

# Cranioplasty in Ancient Peru: A Critical Review of the Evidence, and a Unique Case from the Cuzco Area

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**ABSTRACT** Cranioplasty is a well-known procedure in modern neurosurgery. Although some authors have claimed it was also performed by prehistoric trepanners in various parts of the world, there is little hard evidence to support this. Here we review various claims of cranioplasty in Peru, where trepanation was widely practised in Prehispanic times. We find little support for assertions that cranioplasty was common. One recently discovered burial from the Cuzco region, however, provides the first documented case of the reinsertion of a bone plug into a trepanation opening. Copyright © 2008 John Wiley & Sons, Ltd.

*Key words:* trepanation; cranioplasty; Peru

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## Introduction

Cranioplasty, the repair of a skull vault defect by insertion of some object (bone or non-biological materials such as metal or plastic plates), is a well-known procedure in modern neurosurgery. Motivations for the practice include protection of the exposed brain and cosmetic restoration of normal vault contour (Reeves, 1950; Stula, 1984; Moreira-Gonzalez *et al.*, 2003). In Western medicine, the earliest documented attempts at cranioplasty date to the early to mid-16th century (Sanan & Haines, 1997; Aciduman & Belen, 2007), but it was not until the 19th century that substantial experimentation with human and animal subjects was done (Reeves, 1950; Courville, 1959).

Was cranioplasty practised by ancient trepanners? Some authors have claimed that it was

common in certain geographical areas and time periods, citing anecdotal accounts of the use of gourd, shell, or metal plates by traditional trepanners of the South Pacific and Andean South America (Ford, 1937; Hrdlička, 1939; Rytel, 1962; Asenjo, 1963; Sanan & Haines, 1997). Others are more cautious, finding surprisingly few examples of attempts at repairing skull defects, even in areas where trepanation was commonly practised (Courville, 1959). Unfortunately, anecdotal accounts and secondary sources continue to be accepted uncritically (Carod-Artal & Vázquez-Cabrera, 2004; Aciduman & Belen, 2007), resulting in an aura of truth.

## Trepanation and rondelles

In the 19th century, the discovery at Neolithic sites in France of trepanned crania associated with rondelles (in some cases found within the cranial cavity itself) led to early debates about whether these bone disks had been replaced in trepan

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holes to protect the brain following surgery (Broca, 1877; Lucas-Championnière, 1912; Ruffer, 1918–19). While Broca believed that one example of a trepanned cranium with an associated rondelle found by Prunières at Lozère was convincing, others disagreed.

The Crichel Down skull from Dorset (UK) appears to be the only unequivocal case where a rondelle was cut from a cranium and then replaced in its original position. Piggott (1940), who excavated and described the skeleton, hypothesised that the bone disk was replaced before burial and fixed in place with a bandage or some other device. The margins of the trepanation showed no evidence of bony reaction, however, indicating that the patient had not survived.

## Cranioplasty in ancient Peru

This paper examines the specific question of whether cranioplasty was a widespread practice in ancient Peru, as has been claimed by some authors (Hrdlička, 1939; Rytel, 1962; Asenjo, 1963; Sanan & Haines, 1997). Peru is a good test case for such a review, since it is distinguished by having the largest number of prehistoric trepanned skulls of any region of the world, with a time depth for the practice of over two millennia (Stewart, 1958; Verano, 2003). If cranioplasty were a common practice, or even an occasional experiment, one would expect to find physical evidence to confirm this.

Here we review all relevant examples of: (1) museum specimens; (2) published accounts from the late 19th and early 20th centuries; and (3) modern ethnographic reports, for evidence of cranioplasty in Peru. We find little evidence to support the practice – even published photographs of skulls with purported cranioplasties are unconvincing. Finally, we present a case study of a recently discovered cranium from the Inca site of Kanamarca (department of Cuzco, Peru), with a trepanation in which the plate of bone removed during the procedure was replaced in its original location.

