Trauma Patterns of Different Types of Ammunition: An Analysis of Skeletal Remains

Lindsay A. Petry
The College at Brockport, State University of New York

Lindsay Petry

Trauma Patterns of Different Types of Ammunition: An Analysis of Skeletal Remains

ANT 499

Lindsay Petry
ANT 499
Research Paper

Trauma Patterns of Different types of Ammunition: An analysis of Skeletal Remains

Introduction

Gunshot wounds are the most common cause of homicidal death in the United States. Analysis and interpretation of fatal gunshot wounds is a crucial and common practice among forensic anthropologists (Denton et al., 2006). With Law enforcement, military agencies worldwide, and civilians using specialized types ammunition, more studies are required relating to different types of projectiles available and the signatures of those projectiles (Nelson et al., 2007). This experiment looks at how different projectiles affect the skeleton. Using swine heads, the effects of four varying types of projectiles were tested; full metal jacketed, lead semi wad cutter targets rounds, jacketed hollow points, and flex tip hollow point bullets. Due to the fact that when bone is penetrated or perforated by a bullet, the bullet's impacting surface is often uniquely modeled by the fractured bone (O'Brian et al., 1991), an analysis was then conducted of each skull to determine if the varying forms of projectiles had their own signature fracture patterns.

Material and Methods

The swine used for this particular experiment were killed three days prior to the experiment. Having freshly killed specimens was important for accurate results and reaction of the tissue. The swine were frozen after death till the experiment was ready to be conducted.

Once the experiment was set, the heads were heated up to room temperature to ensure that the skin and tissue would mimic a living human's reaction as closely as possible. Each pig was weighed prior to the experiment. Specimen number one weighed in at 14.5 pounds, specimen number two weighed in at 12.0 pounds, specimen three weighed 13 pounds, and lastly specimen number four weighed 11.5 pounds. Measurements were also taken; the first was from snout to the back of the occipital, the second was taken from ear to ear. Specimen number one measured 12.00 inches from snout to the back of the occipital and 8.00 inches from ear to ear. Specimen two measured 10.75 inches from snout to occipital and 9.00 inches ear to ear, while specimen three measured 10.00 inches from snout to occipital and 9.34 inches from ear to ear. Specimen number four measured 11.75 inches from snout to the back of the occipital, and measured 8.00 inches ear to ear.

The specimens were then randomly assigned to one of the four projectiles. Specimen one was assigned the Winchester 230 GR. full metal jacketed bullet, specimen two received the hand load 185 GR. Lead semi wad cutter target round, specimen three and the Winchester 230 GR. Jacketed hollow point were paired together, and finally specimen four was assigned the Hornady 185 GR. FTX hollow point bullet.

Next, the specimens were set up in a line, on a flat portion of ground. The line was created approximately one foot away from the heads, where the shot would be taken from. Each shot was conducted under standardized conditions. The firearm used in the experiment was a Colt 45, commonly known as a Colt Commander. The caliber of the gun is 0.45 acp (automatic cartridge pistol). The location of the shot was between the eyes, into the frontal sinus area. The angle of the shot was perpendicular to the specimens. Experimental shots were made in each specimen soon after removal from the refrigerator, in which they had equilibrated overnight (Ragsdale et al., 1988).

To prepare the specimens for analysis, defleshing was required. First, the specimens were carved, removing all possible flesh without risking damage to the trauma site. This was done using a variety of household kitchen knives. Once the specimens were cleared of as much flesh as possible, the defleshing process began. The method chosen for this experiment produces high quality specimens for analysis and documentation. This method uses a non-bleaching method due to the fact that bleaching agents degrade bone by consuming calcium, and should not be part of any method that processes human remains from a forensic context. This method is a simple procedure for removing soft tissue to recover osseous remains. The chemicals involved are easily obtained, inexpensive standard household ingredients that can be purchased at most grocery stores, making the process even easier (Fenton et al., 2003). The formula for defleshing used is as follows: "water to submerge the specimens. Powered detergent (biz detergent), approximately 20 cc per 2 L water. A powered sodium carbonate (Arm and Hammer Washing Soda), approximately 20 cc per 2 L water. Specimens to be cooked are placed in the water-detergent-carbonate solution over low heat such that the solution never reaches the rolling boil, but is nevertheless at or just below a low simmer. During this stage, the enzyme-active ingredients in the solution break down the soft tissue. Some specimens had to be cooked in several sequential changes of the solution to remove soft tissue and most of the fats (Fenton et al., 2003). After each cooking episode, the specimens had to be thoroughly rinsed in running water and adhering tissues had to be manually removed. Tongue depressants and wooden skewers were used to help manually remove the remaining flesh; the more tissue that boiled off, the less that had to be manually removed. In the case of the specimens three and four, the brain casing was split in half, making the brain easier to boil off of the bone; therefore less of it had to be manually removed, unlike with specimens one and two. This method was chosen for a variety of reasons, including the fact that cooking has been successfully used in forensic contexts, it is the quickest way to remove the flesh from the bones, although over cooking can ruin the specimen, it does not consume calcium, and it produces high quality specimens for analysis. Despite the fact that there are other defleshing methods that produce a higher quality of remains for analysis, the time, resource, and monetary constraints related to undergraduate research studies deemed that this quicker, easier, and cheaper method be used (Fenton et al., 2003).

