



Characterization of traumatic injuries in human skulls from a contemporary osteological collection.

CARACTERIZACIÓN DE LESIONES TRAUMÁTICAS EN CRÁNEOS HUMANOS A PARTIR DE UNA COLECCIÓN OSTEOLÓGICA CONTEMPORÁNEA.

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RESUMEN: Las lesiones traumáticas encontradas en los huesos proporcionan información sobre episodios ocurridos durante un determinado período de la vida o incluso después. Una vez producidas, los huesos conservan lesiones traumáticas y pueden ser valoradas después de la muerte. El papel del antropólogo forense es caracterizar el patrón de fractura y descifrar estas lesiones, de manera multidisciplinar, junto con otras áreas de conocimiento dentro de las ciencias forenses. Se presenta aquí un estudio transversal descriptivo y analítico de lesiones traumáticas en cráneos humanos contemporáneos. Analizamos 128 cráneos humanos, 55 femeninos y 73 masculinos, de la Colección de Huesos Contemporáneos del Laboratorio de Identificación Humana y Osteología Forense y del Laboratorio de Antropología y Osteología Forense de la Universidad Federal de Pernambuco, Brasil. Los cráneos fueron inspeccionados visualmente para identificar lesiones traumáticas sufridas durante los períodos antemortem, perimortem y postmortem. Se clasificaron según el período, naturaleza de la lesión, ubicación y número de lesiones. Los datos se analizaron para determinar la frecuencia absoluta y relativa, así como las pruebas de Chi Cuadrado, utilizando un IC del 95%. Las lesiones post mortem y contusas fueron las más frecuentes en ambos sexos. Los huesos del cráneo más afectados fueron el nasal, el cigomático y el maxilar, respectivamente. Sin embargo, ninguna de las comparaciones fue estadísticamente significativa. Así, el estudio de las lesiones traumáticas en colecciones identificadas y contemporáneas permite obtener información sobre los estilos de vida, causas y circunstancias de la muerte de un individuo o grupo de personas, determinando el momento en que se produjeron y los mecanismos responsables de su origen.

PALABRAS CLAVE: ANTROPOLOGÍA FORENSE; OSTEOLÓGIA; ANATOMÍA; CRÁNEO; LESIONES TRAUMÁTICAS.

ABSTRACT: The traumatic lesions found in bones provide information about episodes that occurred during a certain period of life or even afterwards. Once affected, bones will retain traumatic injuries after death. The role of the forensic anthropologist is to characterize the pattern of fractures and decipher these injuries, in a multi-professional manner, together with other areas within the forensic sciences. A descriptive and analytical cross-sectional study of traumatic injuries in contemporary human skulls is presented here. We analyzed 128 human skulls, 55 female and 73 male, from the Contemporary Bone Collection of the Human Identification and Forensic Osteology Laboratory and the Anthropology and Forensic Osteology Laboratory of the Federal University of Pernambuco, Brazil. The skulls were visually inspected to identify traumatic injuries sustained during the antemortem, perimortem and postmortem periods. They were classified according to the period, nature of the injury, location and number of injuries. The data was analyzed for absolute and relative frequency, as well as Chi Square tests, using a 95% CI. Post-mortem and blunt injuries were the most frequent in both sexes. The skull bones most affected were the nasal, zygomatic and maxilla bones, respectively. However, none of the comparisons were statistically significant. Thus, the study of traumatic injuries in identified and contemporary collections makes it possible to raise clues about lifestyles, cause and circumstance of death of an individual or group of people, determining the relative time in which they were produced and the techniques responsible for their formation.

KEY WORDS: FORENSIC ANTHROPOLOGY; OSTEOLÓGIA; ANATOMY; SKULL; TRAUMATIC INJURIES.

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1. INTRODUCTION.

Forensic Anthropology consists of applying the science of Physical Anthropology and Human Osteology to criminal cases where the remains are in an advanced stage of decomposition. However, the anthropological examination corresponds to the delineation of the biological profile, i.e. providing information on sex, age at death, population affinity and stature, based on the analysis of bone structures and their individualizing factors[1].

Traumatic injuries are among the marks left on bones that carry the most information, which makes them a unique source of records on violence suffered by the individual, and it is up to the forensic anthropologist to decipher them. Once affected, the bones will retain the traumatic injuries after death, contributing significantly to the knowledge of the osteobiographies of the individuals who possessed them[2].