### *Bony evidence*

Searching for convincing evidence of cranioplasties in ancient Peruvian skulls is admittedly a

difficult task. Most trepanned crania were collected in the late 19th and early 20th centuries from communal tombs or burial caves where skeletal remains were commingled and disturbed by artefact collectors and other taphonomic agents. These specimens exist in museums today as isolated crania with few or no grave associations and little contextual information. It is possible that objects such as shell or metal plates, originally associated with these skulls, were lost. Cranioplasties made from organic materials, such as gourd, would probably decompose in most burial contexts and thus would not be detectable. Portions of cranial vault bone, if they were replaced in trepan openings, might have become separated from crania and lost.

The archaeologist Julio C. Tello, who collected hundreds of trepanned skulls from highland Peruvian burial caves in the early 20th century (Tello, 1913), claimed to have found cranial amulets in the Huarochirí region of central highland Peru, which he believed to have come originally from trepanned skulls. Unfortunately, Tello never described or published these, and the palaeopathologist Pedro Weiss, who later inquired about them, reported that 'unfortunately, they have been lost' (Weiss, 1958: 561). The specific contexts in which these 'amulets' were found were not described by Weiss, but it appears that they were isolated items found in graves, and not in direct association with trepanned skulls.

Mummified bodies with trepanation openings retaining scar tissue or remains of the scalp might provide the best opportunity for identifying cranioplasty, if it were indeed practised. Unfortunately, relatively few mummies with trepanations exist in museum collections. The Peruvian anthropologist Sergio Quevedo, motivated by colleagues and explorers who claimed to have seen mummies with trepan openings covered with pieces of gourd, performed dissections of several well-preserved Cuzco area mummies in which healed trepanations were still covered by intact tissue. In fact, his dissections did not reveal evidence of any foreign body inserted into the bony defects (Quevedo, 1943). Our examination of other trepanned mummies in Peruvian and US museums likewise has not uncovered evidence of any objects covering or inserted into trepanation openings.

## **Published descriptions of cranioplasties in Andean trepanned crania**

### *Initial account*

The earliest description of a possible cranioplasty in an ancient Peruvian skull appears to be that of W.J. McGee, who studied a collection of 19 trepanned skulls brought to the US in 1893 by Manuel Antonio Muñiz, Surgeon General of the Peruvian Army (McGee, 1894; Muñiz & McGee, 1897). In his description of the collection, McGee singled out one of the trepanned skulls as unusual, because reportedly it had been found with a plate covering a trepanned opening:

'The specimen is of interest also in that it was the only one in which a plate is known to have been used, a silver plate having been found in place over the aperture in the mummy [exhibit] case. The presence of the plate, its seat in the skull showing long wear, and the absorption and reparative growth, all indicate that the operation was survived.' (McGee, 1894: 3)

For some reason, this plate did not accompany the cranium to the US, and McGee never observed it personally. Curiously, in a monograph published three years later (Muñiz & McGee, 1897) it is described not as a silver plate, but as 'a plate of shell'. Whatever its composition, it was reported to have been destroyed along with the rest of Muñiz's archaeological collections when his home in Lima was sacked and burned during a political uprising (Muñiz & McGee, 1897: 54). While the 'plate' has been lost, and thus cannot be examined, the cranium to which it belonged was donated to the National Museum of Natural History, Smithsonian Institution. The first author has had the opportunity to examine it to evaluate whether there is evidence, as McGee claimed, of 'long wear' indicating extended contact between the 'plate' and the margins of the trepanation.

Examination of the cranium, in fact, does not support McGee's description. The margins of the trepanation show fresh scrape marks, with exposure of the diploë and no evidence of remodelling of the cut edges (Figures 1 and 2).

The anterior margin of the defect shows ragged edges marking the location of a perimortem depressed fracture, with a radiating fracture line extending inferiorly to the margin of the right orbit and extending along the orbital roof. Separation of the right coronal suture and a portion of the sagittal suture, and a radiating fracture extending across the left parietal, indicate the severity of the blow to the head. Apparently the trepanation was done in an attempt to treat the head injury. Like the trepanation margins, the fracture edges show no osteoclastic or osteoblastic activity, suggesting death during or relatively soon after the trepanation procedure.

