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Cranial modification and trepanation in pre-Hispanic collections from Peru in the Museum of Anthropology and Ethnology, Florence, Italy

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Abstract. Artificial cranial modification (ACM) and trepanation are medical treatments with a long history in many human societies. Here, we present data on ACM and trepanation in pre-Hispanic Peruvian populations from the collections housed at the Museum of Anthropology and Ethnology, University of Florence, Italy. The Museum has a rich and important collection of medical-related specimens, including human remains and instruments. Altogether, we investigated the presence of ACM and trepanation in 370 skulls from Peru and associated medical tools. The majority of the osteological remains came from the Lima region and Cuzco. Among the 370 skulls analyzed, 285 skulls showed ACM. The distribution of these modifications was similar in all age classes; no differences between the sexes were found. However, we found differences in the type of ACM. The Lima samples showed the tabular type, while the Cuzco samples showed the annular type of ACM. Trepanation was found in 12 specimens, mainly from Cuzco. Trepanation was achieved using two methods: scraping and circular grooving. Sixteen instruments related to medical processes were described and studied from the ethnological collection. Chisels were found as funerary belongings, thus indicating the importance such tools had for these populations and the association between medical treatments and magical and religious rituals. This evidence confirmed the specialized knowledge and advanced medical practices that pre-Hispanic populations had because most individuals survived the trepanation events.

Key words: neurosurgery, South America, Inca, medical instruments, osteoarcheology

Introduction

Pre-Hispanic Peruvian populations are well known for their knowledge of medical techniques and treatments (1). Archeological evidence testifies that even early settlers of this region, such as the Paracas, practiced trepanation since 3000 BC (2). Various populations that inhabited this area over the millennia had advanced anatomical and pharmacological knowledge, as documented by the use of different plants rich in antiseptic components such as tannins, saponins, and cinnamic acid (3). Archeological evidence from the Inca empire shows an increase in trepanation frequencies (4, 5). Most trepanned specimens show healing and rarely become infected. Survival rates were higher than 80%, which indicates that these populations had specialized knowledge in these medical treatments and the pharmacological use of plants. By comparison, it is astonishing that in Europe in the 18th-century, trepanation fatality was almost 100% (6).

It has been hypothesized that reasons for trepanation might have been related to traumatic events, fractures, diseases of the cranium and scalp, cranial infections, epilepsy, headaches, mental disease, and even thaumaturgic rituals (3-5, 7). The surgical instruments used for operations were chisels made of copper, silver, gold, obsidian knives, the famous *Tumi* (a metal instrument with a crescent blade and a short

central T-shaped handle), bone elevators, dura protectors, tweezers, and suturing needles (3). Cotton bandages and hemostatic wool tourniquets were also used. Little is known regarding anesthesia, which may have been based on herbal preparations containing coca, datura, or yuca. It is highly probable that alcoholic beverages such as *chicha*, made from fermented corn, were given to patients in large amounts for their soporific effect (2, 3).

Another cultural practice of pre-Hispanic Peruvian populations was artificial cranial modification (ACM). This practice is well known and documented in Peruvian archeological samples (3). The two main types of vault shape modification were tabular and annular with different micro variants (8-12). Tabular modification employed rigid support acting mainly on the frontal bone and the occipital bone, which led to a flattening of the skull with a lateral expansion of the parietal bones. Annular modification probably employed bandages or caps covering the head, which acted on the circumference of the skull (9, 12). ACM is a permanent body modification probably associated with different ethnic and social groups. Head shaping could only occur in the first few years of life when the cranial bones were malleable. The decision to modify the head shape, which was made by a parent or close kin, required specialized knowledge to shape the child's skull in a specific form (10). Since head shape could not be changed later even if an individual wanted, ACM became a powerful, entrenched marker of group identity (5, 8, 10-13) and, importantly, required great attention from the specialist to reach the desired result. Intriguingly, previous studies on cranial modification in the Andes did not find differences based on the skeletal sex of the individuals (8, 10, 11, 13).

We report trepanations and ACM cases and medical instruments composition in the pre-Hispanic Peruvian collection housed in the Museum of Anthropology and Ethnology, University of Florence, Italy. Such evidence highlights the detailed medical knowledge in pre-Hispanic Peruvian populations. We aim to describe and quantify the composition of the collection in order to build a base for future studies on trepanation and ACM. Here, we provided an updated revision of the material housed in the osteological and ethnological collection for the first time.