However, it is possible to state that these injuries say a lot about the episodes that occurred during the individual's life, revealing important information about the circumstances that led to the victim's death. They can be scarred (antemortem), or they can be related to events directly linked to the death, when the injuries have perimortem characteristics. In other situations, the alterations may have been inflicted after death (postmortem)[2].

A study carried out by[3], with the aim of establishing a method for analyzing fractures and revealing the association between the energy of the force and the fracture pattern, revealed a strong association between this pattern and the speed of the impact, and that these factors can serve to predict the nature of the injury. With regard to injuries sustained in life, most are determined by accidental events, while injuries caused by firearms or surgical practices are the result of intentional actions[4].

Proper interpretation of injuries can help identify the location of the impact, establish the sequence of blows and determine the characteristics of the object that caused the injury. From this perspective, studies on injuries in the forensic environment are of great value in elucidating deaths from violent causes (homicides, suicides, falls, traffic accidents, among others)[5,6].

Thus, studies with identified skeletons reinforce the importance of Forensic Osteology as a tool for elucidating causes of death, especially violent ones, as well as helping to delineate the biological profile of the individual, in addition to predicting the nature of the injuries found in human bones.

In view of the above, the aim of this study is to identify and characterize traumatic injuries according to sex, the periods in which they occurred (ante, peri and postmortem) and the

location of the skulls in which they occurred. This type of study also aims to highlight the scientific potential of the contemporary osteological collection both for Forensic Anthropology, as a source of information for the development of new investigations and scientific methods, reconstructing the identity of individuals and complementing existing information on the bones.

2. MATERIALS AND METHODS.

Identified skeleton collections are a valuable tool for forensic anthropology, as they allow direct comparison between the results of an analysis and the biographical data of each individual, increasing the assertiveness of osteological methods and, consequently, positive identifications in forensic anthropology cases.

The collections of identified skeletons from the Federal University of Pernambuco used for this study are contemporary, located in the state of Pernambuco - Brazil. They contain 390 individuals exhumed from modern cemeteries, with ages at death ranging from 17 to 103 years. The individual information is contained in the funerary records and includes: sex, age at death, cause of death, day of death and day of burial. The skeletons are stored individually, duly numbered, bone by bone, and the information compiled in an Excel Office XP® Microsoft Inc. spreadsheet, making it easier to find data on each individual. The scientific value of this collection is therefore invaluable, as it enables studies of various kinds, such as anatomical, population, pathological, dental and forensic, among others.

This is a cross-sectional descriptive and analytical study of traumatic injuries in 128 adult human skulls, 55 of which were female and 73 male. The research was carried out at the Laboratory of Human Identification and Forensic Osteology (LHIFO) and the Laboratory of Anthropology and Forensic Osteology (LAFO) at the Federal University of Pernambuco - Brazil. Ethical consent was obtained from the Research and Ethics Committee of the Federal University of Pernambuco, Vitória Academic Center, on February 28, 2022 under CAAE number 55287722.4.0000.5208.

The skulls were carefully inspected to identify traumatic injuries sustained during the antemortem, perimortem and postmortem periods. All the skulls in the collections that were in a good state of preservation and had traumatic injuries (n=128), whether caused intentionally or unintentionally, were included. Those with injuries of pathological origin or resulting from anatomical variations were excluded. Radial fractures, firearm puncture fractures and blunt fractures were not counted. Only primary fractures are counted and described.

The injuries were classified, in terms of period, as antemortem (figure 1), perimortem (figure 2) and postmortem (figure 3). As for the nature of the injury, it was classified as perforation by firearm (figure 4), surgical practices (figure 5), antemortem traumatic injury with cicatricial aspects (Scarring) (figure 1) and blunt injuries

(figure 2). As for the location of the lesion on the bones: frontal, temporal, parietal, occipital, nasal, zygomatic and maxilla. And the number of lesions: single and multiple. Multiple fractures were considered to be those that affected more than one bone, not counting radiation from other fractures (Table 1).

Tabela 1 - Traumatic Lesions In Human Skulls.