### *Other accounts of cranioplasties*

Following McGee's early report, other authors would assert that cranioplasties had been found in Peruvian trepanned skulls. In a 1939 review of ancient skull surgery, Aleš Hrdlička claimed that in the case of large trepanation openings:

'Andean primitive surgeons used various objects for "stoppers". In some cases these consisted of a gourd, or perhaps a bone; in others they used portions of shell; and in still others, though these were rare, they used beaten silver (The writer heard of three such cases in Peru.) These stoppers were evidently effective, for the several skulls in the US National Museum collection which indicate their use show that the subject survived the operation for a sufficient length of time to permit more or less cicatrisation.' (Hrdlička, 1939: 174–5)

Unfortunately, he did not illustrate or describe these specimens. One of them probably was the Muñiz skull, which was then in the US National Museum collection, and was certainly familiar to Hrdlička.

In subsequent years, other authors would follow Hrdlička in suggesting that cranioplasty was a common procedure in ancient Peru. Asenjo, in a brief review of prehistoric trepanning in Peru, claimed that 'Plates made from gourds, coconuts, silver, or gold were common and have been found in many trephined skulls' (Asenjo, 1963: 23). In



Figure 1. Trepanned cranium from Huarochirí Province, central highland Peru, from the Muñiz Collection (NMNH 178486), oblique view. This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).

support of this, he included a photograph of a skull in the collection of the Instituto de Neurocirugía, Santiago, Chile, that has a small healed defect in the midsagittal plane, into which 'A considerable time after the operation the ancient Peruvians inserted a plate to fill the defect'. In a more recent publication this 'plate' is described as a 'nut shell' (Sanan & Haines, 1997: 590). The cranium, which apparently has no specific provenance or dating, is the only example of its kind, and its authenticity is difficult to confirm.

Another problematic skull is in the collections of the Mujica Gallo Gold Museum in Lima, Peru (Coutts, 1990). Reportedly from the archaeological site of Paracas, it has a rectangular

trepanation filled with gold. Its authenticity is dubious, since rectangular trepanations are not known from Paracas, and the specimen comes from a private collection containing many objects whose provenance and authenticity are in question (Gutierrez, 2008).

Among the many claims of trepanation openings covered with metal plates, there is perhaps only one case with firm archaeological context: a mummy excavated by Julio C. Tello in 1928 in a cemetery on the Paracas Peninsula in southern Peru. Beginning in 1925, Tello excavated hundreds of mummies from a series of cemeteries on the Paracas Peninsula, just south of the modern city of Pisco (Tello & Mejía Xesspe, 1979). In a partially looted cemetery on Cerro



Figure 2. Trepanned cranium from Huarochirí Province, central highland Peru, from the Muñiz Collection (NMNH 178486), superior view. This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).

Colorado, Tello found dozens of skulls with trepanations littering the surface. Fortunately, not all tombs were looted, and Tello managed to find some trepanned individuals in undisturbed contexts. He discovered additional cases in a large cemetery, the Necropolis of Wari Kayan, during the 1927–8 field season. One mummy from this cemetery (Mummy 451), which is on exhibition in Peru's National Museum of Anthropology, Archaeology, and History, has an unhealed trepanation on the left frontal bone. When Tello unwrapped this mummy bundle, he found a thin, hammered sheet of gold over the opening (Tello, 1929).

Was this gold plate a cranioplasty, intentionally placed over the trepanation opening as part of a surgical procedure, as has been suggested by a number of authors (Courville, 1959; Asenjo, 1963; Sanan & Haines, 1997), or was it simply a grave offering? The gold sheet is larger than the cranial defect it covered, and its irregular shape does not correspond to that of the opening, suggesting that it was not specifically made to fit

into the cranial defect itself. The margins of the trepanation show no evidence of vital response, suggesting that the patient died during or shortly after the surgery. Tello himself was conservative in interpreting the discovery, describing it simply as 'a trepanation protected by a thin plate of gold' (Tello & Mejía Xesspe, 1979: Lámina XII).