Results

Examination of the entrance sites directly after firing revealed no differences between the various bullet types, only circular defect with a diameter corresponding to the projectile. Analysis of the skulls was based on measurements and observations. Digital osteometric calipers were used to measure the entrance and exit wounds; Table 1. shows the results.

Table 1. Measurements of Entrance and Exit wounds (in millimeters)

	Specimen one	**Specimen two**	**Specimen three**	**Specimen four**
Vertical Measurements of entrance wound	13.00	13.00	22.30	20.10
Horizontal Measurements of entrance wound	11.40	14.10	26.00	22.90
Vertical Measurements of exit wound	23.50	23.90	75.20	89.70
Horizontal Measurements of exit wound	12.80	18.70	Most narrow portion: 25.90 Widest portion: 47.50	Most narrow portion: 23.10 Widest portion: 33.20

**Some sites were so irregular in shape they required two measurements

Specimen one displayed the classic punched out appearance of an entrance wound as (Appendix A). The specimen showed very little internal beveling at the entrance site; however, it was present in an asymmetric fashion, meaning one side of the hole was more pronounced (Quatrehomme et al., 1998). The entrance wound did show evidence of radiating fractures, although concentric fractures were absent (Appendix B). The exit wound was irregular in shape, and did display some signs of external beveling, again asymmetrical. There were approximately two radiating fractures from the site, but like the entrance wound, lacked any concentric fracture (Appendix C). Micro-fracturing was present at both the entrance and exit wounds. Additionally, specimen one was in one piece after defleshing, and most of the internal structures seemed completely intact as well. Some were loosened, and some did sustain damages, but most of the features are identifiable and present. It appears as though the bullet took out what was in its path, but nothing more.

Specimen two, like specimen one, showed the round, punched out appearance of a gunshot entrance site, as demonstrated in Appendix D. However, specimen two did not present with any radiating fractures at the entrance site, nor did not show any signs of internal beveling (see Appendix E). Concentric fractures were also absent from the entrance wound. The exit wound was very irregular in shape, but did show the classic signs of external beveling. There were minimal radiating fractures from the exit wound, and no concentric fractures. The exit site also had extensive micro-fracturing present; see Appendix F and G. Again, similar to specimen one, the skull was recovered in one whole piece, and the internal structure of specimen two was intact and mostly identifiable.

The defleshing process revealed that specimen three was split into two pieces (see Appendix H), down the middle of the nasal bone; although I suspect this is due to a preexisting cut down the cranial vault that was produced as a result of killing the swine. With the specimen in two pieces, it was plainly obvious that the internal structure of the skull was completely obliterated (note Appendix I). Most features were either gone, or so damaged that they became unidentifiable. Specimen three has to be reconstructed prior to analysis, this was done using glue and clay. The pieces were strained through a colander after the defleshing process and collected. The pieces were reconstructed to the best of my ability. The entrance wound was extremely irregular in shape; again, this is suspected to be a product of the expanding pressure of the bullet in combination with the preexisting cranial cut, which made the bone weaker in areas and therefore more susceptible to damage (Appendix J). As a result of the irregularity, multiple measurements of the wounds were necessary in order to gain a comprehensive understanding of the trauma pattern. The entrance site also shows signs of asymmetrical internal beveling, as well as long radiating fractures that spread to the sides of the nasal bone (Appendix K and L). Micro-fracturing is present at the entrance wound, and is quite abundant. As with all other specimens, there are no concentric fractures visible at the entrance wound. The exit wound is extremely large, showed external beveling, and had multiple radiating fractures present. Again, no concentric fractures were discovered. Micro-fracturing was also present at the exit site, and like at the entrance site was plentiful (Appendix M).

Specimen four was also split into two pieces along the center of the skull. It too had to be reconstructed prior to analysis; the same method of reconstruction was used. The bullet, as expected, caused massive fracturing and displacement of the bones of the cranium (Mann et al., 1992). The internal structure of the specimen was again, just obliterated. Internal features were wiped out; in fact, you could see through the entrance wound to the exit wound and beyond (Appendix N). The entrance wound showed no internal beveling, no radiating fractures, and no concentric fractures (Appendix O, P and Q). However, there was micro-fracturing present at the site. The exit wound was elongated, and did show external beveling. Again, micro-fracturing was prominent at the exit site (Appendix R).