Variable	Definition	Categorization
Sex	The totality of the characteristics of the reproductive structures, phenotype and genotype functions that distinguish the male and female organism.	Male Female
Identification of lesions	Ante - Healed injuries (osteogenic responses) from episodes that occurred during life. Peri - injuries with perimortem characteristics (bony folding and sharp edges associated with hemorrhagic signs in the injured area) from events directly related to death. Post - injuries that may have been inflicted after death, absence of any type of bone response and color variations on the fracture surfaces.	ANTE – Antemortem PERI – Perimortem POST – Postmortem
Characterization in terms of types:	1 - Circular hole with regular edges on the outer plate of the bone. On the inner plate of the bone, it creates a torn cone-shaped internal bevel with irregular edges. In the exit hole, the characteristics are reversed. 2 - Injuries (non-traumatic) characterized by the action of surgical procedures such as trepanation. Generally with the presence of bone callus if death did not occur during surgery but at some point in the individual's life. 3 - Signs of osteogenic responses with marks of bone remodeling showing healing. For example, the presence of bone callus. 4 - Injuries caused by interpersonal aggression or accidents with obtuse protruding instruments. These can cause the bone plates to bend inwards or even shatter the affected bones.	1 - Firearm injuries 2 - Surgical practices 3 - Antemortem traumatic injuries with scarring aspects, bone resorption and remodeling. 4 - Blunt injuries
Location of lesions	Identification of the structures where the lesions are located	Affected region, according to the distribution of the bones in the head.
Number of lesions found on each skull.	One or more lesions on the same skull.	1 - single lesion 2 - multiple lesions

The data relating to the study objectives was organized in a spreadsheet using Microsoft Office Excel 2013 software and then exported to the Statistical Package for the Social Sciences (SPSS) software, version 26.0, with double entry.

The data was analyzed in terms of absolute and relative frequency, as well as Chi Square statistical tests, adopting a 95% CI (p<0.05). The findings of the study were presented in table format.

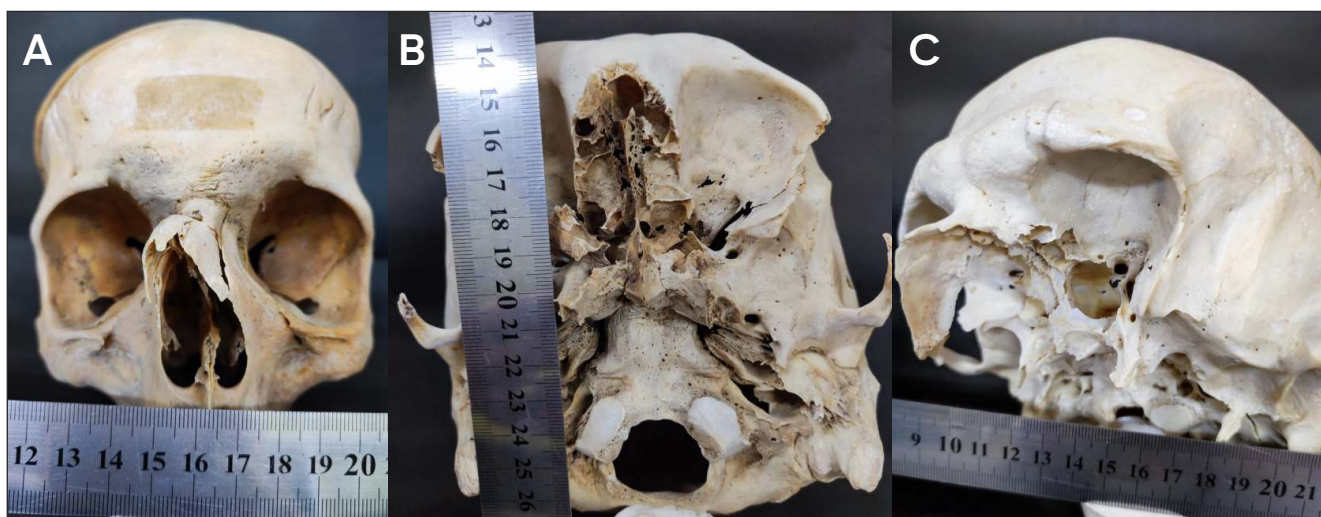


Figure 1: Classification of lesions according to period, nature, location and number of lesions. In A antemortem lesion with scarring aspects, in the nasal bone (Single lesion); In B perimortem lesion with blunt characteristics, located in the region of the maxilla, nasal and zygomatic bones (Multiple lesions); In C postmortem lesion with the property of a blunt lesion, located in the nasal, maxillary and zygomatic bones (Multiple lesions). SOURCE: Bones from the LHIFO / LAFO collection.