Materials and Methods:

A total of 370 skulls and calvaria housed in the Museum of Anthropology and Ethnology of Florence were studied. The specimens belonged to the Peruvian collection and were collected by different scientists and explorers during the end of the XIX and beginning and XX centuries. The specimens came from different places (Tab. 1). This collection was primarily contributed to the Museum by Ernesto Mazzei (1843- 1905), a medical doctor and professor. Between 1875 and 1884, Mazzei lived in South America and collected a large sample of osteological and ethnological specimens from pre-Hispanic Peruvian sites (14-16). The pre-Hispanic Peruvian collection housed in Florence is also composed of smaller donations and acquisitions from the end of the XIX and the beginning of the XX century. Unfortunately, the provenience and age of specimens are not always well documented. While the cultural material can often be connected to a specific culture through stylistic, contextual, and iconographic associations (*i.e.,* the Chimù culture), the osteological samples often lack specific chronological information for the period and culture they belonged to. This is a common problem for 19th-century European scientific collections.

However, we know that most specimens come from a pre-Hispanic chronological framework. This is true for most of the Lima specimens. This regional group comprised many specimens collected from the Ancon necropolis. Ancon necropolis was occupied sometimes around the Middle Horizon (600-1000 AD) until the Late Horizon (1450 AD- 1540 ca. AD) (17). Specimens from Ancon are 210 on 275 specimens grouped from the Lima region. Another 34 specimens from Lima were collected from *Huacas* in Lima; we lack more precise information regarding which *Huaca* but such places were built and used by pre-Hispanic cultures (18). The specimens from Cuzco, rich in annular cranial modification, could also date to the Middle Horizon or the Late Horizon, when this kind of ACM was more common (8). As for the other collections, we have no indication of their exact chronology except the presence of ACM, a practice that disappeared after European colonization. Future analysis involving direct dating of the specimens could resolve this issue.

Table 1. Geographic distribution of the specimens housed in the Florence osteological collection.

Geographic Location	N of individuals
Lima region	275
Cuzco region	48
Tacna	3
Cajamarca	1
Titicaca Lake	2
Unknown	41
Total	370

We then investigated the presence of medical instruments in the ethnological collection. We selected a total of 16 specimens from the historical catalog. Historical and ethnological studies on these specimens were carried out to associate them with specific chronological and cultural periods (14-16, 19, 20). We also compared the Florentine collection with the information from the online catalog of the British Museum and the Metropolitan Museum. Following these analyses, a brief description of the use and manufacturing of these tools was made.

This research grew out of investigations into the composition of the Museum's collections. Sex assessment and age estimation followed standard methods used for other Museum osteological collections. Sex was assessed by cranial features of the specimen (21), while age was estimated by dental eruption (22), dental wear (23), and suture closure (24). The sample was divided into the six age classes traditionally used at the Museum for the osteological collections: I infancy (0-7 years old), II infancy (up to 14 years old), adolescence (up to 18 years old), adult (up to 40 years old), mature (up to 60 years old), senile (above 60 years old).

For each specimen, we recorded the presence or absence of Artificial Cranial Modification (ACM) following the standards of Torres-Rouff (10, 11). The two main types of ACM were visually categorized as tabular (presence of parietal expansion) or annular (circumferential elongation) "Since vault modification relies on the visibility of the deformation as a social signifier." (10). It is essential to correctly identify ACM since other pathological conditions might mimic this morphology, such as micro-, macro-, and hydrocephaly, osteomalacia, and craniostenosis. However, as mentioned by Torres-Rouff (12), it is hard to confuse ACM with other pathological conditions. In any case, our sample did not present any of the other characteristics linked to such pathologies (i.e., disproportion of the neurocranium, low weight, unexpected and/or asymmetrical suture closure pattern) (12). All micro variants associated with varied angles, pressure, number of pads used, their positioning within the sample were documented in the laboratory following Pardini (25). However, comparison, frequency, and statistical analyses were only completed on the main types' frequencies because this study addresses questions regarding the overall composition of modified skulls in the collection. Moreover, in contrast to micro variants, which were more variable and changed frequently, the main types (tabular and annular) were practiced in a region for a longer time (8).