No other trepanned skulls have been found at Paracas with gold sheets or other coverings over trepanation openings, so this appears to be a unique case. Given the lack of bony response and the absence of preserved soft tissue around the trepanation site, it remains unclear whether the gold sheet was directly related to the surgery, or whether it was a grave offering.

### **Ethnographic reports of modern trepanation and cranioplasty**

Modern reports of cranioplasty among indigenous Peruvian populations may help to inform ancient practices. For example, Adolf Bandelier, while conducting archaeological investigations for the American Museum of Natural History in highland Bolivia in the late 19<sup>th</sup> century, found a number of trepanned skulls in the La Paz and Lake Titicaca area (Bandelier, 1904, 1910). Inquiring among local informants, he was told that trepanation was still performed in the area by traditional healers. Bandelier was able to locate and briefly interview only one of these reported patients, a Bolivian woman who said she had been trepanned successfully after a head injury, but who was unwilling to provide details. Bandelier heard accounts from other informants, however, including several descriptions of individuals who were claimed to have had trepanation orifices closed with pieces of gourd. He reported:

'While at Umayo, near the northwestern shore of Lake Titicaca, the administrator of the hacienda informed me that some twenty-five years before he had known a man near Cuzco who had been trephined for skull-fracture and who wore a piece of gourd inserted into the orifice.' (Bandelier, 1904: 441)

'In regard to the instruments used, our informants knew nothing, but they declared

to have seen individuals who survived the operation for many years, with a piece of mate (gourd or squash) in their skulls, over which the skin had been stitched together.' (Bandelier, 1910: 174)

Unfortunately, Bandelier was never able to physically observe any examples of trepanations with gourd implants, nor have subsequent researchers been able to confirm the practice. Occasional reports of indigenous trepanation in

remote areas of highland Peru and Bolivia continue to the present day (Bastien, 1987), but none have been documented by outside observers.

Despite claims that cranioplasty was a common practice among Andean trepanners, our review finds little evidence to support it. In fact, our review found little evidence of any insertion of bone or objects in trepanned crania, regardless of intent. One recently discovered Inca burial from the Cuzco area, however, is an exception. In this



Figure 3. The Kanamarca cranium prior to cleaning. This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).

unique case, a rectangular piece of bone removed during surgery was placed back in the patient's head and secured with a paste of unknown composition. This skull represents the first documented case from the New World of a trepanation with the excised bone plug reinserted into the cranium.

## **Case report**

### *Physical findings*

The individual was excavated from the Inca site of Kanamarca, located in Espinar Province, approximately 148 km southeast of the Inca capital city of Cuzco. This individual (Burial 8) was one of 38 excavated during the 2004–05 field season. Burial 8 was interred in a sandy matrix within a circular stone tomb and positioned in a tightly flexed,

seated posture, oriented toward the east (Benavides, 2004). Funerary offerings found in the tomb included a spondylus shell necklace with drilled pendants, seven polychrome ceramic vessels (including an Inca vessel with bird appliqué on the neck), a metal spoon, and two metal shawl pins (*tupus*). A second individual, a child between one and two years of age, was also interred in the tomb.

Laboratory analysis revealed Burial 8 to be a female, aged approximately 46 years or older at the time of death, based on criteria outlined in Buikstra & Ubelaker (1994) and detailed in Andrushko (2007). The woman showed extensive dental pathological conditions, including the antemortem loss of three teeth with complete alveolar resorption, active carious lesions on eight teeth, two periapical abscesses, one periodontal abscess, pulp exposure due to caries (one tooth) and attrition (one tooth), and moderate-to-severe



Figure 4. The Kanamarca cranium during the removal of material covering the trepanation site. This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).

attrition. Skeletal pathological conditions were limited to moderate spinal joint disease (osteophytes on thoracic and lumbar centra) and slight degenerative joint disease in the right and left hip joints.

