7 cm. The average and median height is 3.2 cm; the average and median width is 1.2 cm. Height to width ratios range from 1.94 to 5.00, with an average of 3.08 cm and a median of 2.85 cm. There is slightly greater consistency in lesion size within individuals than between individuals. This variation likely stems from a number of factors including differing magnitude of force, differing angle of blows, differing weapon types, and within a given weapon type, differing individual implements. When the height to width ratios of the detached fractures, which may more accurately reflect weapon size than the attached or partially attached fractures, are plotted on to a histogram, there is a clear division between lesions with ratios between 1.5 and 3.0 and lesions with ratios between 3.5 and 5.5. All but two of the attached lesions fall into the latter category.
This may indicate two differing weapon types, one producing narrower wounds with a greater potential for penetration than the other.

As previously described, fracture patterns associated with these lesions are most consistent with relatively dull or heavy sharp implements used in a chopping or hacking manner to inflict localized blunt force trauma against the cranium. Based on the available data, it seems most likely that the majority of the ellipsoid depressed fractures resulted from quick blows/chops delivered by swords and possibly by iron spearheads. The thin beveled edge of such weapons offers a logical explanation for the sharp midline grooves seen along most of the attached fractures. Further, if swords are responsible for these depressions, variations in lesion size could reflect how far back the impacting surface was on the overall blade. As blades tend to increase in width towards the hilt, larger and wider wounds may represent proximal blade blows and narrower wounds distal blade blows.

This manner of sword use, as opposed to stabbing or slicing according to the weapon design, suggests that warfare at Hasanlu involved close hand-to-hand combat. In order to strike another individual over the head with the back of a sword blade, one need be very near to him. Moreover, as brandishing it as a blunt object is not the most efficient way to wound or kill someone with a sharp instrument such as a sword or spear, that it was a tactic used with relative frequency may mean that there was not enough space to properly thrust the long, heavy weapons. While thrusting a weapon through someone is an act that requires horizontal motion and therefore horizontal maneuvering space, clouting someone over the head with a weapon is an act that primarily requires vertical motion and vertical maneuvering space. Given that the battle at Hasanlu took place within a small, largely gated city actively on fire and with at least 246 people present (not including the surviving invaders, who may have been great in number), it is likely
that there was little room for exaggerated horizontal movements with no constraints on vertical motility.

It is also possible that this alternative style of sword use was a tactic used to finish off those who did not die readily enough from their flesh wounds. However, that wounds are often located on multiple, and even opposing, sides of single skulls suggests that the victims of these strikes were dynamic when bludgeoning began.

CONCLUSION

In brief, it seems that the cranial traumas found at Hasanlu collaborate the understanding of the site derived from the other archaeological materials. Several crania were subject to excessive blunt force trauma with no clear point of impact, consistent with being crushed under a collapsed roof. Fracturing around the basicraniums of other individuals suggests that they jumped from or were flung from a moderate height, possibly the second story of a burning building. Still other skulls exhibit concentric and radiating fracture patterns indicative of blunt force trauma with a mace. The presence of a few incised sharp force wounds shows that swords were used in the battle; two stabbing wounds imply that daggers were likewise employed. Additionally, a series of ellipsoid depressed fractures seems to be consistent with trauma induced by swords and possibly spearheads used in a chopping manner. If the future results of current genetic analyses on the collection are able to differentiate between the remains of fallen invaders and the remains of the local populace, it may be possible to discern differing patterns of weapon use between the invader and the invaded and perhaps even elucidate why the people of Hasanlu so readily met death at the hands of their attackers.
However, this novel association of the cranial traumas with causative weapons and actions does suggest something previously unknown about the battle at Hasanlu: that combat took place at very close range. This potential proximity is interesting in the larger context of human warfare and is consistent with the trend to physically distance oneself from the enemy with time: from literal hand-to-hand combat, to fights with handheld weapons, to projectiles fired from handheld machines, to bombs dropped from manned planes, and now to destruction delivered with the press of a button located miles away. This study thus not only elucidates the downfall of a specific people, it serves as a springboard for research on the prehistory and subsequent development of war and patterns of human violence.
REFERENCES CITED


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APPENDIX: CRANIAL FRACTURE DIAGRAMS