We also investigated the presence or absence of trepanation in the entire sample of 370 specimens. The side, size, bone location, number of trepanation events, and evidence of healing and bone remodeling for each individual were recorded. We grouped the trepanation types as in previous publications according to the different techniques used: scraping, circular grooving, drilling and cutting, linear cutting (3, 5, 26). As per ACM, trepanation can also be confused with other pathological conditions such as congenital and developmental anomalies, trauma, infection, neoplasm, and taphonomic damage (26). When bone shows evidence of trepanation, such as cut marks or scrape marks, it is easier to identify and correctly address trepanation techniques. However, healed cranial defects are challenging to interpret. In these cases, the causative mechanism may be obscured by bone remodeling. However, position, presence or absence of radial or concentric fractures, evidence of taphonomic damages are all factors that need to be considered to increase our confidence in identifying trepanation. Verano (26) noted that this is particularly problematic when describing trepanation cases in a population where trepanation was not previously reported. In our case, the collection studied is derived from populations well known for their neurosurgical ability and, therefore, we are confident that bone loss found in the sample most of the time is related to trepanation events.

Statistical analysis

We investigated the frequencies of ACM events. As mentioned above, all analyses were conducted grouping ACM in two main types of bone modification: annular and tabular. We tested whether different age classes showed different ACM frequencies across the complete sample by performing a chi-square test on the frequencies of modified and unmodified specimens in each age class. Then we focused on two subgroups based on geographical origin: the first and more abundant group comes from the Lima region and comprises the vast collection from the Ancon necropolis; the second group comprises specimens from the Cuzco region. Focusing on these two subgroups, we compared similarities and differences in frequencies of modification, sex distribution. We performed a chi-square test to evaluate the sex distribution in ACM (27). Another chi-square test was performed to evaluate the difference in the type of modification. When contingency tables had cells with less than 5 cases, we calculated the p-value using a Monte Carlo simulation (28) with 2000 replicates. Analyses were performed in the R environment (29). As shown in table 1, these two groups (Lima, Cuzco) together represent most of the collection.

Results

ACM in the Museum collection

The majority of the skulls and calvaria present in the collection were modified. Considering both types of ACM modification, there were a total of 285 modified skulls (77.0% of the total sample N = 370).

The modification frequency in each age class ranged between 71.4 and 89.5% of modified crania for each age group (Fig. 1). Specifically: I infancy group 34 out of 45 were modified, II infancy 10 out of 14, adolescence 17 out of 19, adult 168 out of 211, mature 44 out of 57, senile 12 out of 15. No statistical difference among age classes was found (chi-square test p = 0.828). Cranial modifications were present with a similar frequency in both geographical regions (Lima and Cuzco). The modified crania from Lima were 77.0% of the total specimens investigated (212 modified skulls on 275 total specimens); in Cuzco, this percentage increased to 91.7% (44 modified on 48 total specimens). The dominant type of modification at the two sites was highly different. Almost all the modified specimens from Lima exhibited tabular modification (96.7%, 205/212), while most of the specimens from Cuzco were modified using the annular technique (97.5%,