Discussion

In order to understand the impact each projectile made, the way in which the bullet works must first be understood. Terminal ballistics (aka wound ballistics) is the study of how a projectile behaves when it hits its target and transfers its kinetic energy to the target (Hornady, 2013). There are four components of projectile wounding; the first is Penetration. Penetration is the act of passing through tissue by the projectile, which disrupts and destroys the tissue. Next is the permanent cavity, or the volume of space once occupied by tissue that has been destroyed by the passage of the projectile, quite simply, the hole left by the passage of the bullet. Third is the temporary cavity, which is the expansion of the permanent cavity by stretching due to the transfer of kinetic energy during the projectiles passage. Lastly is fragmentation, or projectile pieces of secondary fragments of bone which are blown outward from the permanent cavity. Fragmentation is not necessarily present in every projectile wound though (Department of Justice, 1989). The primary way a bullet causes damage is through the permanent cavity it leaves. The hole that is created as the bullet passes through the skin, bone, or flesh. This wound channel is the same diameter as the bullet or bullet fragments and is a function of bullet penetration and expansion. The secondary way a bullet causes damage is by the temporary cavity it causes. Both permanent and temporary cavities are greatly affected by a bullet's design, sectional density, and velocity at the time of impact. Bullets designed with heavier jackets tend to stay together better and penetrate deeper, while lighter jacketed bullets tend to fragment and expand more rapidly, creating a wider wound channel and increasing temporary cavitation, but generally don't achieve as much penetration. Expansion can be controlled by the bullet's tip design and by the jacket construction. Rapidly expanding bullets create wider wound channels, displacing even more tissue and increasing temporary cavitation. However, they also create drag, thus requiring more energy and momentum to drive through tissue, and in general don't penetrate as deeply as bullets designed to expand more slowly. Basically, a bullet's design, as well as its impact velocity, plays a huge role in how the energy is transferred (Hornady, 2013). Today, new high density metal alloys have been developed and ensure the transfer of a large amount of energy to the target (Stuehmert et al., 2009).

Hollow points are designed to mushroom on impact, which causes more tissue damage. Hollow points also have a softer core that is covered with a copper alloy coating to increase stability. As a result, this projectile completely fragments when it strikes the target. A copper plate at the projectile base provides additional support and prevents premature fragmentation. Hollow points are partial metal-jacketed projectiles with a core that is not fully covered by the jacket and a nose that is left open and has a cavity to increase deformation on penetration of a target. As a result of this construction, the projectile fragments in a controlled manner and transfers an extremely large amount of energy along a short path. It should be noted that shape and material composition of the projectiles have a stronger influence than velocity (Stuehmert et al., 2009). In contrast a full metal jacketed bullet is designed for deep penetration, with no expansion.

Ballistic behavior of projectiles at the impact site have changed wound morphology considerably. The Projectiles showed different patterns of destruction, specimen one and two showing an extreme amount less destruction than specimen three and four (Stuehmert et al., 2009). This was expected, due to the jacketing of the bullets used on specimen one and two, compared to the hollow point bullets used on specimens three and four. Even though Internal beveling is the classic hallmark of entrance wounds, and the shape of the beveling has been considered an indicator of the direction of fire, and to a certain extent the type of weapon and caliber of the bullet, many cases have been reported of the absence of internal beveling (Quatrehomme et al., 1998). For example, in specimen two and four there was no interval beveling at the entrance site. This could be due to the velocity, angle, and so forth of the bullet. Each shot is different, and the wounds will reflect those differences in how they look. There has also been evidence of no beveling when the bone is too thin and the creation of inverted funnel-shaped wound tract is not possible, which suggests that a minimum bone thickness is necessary. This too could explain no internal beveling on specimens two and four (Quatrehomme et al., 1998).

Most entrance wounds are round, yet exhibit asymmetrical internal beveling, which we see in specimen one and three (Quatrehomme et al., 1998). Specimen three and four, however, presented more of an oval shape. This is most likely due to the expansion of the bullet upon impact.

Exit wounds are roughly round, but always somewhat irregular (Quatrehomme et al., 1997). This can be seen in this experiment as well. Specimens one and two had oval exit wounds, while specimens three and four had a highly irregular exit wounds (Quatrehomme et al., 1998). Exit wounds tend be more inconsistent in their features than entrance wounds, which is a result of a combination of several factors. These include the angle of the shot, the twisting force of the rotating bullet, the blow-back effect, the velocity, shape and size of the bullet, spread of kinetic energy form the bullet, and resistance of the skull (Quatrehomme et al., 1997). The exit wound is almost always larger than the entrance and can display significant variations. This was obvious in all four specimens. Some shootings can even result in atypical features that look more like blunt force trauma (Quatrehomme et al., 1998, Comparison).

Since none of my specimens produced concentric fractures, research was done specifically on this event. It was discovered that radial fractures signify a release of circumferential hoop stresses created by the bullet's impact. Frequently, radial fractures alone appear to adequately relieve stresses and concentric fractures are not formed (Smith et al., 1987). Additionally, a rough positive correlation was noted between the length or magnitude of the radial fractures and the relative power of the weapon and or bullet type (Smith et el., 1987). This explains why specimens three and four show longer and more numerous radiating fractures

There is a clear difference in the trauma of each specimen. As hypothesized, each specimen's injuries were worse than the one before. This progression of bullet type, going from least damaging to most damaging allowed analysis to be done looking at the possible patterns, similarities, and differences between each type of projectile. It should be noted that bullets with the highest velocity are not universally the most damaging; sometimes they impart little wounding energy into the target (Santucci et al., 2004). In addition, intentional deformation through the bullets design causes greater damage. An unjacketed bullet can cause a wound volume forty times larger than a jacketed bullet (Santucci et al., 2004). These facts are consistent with my results; the hollow point bullets wreaked much more havoc on the specimens than the jacketed bullets.