Figure 2 - Classification of lesions according to the nature of the injury. In A, firearm puncture wounds, located in the occipital bone. In B injuries from surgical practices (craniotomy). In C blunt injuries to the face (multiple injuries). SOURCE: Bones from the LHIFO / LAFO collection.

3. RESULTS.

With a total of 128 skulls investigated, it was possible to identify that 42.97% (N=55) were female and 57.03% (N=73)

were male. However, only 52 (40.63%) skulls had lesions, of which 25 (45.45%) were female and 27 (36.99%) male (Table 2).

Table 2: Distribution of the skulls analyzed according to gender, presence and absence of lesions.

Variables	Sex			
	Female		Male	
	FR	%	FR	%
Skulls Investigated*	55	42.97	73	57.03
Presence of lesions**	25	45.45	27	36.99
Absence of lesions***	30	54.55	46	63.01

*N = 128, **N = 52, ***N = 76, FR = Frequency

Regarding the period of the lesions, the findings showed that 20% (N=5) of the skulls with antemortem lesions were female and 37.4% (N=10) male. Perimortem lesions were 44.0%

(N=11) female and 37.4% (N=10) male, and postmortem lesions were 56.0% (N=14) female and 48.15% (N=13) male (Table 3).

Table 3: Distribution of lesions according to period and sex of the bones.

Variables	Injury Periods					
	Antemortem		Perimortem		Postmortem	
Sex	FR	%	FR	%	FR	%
Female	5	20.0	11	44.0	14	56.0
Male	10	37.4	10	37.4	13	48.15

Legend: FR = Frequency; With regard to the total N, some individuals, in both sexes, had lesions in more than one period.

With regard to the distribution according to the nature of the injuries, it was possible to identify that in the type of firearm perforation, 4% (N=1) were female and 4% (n=1) male, for antemortem traumatic injuries with scarring ATL aspects

12.0% (N=3) were female and 4.0% (N=1) male. Surgical injuries 0.0% (N=0) were female and 7.41% (N=2) male. In blunt injuries, 92.0% (N=23) were female and 81.4% (N=22) were male (Table 4)

Table 4: Distribution of injuries according to gender and nature of injury.

Variables	Sex			
	Female		Male	
Nature of Lesions	FR	%	FR	%
Perforation by firearm	1	4.0	1	4.0
Scarring	3	12.0	1	4.0
Surgical practices	0	0.0	2	7.41
Blunt	23	92.0	22	81.4

Legend: FR = Frequency

With regard to the location of the lesion on the bones of the skull, we found that 8.0% (N=2) of females and 14.81% (N=4) of males had lesions on the frontal bone, 16.0% (N=4) of females and 18.52% (N=5) of males on the temporal bone, 16.0% (N=4) of females and 14.81% (N=4) of males on the parietal bone,

12.0% (N=3) females and 3.7% (N=1) males in the occipital bone, 52.0% (N=13) females and 59.26% (N=16) males in the nasal bone, 40.0% (N=10) females and 33.33% (N=9) males in the zygomatic bone and 28.0% (N=7) females and 44.44% (N=12) males in the maxilla bone (table 5).

Table 5: Distribution of skull lesions according to sex and exact location of the bones where the lesions were observed.

Variables	Sex			
	Female		Male	
Location of injuries	FR	%	FR	%
Frontal	2	8.0	4	14.81
Temporal	4	16.0	5	18.52
Parietal	4	16.0	4	14.81
Occipital	3	12.0	1	3.70
Nasal	13	52.0	16	59.20
Zigomatic	10	40.0	9	33.30
Maxillary	7	28.0	12	44.40

Legend: FR = Frequency; Some individuals, in both sexes, had lesions in more than one location.