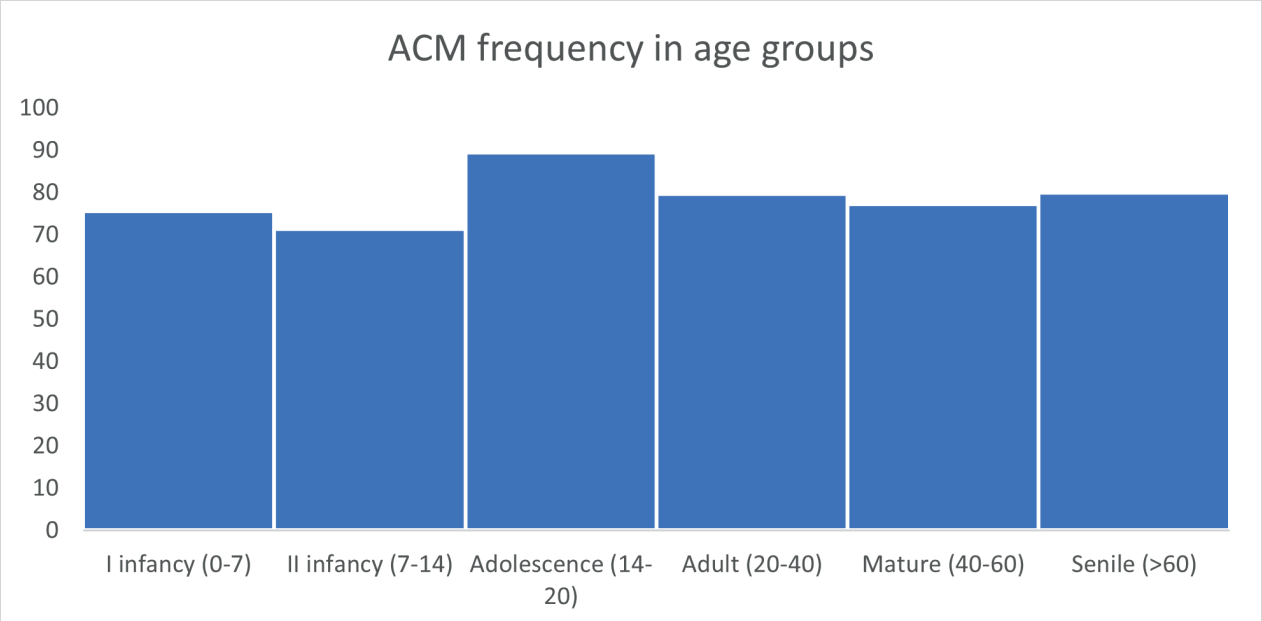

Figure 1. Histogram of the frequency of cranial modification in each age group.

42/44); the chi-square test confirms that the two distributions are different (p-value = 0.002) (Fig. 2).

Among the whole sample of skulls, sex distribution was as follows: from Lima, 165 belonged to males, 79 to females, and 31 to undetermined sex; from Cuzco: 16 to males, 21 to females, and 11 were undetermined. When considering the modified skulls from Lima: 127 specimens were sexed as males, 65 as females, and 20 as unknown; in Cuzco: 16 specimens were assigned to male, 17 to female, and 11 to unknown specimens. The modified skulls were relatively abundant in each sex group in each geographical region. In Cuzco, modified males were 16 out of 16, females 17/21; from Lima, modified males were 127/165, females 65/79. In Figure 3 (Fig. 3) the frequency for each group is shown. No statistical differences were found between males and females frequencies in the two regions (chi-square test, $p > 0.05$).

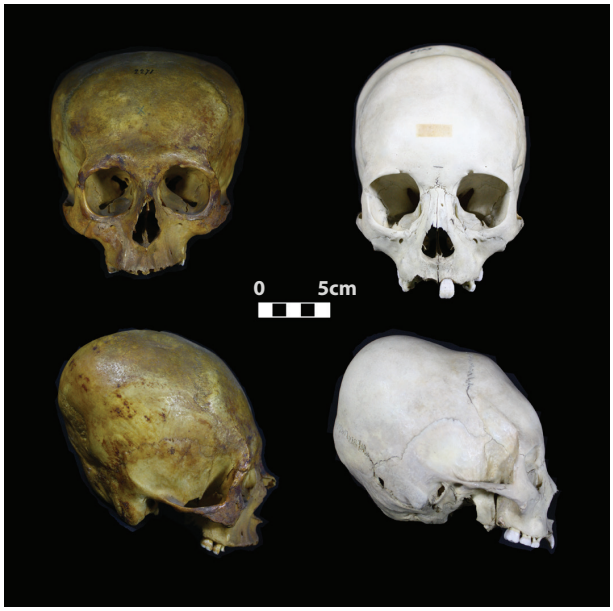

Figure 2. Types of cranial modification. Left tabular type (Cat. N. 2271), right annular type (Cat. N. 6153).

Trepanation cases in the Museum collection

Trepanation was observed in 12 specimens (Tab. 2): one from Lima (1/275), nine from Cuzco (9/48), and two of unknown origin (2/41). All individuals fell in the adult age class. Among the 12 specimens with trepanation, five were females and five males (for the remaining two specimens, sex could not be assessed); the low numbers do not allow statistically testing the difference. Only two types of trepanation were observed: circular grooving and scraping. Circular grooving was observed only in four individuals from Cuzco. The scraping technique was observed in eight individuals. In 10 individuals, we observed bone remodeling, indicating that the majority of the individuals survived the trepanation act.