Figure 1a: Hasanlu 61-5-340, anterior view
Figure 1b: Hasanlu 61-5-340, posterior view
Figure 1c: Hasanlu 61-5-340, right lateral view
Figure 1d: Hasanlu 61-5-340, left lateral view
Figure 1e: Hasanlu 61-5-340, superior view
Figure 1f: Hasanlu 61-5-340, inferior view
Figure 2a: Hasanlu 63-5-308, anterior view
Figure 2b: Hasanlu 63-5-308, posterior view
Figure 2c: Hasanlu 63-5-308, right lateral view
Figure 2d: Hasanlu 63-5-308, left lateral view
Figure 2e: Hasanlu 63-5-308, superior view
Figure 2f: Hasanlu 63-5-308, inferior view
Figure 3a: Hasanlu 63-5-311, anterior view
Figure 3b: Hasanlu 63-5-311, posterior view
Figure 3c: Hasanlu 63-5-311, right lateral view
Figure 3d: Hasanlu 63-5-311, left lateral view
Figure 3e: Hasanlu 63-5-311, superior view
Figure 4a: Hasanlu 63-5-314, anterior view
Figure 4b: Hasanlu 63-5-314, posterior view
Figure 4c: Hasanlu 63-5-314, right lateral view
Figure 4d: Hasanlu 63-5-314, left lateral view
Figure 4e: Hasanlu 63-5-314, superior view
Figure 4f: Hasanlu 63-5-314, inferior view
Figure 5a: Hasanlu 65-31-760, right lateral view
Figure 5b: Hasanlu 65-31-760, left lateral view
Figure 6a: Hasanlu 65-31-781, anterior view
Figure 6b: Hasanlu 65-31-781, posterior view
Figure 6c: Hasanlu 65-31-781, right lateral view
Figure 6d: Hasanlu 65-31-781, left lateral view
Figure 4e: Hasanlu 65-31-781, superior view
Figure 6f: Hasanlu 65-31-781, inferior view
Figure 7a: Hasanlu 66-23-405, anterior view
Figure 7b: Hasanlu 66-23-405, posterior view
Figure 7c: Hasanlu 66-23-405, right lateral view
Figure 7d: Hasanlu 66-23-405, left lateral view
Figure 7e: Hasanlu 66-23-405, superior view
Figure 8a: Hasanlu 71-23-526, anterior view
Figure 8b: Hasanlu 71-23-526, posterior view
Figure 8c: Hasanlu 71-23-526, right lateral view
Figure 8d: Hasanlu 71-23-526, left lateral view
Figure 8e: Hasanlu 71-23-526, superior view
Figure 8f: Hasanlu 71-23-526, inferior view
Figure 9a: Hasanlu 75-29-501, anterior view
Figure 9b: Hasanlu 75-29-501, posterior view
Figure 9c: Hasanlu 75-29-501, right lateral view
Figure 9d: Hasanlu 75-29-501, left lateral view
Figure 9e: Hasanlu 75-29-501, superior view
Figure 9f: Hasanlu 75-29-501, inferior view
Figure 10a: Hasanlu 75-29-503, anterior view
Figure 10b: Hasanlu 75-29-503, posterior view
Figure 10c: Hasanlu 75-29-503, right lateral view
Figure 10d: Hasanlu 75-29-503, left lateral view
Figure 10e: Hasanlu 75-29-503, superior view
Figure 10f: Hasanlu 75-29-503, inferior view
Figure 11a: Hasanlu 75-29-504, anterior view
Figure 11b: Hasanlu 75-29-504, posterior view
Figure 11c: Hasanlu 75-29-504, right lateral view
Figure 11d: Hasanlu 75-29-504, left lateral view
Figure 11e: Hasanlu 75-29-504, superior view
Figure 11f: Hasanlu 75-29-504, inferior view
Figure 12a: Hasanlu 75-29-510, anterior view
Figure 12b: Hasanlu 75-29-510, posterior view
Figure 12d: Hasanlu 75-29-510, left lateral view
Figure 12e: Hasanlu 75-29-510, superior view
Figure 12f: Hasanlu 75-29-510, inferior view
Figure 13a: Hasanlu 75-29-531A, anterior view
Figure 13b: Hasanlu 75-29-531A, posterior view
Figure 13c: Hasanlu 75-29-531A, right lateral view
Figure 13d: Hasanlu 75-29-531A, left lateral view
Figure 13e: Hasanlu 75-29-531A, superior view
Figure 13f: Hasanlu 75-29-531A, inferior view
Figure 14a: Hasanlu 75-29-531B, anterior view
Figure 14b: Hasanlu 75-29-531B, posterior view
Figure 14c: Hasanlu 75-29-531B, right lateral view
Figure 14d: Hasanlu 75-29-531B, left lateral view
Figure 14e: Hasanlu 75-29-531B, superior view
Figure 14f: Hasanlu 75-29-531B, inferior view
Figure 15a: Hasanlu 75-29-532, superior view
Figure 16a: Hasanlu 75-29-534, anterior view
Figure 16b: Hasanlu 75-29-534, posterior view
Figure 16c: Hasanlu 75-29-534, right lateral view
Figure 16d: Hasanlu 75-29-534, left lateral view
Figure 16e: Hasanlu 75-29-534, superior view
Figure 16f: Hasanlu 75-29-534, inferior view
Figure 17a: Hasanlu 75-29-542, anterior view
Figure 17b: Hasanlu 75-29-542, posterior view
Figure 17c: Hasanlu 75-29-542, right lateral view
Figure 17d: Hasanlu 75-29-542, left lateral view
Figure 17e: Hasanlu 75-29-542, superior view
Figure 17f: Hasanlu 75-29-542, inferior view