Conclusion

Since the invention of new bullet types, such as jacketed hallow-points and flex tip hollow points, in the nineteenth century (Dougherty et al., 2009), use for scientific study in the area has increased. The Winchester 230 GR jacketed hallow point and the Hornady 185 GR. FTX hollow point were able to completely obliterate the internal structure of the crania, and fragment the external structure due to their powerful expansion abilities. On the other hand, the Winchester 230 GR. full metal jacketed bullet and the hand load 185 GR lead semi wad cutter target round kept most of the internal structure intact due to their deep penetrating design. Each bullets design is vastly different, and thus causes different trauma patterns. All four specimens did, however, exhibit some of the common features of gunshot wounds; while still maintaining their own unique factors. For forensic anthropologists, this is significant because it may aid in identifying what type of ammunition was used in an investigation. This study may also help in identifying the weapon used. For instance, the fact that specimen four's crania looked so blow apart, it could resemble blunt force trauma. Knowing that FTX hollow point bullets cause such a trauma may be helpful in the future. Additionally, I would like to point out some flaws in the experiment. Due to time, facilities, and monetary constraints the experiment only allowed for four specimens. In a proper scientific study, the number of specimens should have been increase, in order to establish a consistent pattern for each projectile type. Furthermore, the analysis was only conducted using observation and research; I was unable to use many of the great technologies that are available in today's forensic laboratories. I think it is worth noting that forensic anthropologists should be very careful about advancing any but the most solid of conclusions, and although this article is not that, it is a verbal speculation (Maples, 1986).

References

A.Stuehmert, N.C Gellrich, K.S Blum, K.H Bormann, M. Rucker. 2009. Wound Ballistics of Injuries Caused by Handguns with Different Types of Projectiles. Military Medicine. Vol. 174: 757-761.

B.D. Ragsdale, A. Josselson. 1988. Experimental Gunshot Fractures. Journal of Trauma.

C. L. Nelson, D. C. Winston. 2007. A New Type of Shotgun Ammunition Produces Unique Wound Characteristics. Journal of Forensic Science. Vol. 52: 195-198.

E.S. Gurdjian, J.E. Webster, H.R. Lissner. 1950. The Mechanism of Skull Fracture. Journal of Radiology. 54:3: 313-339.

G.Quatrehomme, M.Y Iscan. 1998. Analysis of beveling in gunshot entrance wounds. Forensic Science International. 93: 45-60

G.Quatrehomme, M.Y Iscan. 1997. Bevelling in exit gunshot wounds in bones. Forensic Science International. 89: 93-101

G.Quatrehomme, M.Y Iscan. 1998. Gunshot wounds to the skull: Comparison of entries and exits. Forensic Science International. 94: 141-146.

Handgun Wounding Factors and Effectiveness: Mechanics of Projectile Wounding. 1989. U.S. Department of Justice: Federal Bureau of Investigation. http://www.firearmstactical.com/pdf/fbi-hwfe.pdf

J. Scott Denton, A. Segovia, J. A. Filkins. 2006. Practical Pathology of Gunshot Wounds. Archives of Pathology & Laboratory Medicine. Vol. 130:1283–1289.

J.S. Rhine, B.K. Curran. 1990. Multiple Gunshot Wounds of the Head: An Anthropological View. Journal of Forensic Sciences. 35:5: 1236-1245.

O.C. Smith, H.E. Berryman, C.H. Lahren. 1987. Cranial Fracture Patterns and Estimate of Direction from Low velocity Gunshot Wounds. Journal of Forensic Sciences. 32:5: 1416-1421.

O.C. Smith, S.A. Symes, H.E. Berryman, M.A. LeVaughn. 1991. Matching Bullets t Bone Impact Signatures. Journal of Forensic Sciences. 36:6: 1736-1739.

P.J Dougherty, H.C Eidt. 2009. Wound ballistics: Mini Ball vs. Full Metal Jacketed Bullets-- A Comparison of Civil War and Spanish American War firearms. Military Medicine. 174: 403-407.

R.A. Santucci, Y. Chang. 2004. Ballistics for Physicians: Myths about Wound Ballistics and Gunshot Injuries. Journal of Urology. 171: 1408-1414.

R.W. Mann, D.W. Owsely. 1992. Human Osteology: Key to the Sequence of Events in a Postmortem Shooting. Journal of Forensic Sciences. 37:5: 1386-1392.

Terminal Ballistics. 2013. Hornady Manufacturing. http://www.hornady.com/ballisticsresource/terminal

T.W. Fenton, W.H. Birky, J. Cornelison. 2003. A Fast and Safe Non-Bleaching Method for Forensic Skeletal Preparation. Journal of Forensic Science. 48: 1-3.