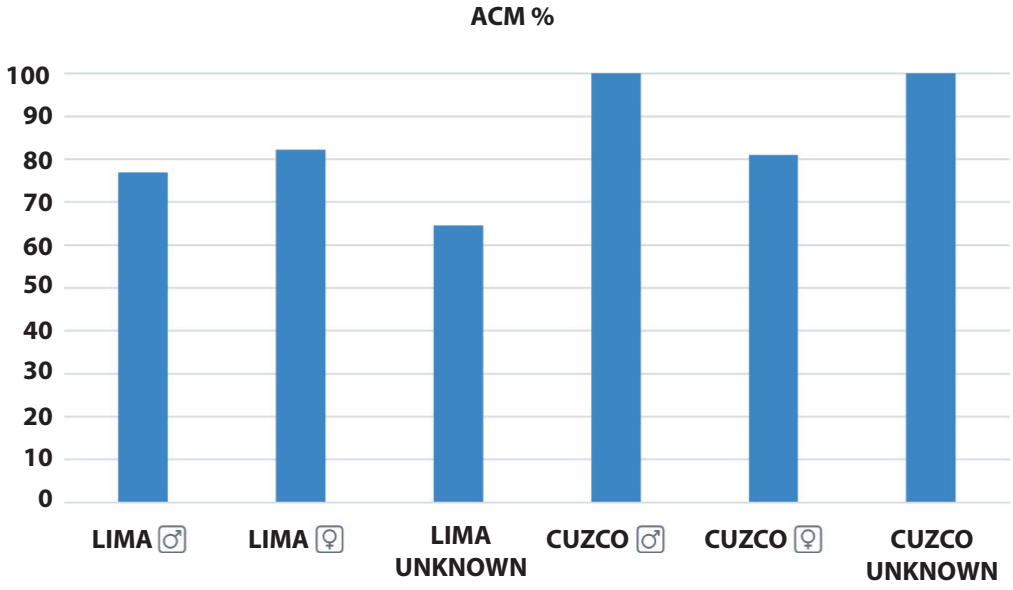

Figure 3. ACM frequency by sex in Lima and Cuzco regions.

Table 2. Type of trepanation compared among regions and sexes.

	Lima (1/275)				Cuzco (N tot. 9/48)				Unknown (N tot. 2/41)			
Type of trepanation	M	F	ind	Tot	M	F	ind	Tot	M	F	ind	Tot
Circular	-	-	-	0	1	3	2	6	-	-	-	0
Scraping	-	1	-	1	2	1	-	3	2	-	-	2

Trepanation was recorded only on parietal bones and the frontal bone. Since there was always some lateralization, we report here on which side they were found. Six specimens were trepanned on the left side of the neurocranium, four individuals on the right, and two specimens on both sides. The 12 trepanned specimens were often modified: ten individuals exhibited annular ACM while no tabular modification was found.

The ethnological material

Table 3 (Tab. 3) shows the instruments present in the collection linked to medical applications and their cultural and chronological framework. Most of the specimens were associated with the Chimù culture (8/16), and the more abundant type of instruments were tweezers. We also found evidence of needles, chisels, knives, and one Tumi in the collection. The instruments date mainly around the 12th and 16th centuries AD, and they belonged to the Tiahuanaco, Chimù, and Inca cultures (Fig. 4). A brief description of the different instruments follows.

Tweezers: Most of the specimens housed in the Florence collection were made of copper or bronze, while two of them (n 3597 and N 3689) were made of an alloy of copper and silver, and pure silver.

Needle: Specimen n 1081 is a bronze needle. The ethnological analysis assigns it to the Inca culture.

Chisels: There were two bronze chisels associated with grave goods.

Ritual Knives: These instruments are not considered weapons, but they were probably used as ritual tools and/or surgical instruments. Probably they belonged to the Tiahuanaco culture, and N 3604 is of particular interest; Prof. Giuseppe Orefici (Director of the *Centro de Estudio Arquelogicos Precolombinos* and the head of the *Proyecto Nasca*) through a recent comparison with other similar tools, identified it as a sacrificial knife linked to the Inca culture (personal communication).

Table 3. Medical instruments from the ethnological collection.

Cat. N.	Type	Cultural attribution	Chronology
831	Ritual Knife	Tiahuanaco	VII-X d.C.
1081	Needle	Inca	XV-XVI d.C.
3590	Chisel	Late intermediate period	XI-XVI d.C.
3595	Tweezers	Chimù	XII-XV d.C.
3596	Tweezers	Chimù	XII-XV d.C.
3597	Tweezers	Chimù	XII-XV d.C.
3598	Tweezers	Chimù	XII-XV d.C.
3599	Tweezers	Chimù	XII-XV d.C.
3600	Tweezers	Late intermediate period	XI-XVI d.C.
3602	Chisel	Late intermediate period	XI-XVI d.C.
3604	Ritual Knife	Inca	XV-XVI d.C.
3615	Ritual Knife	Tihauanaco	VII-X d.C.
3623	Tweezers	Chimù	XII-XV d.C.
3689	Tweezers	Chimù	XII-XV d.C.
6047	Tweezers	Late intermediate period	XI-XVI d.C.
6048	Tumi	Chimù	XII-XIV d.C.