When excavated, the trepanation was not immediately visible: a clump of apparent organic material adhered to the antero-lateral portion of the left parietal (Figures 3 and 4). When the material was removed in the laboratory, the trepanation was found to be distinctive in technique from most examples known from the Cuzco area. The opening was created by four intersecting linear incisions (Figure 5), creating a square-shaped defect – in contrast to the typical round or oval perforations with externally bevelled edges made by a circular cutting or scraping technique (Andrushko & Verano, 2008). But even more unusual in this case, the excised piece of bone had been reinserted into the skull.

The physical characteristics of the trepanation provide information on the method and timing of the surgery (Figure 6). The square trepanation measures 40 mm (anterior-posterior) by 39 mm (inferior-superior); at each corner, deep parallel and perpendicular grooves indicate that a linear cutting technique was used. The deepest of these grooves is located on the superior-medial corner of the square, where the groove continues for 11 mm past the corner of the trepanation. Four long cutmarks (28–30 mm) run parallel to the superior margin of the trepanation. The cutmarks show no remodelling or other signs of healing, nor is there any indication of osteoclastic activity around the trepanation margins – indicating that the patient died during or shortly after the trepanation procedure (Verano, 2003; Barbian & Sledzik, 2008).

Physical characteristics also provide a possible rationale for surgery. A radiating fracture line starts just below the anterior corner of the



Figure 5. Left lateral view of the Kanamarca cranium. This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).



Figure 6. Trepanation opening (detail). This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).

trepanation and continues anteriorly for 31 mm, impacting the greater wing of the left sphenoid (Figures 5 and 6). This fracture line may have resulted from blunt force trauma to the left parietal that produced bleeding or increased intracranial pressure, which the trepanation practitioner probably sought to relieve through surgery. The direct association between the radiating fracture and the trepanation certainly suggests that the intervention was performed in response to cranial injury.

The excised piece of bone also shows intriguing characteristics that explore the circumstances of the surgery (Figure 7). Firstly, the square plug (36 mm anterior-posterior by 32 mm medial-lateral) is smaller than the trepanation opening, reflecting a loss of bone during the cutting procedure. Also, the margins, like that of the trepanation, are sharp and straight rather than bevelled. Numerous cutmarks (approximately 15) transect the bone square, oriented haphazardly – some parallel, some perpendicular, some oblique.

Finally, on all four borders there are perimortem chopmarks (six in total) that impact the outer table and may reflect attempts to loosen and lever the bone plug. The haphazard arrangement of cutmarks and chopmarks along the margins suggests an impromptu and rapid surgical procedure to save a patient with an acute head injury.

## Discussion

In the case of the Kanamarca burial, neither the archaeological context nor direct skeletal evidence shed light on the specific timing or the purpose of replacing the excised bone in the trepanation opening. Given the absence of bony response, it cannot be determined whether the plug was replaced during the trepanation procedure itself or following the death of the patient. If the bone plug was indeed replaced as part of the surgical procedure, the paste applied over the



Figure 7. Bone plug, external surface. This figure is available in colour online at [www.interscience.wiley.com/journal/oa](http://www.interscience.wiley.com/journal/oa).

trepanation area might represent some form of poultice intended to aid in healing of the wound. But it is also possible that the paste was simply a *post mortem* application used to relocate the excised bone and seal the wound prior to burial.

Therefore, as in the case of the Crichel Down skull, the osteological evidence is insufficient to allow us to identify the Kanamarca trepanation as a true cranioplasty. To support such an interpretation, other examples showing clear evidence of bone reaction following surgery will need to be found. The Kanamarca skull is nevertheless important, as it is the first unequivocal case in the Prehispanic Americas where a bone plug was removed and replaced in a trepanation opening. At the present time, evidence of cranioplasty in ancient Peru remains largely unsupported. Our critical review of the literature emphasises the need for caution in evaluating secondary accounts and skeletal remains from undocumented contexts.

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