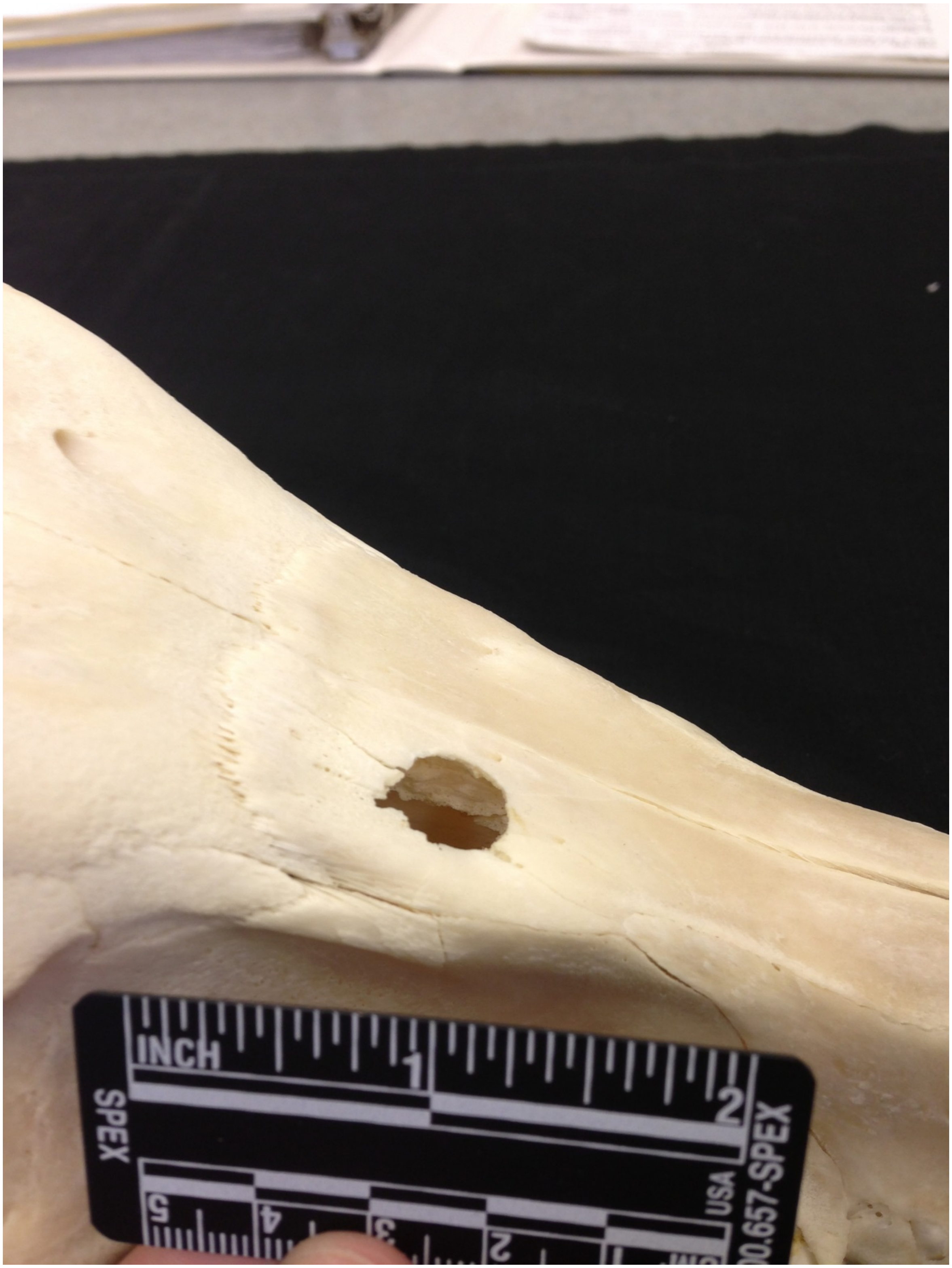
W.R. Maples. 1986. Trauma Analysis by the Forensic Anthropologists. Forensic Osteology.

Appendix

Appendix A.

Frontal view of the entrance view in specimen one

Appendix B.