Tumi. This crescent moon-shaped knife is characteristic of many Peruvian cultures. The one present in the collection (N. 6048) is a simple bronze *Tumi*. Given its style, we consider it evidence of the Chimù culture (2,19).

Discussion and Conclusion

ACM is a well-known practice that was performed by South American populations (8-13). A careful and prolonged activity performed by either parents or

Figure 4. Some of the surgical instruments in the ethnographic collection: the chisel n. 3590, the ritual knife n. 3604, the tweezer n. 3597 (copper and silver alloy) and the needle n. 1081. All these instruments belong to the Mazzei collection (photos S. Bambi).

specialized professionals was needed to achieve these results. The modification process must have begun immediately after birth since cranial sutures are still open at this ontogenetic stage, and the bone could be easily modified. The extreme modification could have been achieved only when the deformative process began in the first years of life. For instance, specimen N 3037 (Fig. 5) is an infant with an estimated age of around 6 to 12 months that already shows a completely modified neurocranium.

To not compress the neurocranium dangerously, the deformative tools (bandages, rigid supports) needed to be changed accordingly to the brain growth that occurs mainly during the first six years of life (30). All this care and attention means that the Peruvian pre-Hispanic populations had good knowledge concerning the processes of bone growth and skeletal maturation. Our results show no differences among the age classes in ACM frequency; this supports the idea that ACM does not increase mortality in any particular age class.

In Eurasia and Africa, other populations have practiced cranial modification (31); however, this was common in pre-Hispanic Meso and South America (12, 13, 32). Our results show that most of the skulls collected were modified (77% of the 370 specimens are

Figure 5. Specimen N. 3037 (lateral view) with visible annular modification. The neurocranium is elongated anteroposteriorly. The facial skeleton is missing.

modified). However, we should consider the possibility that this percentage was the result of a collector bias. The Florentine collection was put together between

the 19th and 20th centuries by scientists and explorers who probably selected the most interesting and unusual specimens. Unfortunately, we do not have precise information about collection methods and criteria. We also lack a precise chronology of the individuals, and we can only define a broad chronology based on the ethnological remains present in the museum and catalog information regarding the localities where the osteological material was collected. On the other hand, the high number of specimens housed in the collection may well mitigate collection bias. Indeed, our results probably reflect and support a relatively high frequency of cranial modifications. In Cuzco, however, given the limited number of specimens - 48, the high frequency of modified skulls (91%) probably was related to this source of bias to the extent that there could be an over-representation of modified skulls.

The two main geographical groups were similar in ACM frequency; the only difference documented was the dominant type of modification. In the Lima region, we observed a dominant tabular ACM; in the Cuzco region, the picture was the opposite, and the annular ACM was dominant. This difference was probably related to cultural and population aspects (8, 11). It should be noted that the two ACMs were not achieved in the same way. The main difference was in the tools used. The tabular ACM needed rigid support that applied pressure both in the frontal area and the occipital region; the annular ACM instead used bandages (1, 9). The tabular type was probably more challenging to perform because sometimes the tools could have applied an asymmetrical pressure resulting in an asymmetric cranial shape. For this reason, the operator who placed the rigid plates needed to be careful to guarantee the desired result. On the other hand, the annular modification exploited the natural physics of a deformable tool that applied the same pressure to each point of the head when placed in the correct position. These skulls were symmetrically modified, and this technique had a lower chance of an asymmetrical shape. For this reason, it seems that a tabular modification needed more highly specialized practitioners.

When considering differences in frequencies between sexes in Lima and Cuzco samples, our results did not show any statistically significant difference between males and females. These results were consistent with previous research on archeological materials, which showed no differences between males and females in ACM frequencies (8, 12).

As far as trepanation, this was mainly documented by specimens from Cuzco in our sample. The sample was composed of different types of trepanation. The circular grooving (Fig. 6) showed cut marks on the bone with clear incisions.

Generally, this kind of trepanation had a shape of the holes that were often more regular, almost circular, than holes resulting from the scraping method. Given the more circular shape of the holes and their position aligned along the sagittal suture in number 3084, it is probable that these interventions were planned and they tried to solve a pathological condition. A previous analysis that investigated these specimens using medical radiography (33) showed that skulls with a circular grooving type of trepanation (e.g., specimen number 3084) also had high vascularization of the diploe, probably associated with migraines or other pathological conditions (34). Specimen 3084 did not show extended bone remodeling, thus, this individual probably died immediately after the intervention.