Finally, with regard to the number of lesions identified on the skulls, the study showed that 60.0% (N=15) of the female skulls and 55.56% (N=15) of the male skulls had a single lesion,

while 40.0% (N=10) of the female skulls and 44.44% (N=12) of the male skulls had multiple lesions (Table 6).

Table 6: Distribution of lesions according to gender and number of lesions found in each skull.

Variable	Sex			
	Female		Male	
Number of injuries	FR	%	FR	%
Single	15	60.0	15	55.56
Multiple	10	40.0	12	44.44

Legend: FR = Frequency

4. DISCUSSION.

According to[8], the methods applied by Forensic Anthropology seek to obtain answers to the key questions that arise in a forensic case: when, how and who. The answers to these questions will be answered jointly by professionals in the forensic field, and may provide information that reveals episodes that occurred during the individual's life, or even after their death.

The period in which the injuries occurred leaves unique characteristics in the bones. Based on the analyses carried out during this research, the antemortem injuries showed characteristics of an impact area, roundness and porosity near the fractured edges, in agreement with[9]. According to[5], these are characteristics resulting from bone activity, resorption and consolidation of the fracture. Detecting signs of an osteogenic response is proof that the damage occurred in the individual's lifetime[2]. According to[10] the basic attribute of antemortem injuries is the presence of an

osteogenic reaction which can be detected macroscopically, radiographically or histologically.

Perimortem injuries have different characteristics to antemortem injuries and are much more frequent in cranial bones than in any other bone, as this is a region with a higher degree of lethality than the others. The fractures were sharp and smooth, in agreement with[9]. The post-mortem lesions, on the other hand, showed chipped fractures and bone flaking, as well as a whitish color. According to the results of the analyses obtained in this study, post-mortem lesions were the most commonly found in both female and male skulls.

In addition to the time period, the nature of the injuries also influences the methods applied by Forensic Anthropology in the search for answers to a given case. The most prevalent perimortem injuries in the study were of the blunt type. Corroborating our findings,[11] states that the types of perimortem injuries most commonly reported in forensic anthropology examinations are those caused by firearms,

blunt trauma and sharp or incised injuries.

In two skulls from the collection, we observed the presence of an entry wound, which was the most prominent feature observed among the bones with ballistic injuries. The ballistic bones in this study showed a circumferential and radially branched fracture around the affected region. Several authors have associated ballistic injuries with the presence of a projectile, fractures associated with high-velocity impact, broken materials found inside bones or in the environment, and entry wounds that are most often smaller than exit wounds[12,13].

Nazaré[14], found a greater number of male individuals among the forensic context cases analyzed. In the present study, the number of individuals classified with the presence of any type of injury was higher among male bones than female bones. [15] provided data from an unprecedented analysis of hospital and medico-legal documentation from Coimbra and Lisbon, where it was found that there was a high prevalence of fractures in males compared to females. This reveals higher risk behaviors in men, particularly young adults, who are more exposed to accidents and interpersonal violence.

As the most exposed region of the human body, the cranio-maxillofacial region is the site most affected by violent trauma. In addition, the severity and mortality rate of these injuries depend on the instrument and the anatomical regions involved[16]. In agreement with the data presented, in another analysis obtained in this study, this time following the classification of the location of the injuries, the most affected skull bones were the nasal, zygomatic and maxilla bones, respectively, in both sexes. [17]detailed that blunt trauma was the most frequent type of injury observed during autopsies and the head was the most common location, especially in homicides, data similar to that observed in this study. The head also accounts for the majority of injuries resulting from accidental falls, some of which have several fracture lines, which can lead to other bones in the skull base and the ipsilateral orbit[18].

5. CONCLUSION.

The analysis of traumatic injuries to human skulls plays a decisive role in identification. The forensic anthropologist assists the pathologist in assessing the cause and circumstances of death in order to identify the individual. It is therefore essential for forensic anthropology to recognize the threefold distinction between injuries sustained before, during or after death. In this article, we learn a little about the language of fractures and their correct decoding, particularly

in the case of data from Brazilians, revealing the informative potential of documentary sources from identified and contemporary collections. Therefore, the more information that interprets injuries on human bones, the more experience, allowing a reliable and conscious reading of the language of fractures.

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7. CONFLICT OF INTEREST.

There are no known conflicts of interest associated with this publication and there was no significant financial support for this work that could have influenced its outcome.

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