Side view of specimen one’s entrance site—note the raidial fractures

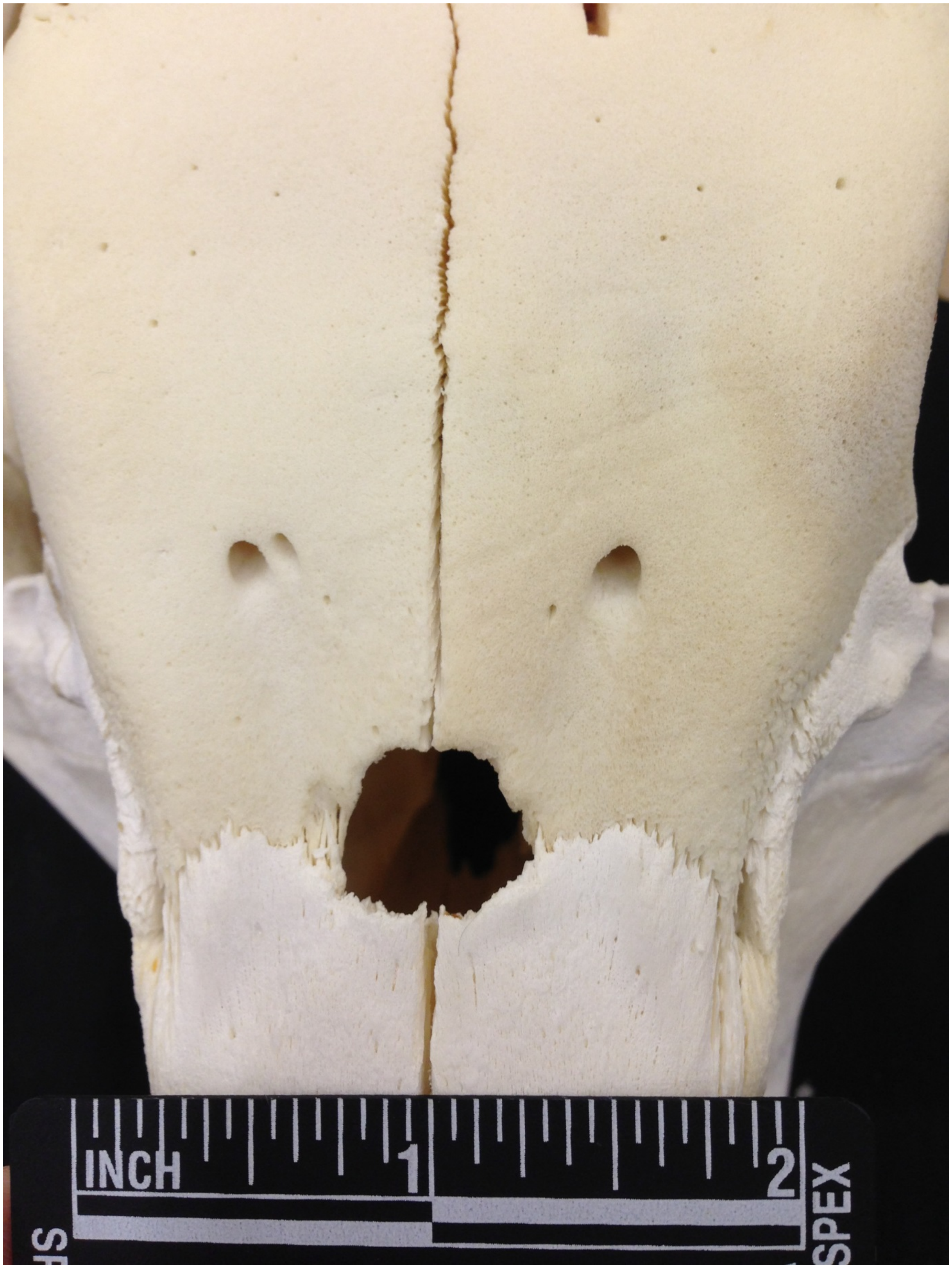
Appendix C.

Exit wound of specimen one

Appendix D.

Entrance would of specimen two

Appendix E.



Close up of entrance would of specimen two—note no fracturing around the wound

Appendix F.

Exit wound of specimen two

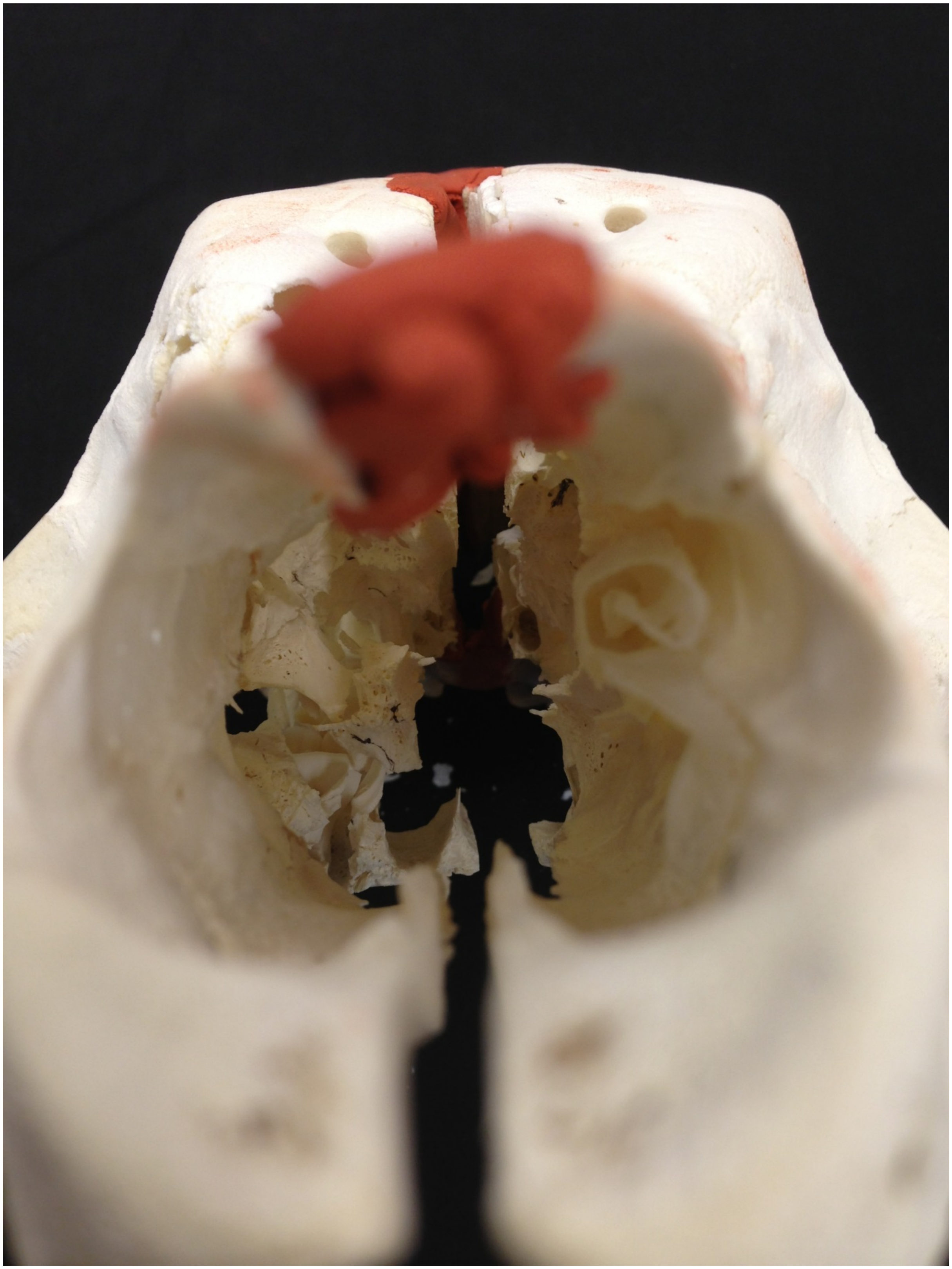
Appendix G.