Despite the reason and cause of the cranial defect, the final result in almost all cases found in the collection showed bone remodeling and no signs of infections. Bone remodeling could be a problem for the correct assessment of trepanation cases. Since the remodeling removes evidence of cutmarks or other signs left by the instruments responsible for the trepanation, it is possible to confound trepanation events with traumas (26). Eight individuals showed completely healed cranial defects that are most likely trepanation by scraping and circular grooving. These individuals showed smooth-edged holes surrounded by a larger area of remodeled bone. A possible differential diagnosis would be a healed trauma with loss of broken fragments in the center of the wound, but there are no radial or concentric fractures. Also, the location of the holes are not sites where one might expect ossification or developmental defects to occur. The only clear evidence is that these individuals survived with a healed defect in the skull for an extended period. The most probable diagnosis for such cranial defect is trepanation for these individuals. Moreover, in our case, individuals lived in societies where

trepanation interventions were widespread; therefore, despite the possible traumatic origin, traumas were probably treated, cleaned, and healed using trepanation methods. The high survivorship of trepanned individuals, as shown by the presence of bone remodeling (8/12: eight individuals with completely healed defects, two with partial evidence of bone reaction, and two with no signs of bone reactions), suggests that the medical knowledge required to maintain a person alive with such a missing portion of the vault must have been remarkable.

Our results suggest that the population from Cuzco performed neurosurgical intervention more often compared to the population from the Lima region, in agreement with other reports (2, 3, 5, 7, 35). Together with the difference in the ACM types described above, this difference suggests cultural and probably ethnic differences between the two groups. The higher prevalence of trepanations in the Cuzco sample could be related to different causal factors - not mutually exclusive. One of these could be related to warfare since the Inca Empire expanded in a relatively short timeframe, and this expansion was accompanied by many wars and battles (1, 3-5, 36). The high occurrence of trepanation events could be related to an increased frequency of cranial traumas probably treated through trepanation and cleaning of the wounds. The surgeons became experts in treating these traumas via trepanation, which is also evident by the high survival rate they accomplished. This hypothesis is also supported by the position and side of the cranial defect, which in this sample are located on the cranial vault (frontal and parietal bones). This hypothesis agrees with the results of the analysis of the archeological sample excavated in Cuzco (4). Further, more profound knowledge of neurosurgical techniques might have allowed this kind of intervention to be carried out more frequently than in other populations.

Figure 6. Specimen 3084 (posterior view) with circular grooving trepanation. In detail, it is visible the trepanation close to the osteometric point Bregma. This trepanation did not completely remove the inner table of the diploe, and cut-marks are visible on the margins.

An interesting case among the trepanned skulls was the individual N 3072 (Fig. 7). This individual is an adult of unknown sex, and it shows three cranial defects. The first (on the frontal bone) was irregular in shape and probably of traumatic origin (see below); in this case, trepanation was probably performed with a scraping technique. The other two were almost circular and symmetrical trepanations on the opposite sides of the sagittal suture. Avoiding the sagittal suture suggests that the practitioner knew that intervention in this region could have damaged the superior sagittal sinus, causing the patient's death. The radiography of this specimen showed a high vascularization of the diploe (33), probably associated with inflammatory diseases. We can speculate about the clinical history of this individual: first, it suffered trauma on the forehead, which caused the first damage to the frontal bone healed using scraping technique. Later, the outcome of the trauma caused inflammation with probably a higher vascularization of the outer table of the frontal bone (37) and probably other disorders linked to the evidence found in the radiography of such specimen (33). Such conditions could have led the practitioner to perform the other two neurosurgeries. Further analysis would be necessary to test this hypothesis, but it looks like two different reasons for the trepanations required the choice of two different techniques. Moreover, the frontal trepanation show advanced bone remodeling, while the two on the parietal bones did not show extended remodeling. This evidence confirms the different timing of the two interventions and the survivorship to the first one but probably not to the second one. Our final hypothesis is that the first trepanation was to heal and cure trauma (the frontal bone defect) and the second to cure other diseases, such as headache, epilepsy, or others, as indicated by the symmetrical and precise location of the trepanations that seems to suggest planning of the intervention.

The instruments housed in the collection had different uses. Tweezers, for example, were used as a

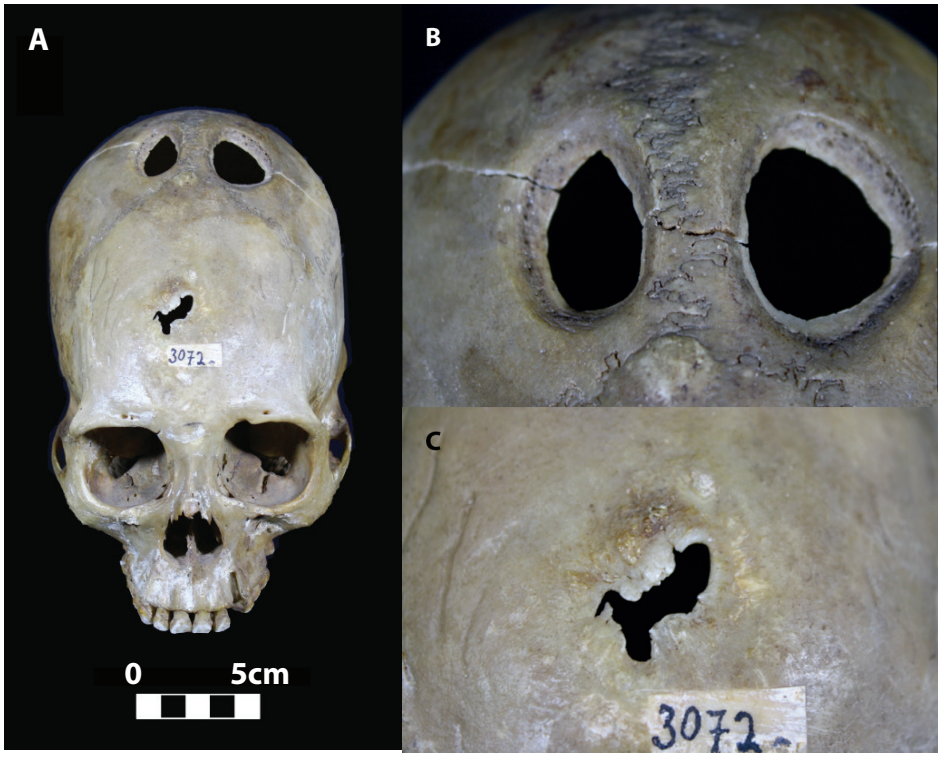

Figure 7. Specimen N 3072 (superior view) showing the three cranial defects. In detail, the different trepanation events. The upper detail shows the two trepanation on the side of the sagittal suture with little evidence of bone remodeling. The lower detail shows the frontal trepanation with a more advanced bone remodeling.

personal tool, and they were widespread in the Andean community. Often they were related to personal hygiene to remove body hair. However, they were most probably used in surgical practices to remove small fragments of residues such as bone fragments. The more precious ones (i.e., the ones made in silver) probably belonged to a member of the social elite (19). Needles were probably used to suture wounds. Chisels and the *Tumi* were helpful in surgical operations, probably capable of penetrating the bone (1, 2). The presence of chisels in the funerary belongings of a dead person is of particular interest. These instruments were not only characteristic of specialists but also had an esoteric meaning and relevance. These tools were considered of such importance that they were included in the funerary belongings. This is another piece of evidence that linked the medical treatment with magical and religious rituals in the Peruvian pre-Hispanic populations (1).

The rich pre-Hispanic collections of the Museum of Anthropology and Ethnology in Florence offer the unique opportunity to combine the study of both human remains, in the form of modified and trepanned skulls, and the medical instruments used in these practices. Their study confirms the rich and advanced pre-Hispanic Peru's cultures, with sophisticated medical techniques and deep anatomical and pharmacological knowledge. Our results confirm previous observations of a high frequency of trepanation cases in the Cuzco region and add to our knowledge of the more common cranial modification types in the areas of Lima and Cuzco.

The collection contains many cases of medical interest: the present work has highlighted the occurrence of only two cultural aspects of the pre-Hispanic Peruvian population linked to medical knowledge. More can be done in the future by analyzing paleopathological cases to address other interesting aspects, such as dental treatments in ancient Peru. In this context, our work can put the basis for more detailed analyses on the trepanation and ACM cases. In the future, we aim to have more detailed analyses with the help of more advanced technologies such as computed tomography to deepen our knowledge of trepanation cases and ACM. The study of historical collections is essential for the documentation of ancient cultures and for reporting new cases, which may give us new information regarding past human behavior. Such collections are often understudied and we hope that our research will stimulate future work to address these populations' important cultural and biological aspects.

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