Close up of exit wound of specimen two

Appendix H.

Two halves of specimen three, internal view

Appendix I.

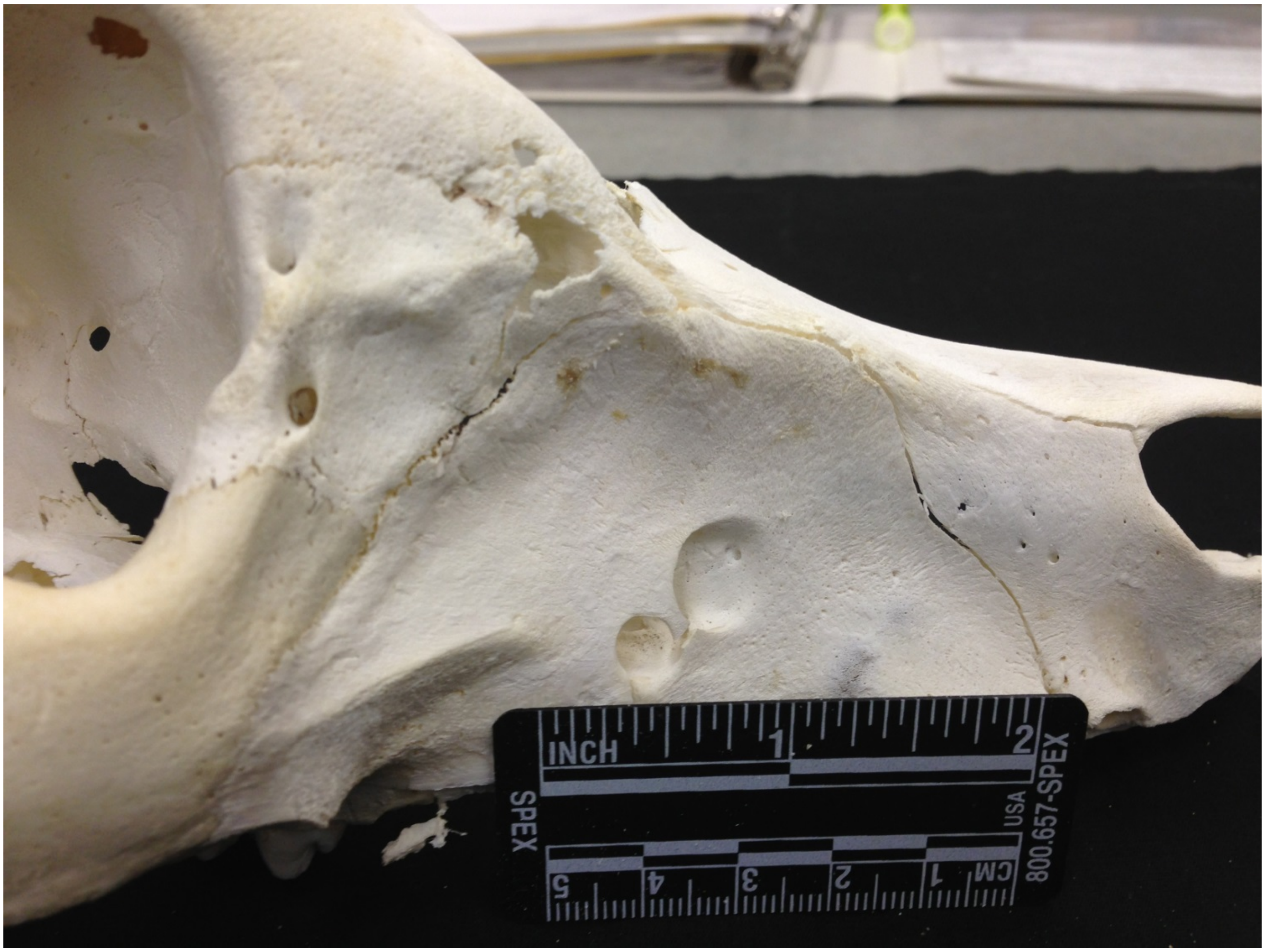


Internal structure damage of specimen three

Appendix J.

Entrance wound of specimen three

Appendix K.



Side view of radiating fracture in specimen three

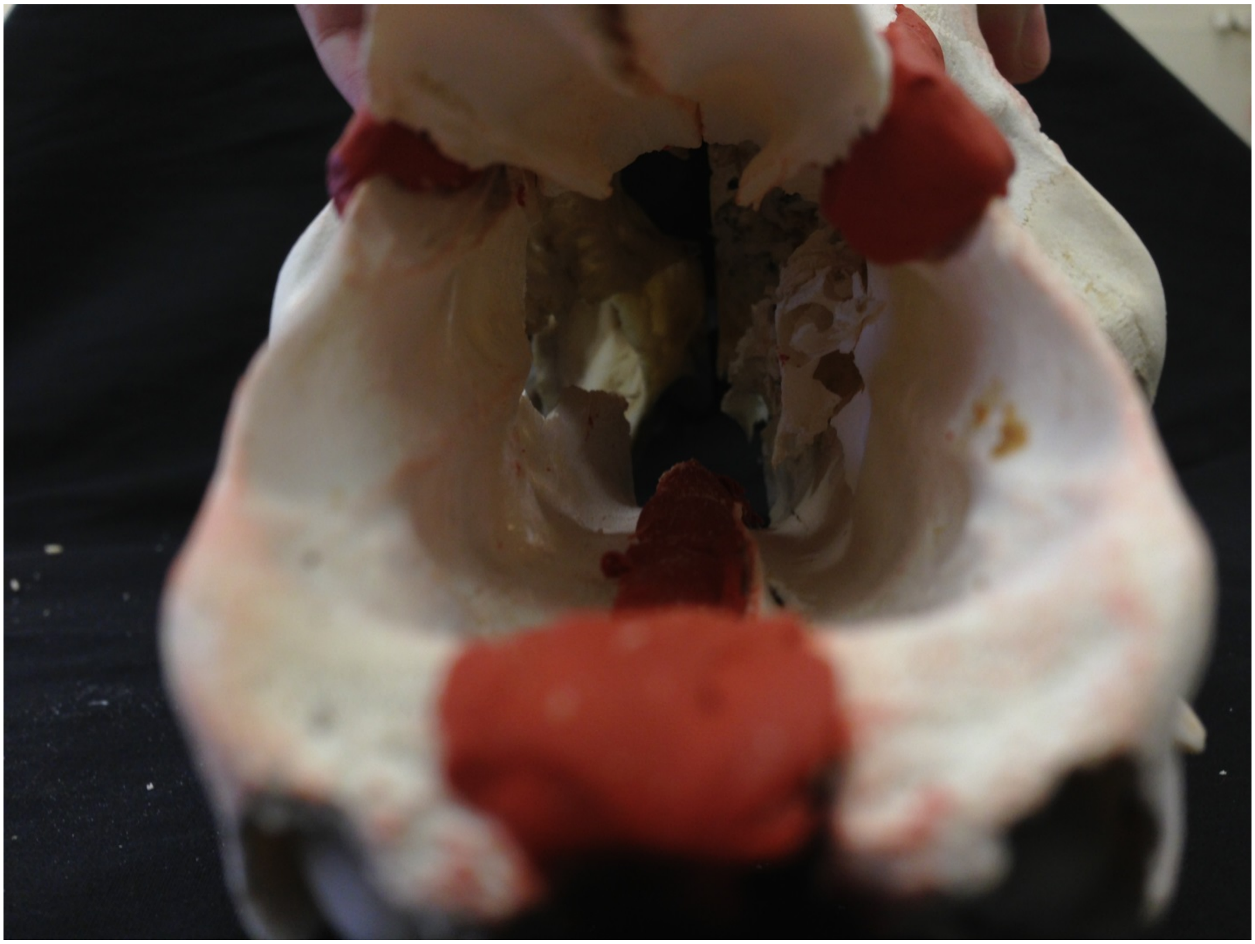
Appendix L.

Close up of entrance wound in specimen three

Appendix M.

Exit wound of specimen three

Appendix N.



Internal damage of specimen four

Appendix O.

Entrance wound of specimen four

Appendix P.

Close up of entrance wound of specimen four

Appendix Q.

Side view of specimen four—note the damage

Appendix R.

Exit wound of specimen four