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Case Study

Three trepanned skulls from the Copacabana Peninsula in the Titicaca Basin, Bolivia (800 BC–AD 1000)

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ABSTRACT

This paper presents three trepanned skulls from the Copacabana Peninsula in the Titicaca Basin, dating from 800 BC to AD 1000. Trepanation has been practiced for two millennia in the Andes, with the earliest specimens coming from the coastal Paracas culture (circa 400 BC). Trepanned skulls have been found throughout the Andes, displaying a variety of techniques. This modification was practiced as surgical intervention after injury and treatment for headaches and other ailments, among other reasons (Verano, 2003: 234). With the exception of four examples from the Island of the Sun, few early cases of trepanation have been found in the Titicaca Basin of Peru and Bolivia. The three skulls presented here are important for several reasons: (1) they originate from a region under-represented in the literature on Andean trepanation, (2) they represent a variety of trepanation techniques, and (3) they confirm the practice of trepanation in the lake basin during the Early Horizon.

1. Introduction

Trepanation in the Andes has a long history. The earliest examples of trepanned skulls are associated with Paracas, a culture that thrived from 800–100 BC on the coast of modern-day Peru (Tello, 1913; Verano, 2003). This medical and ritual practice became increasingly sophisticated over time, resulting in high rates of survival and often full recovery. By the time of the Inka Empire (AD 1400–1532), 81% of known trepanations from the Cusco region show full healing, indicating survival (Andrushko and Verano, 2008). While the skill associated with trepanation is undoubted, when and where people began to trepan and how the practice was adopted in new areas remain unclear.

Most trepanned crania in the Andes were from the south coast of Peru or the central and southern highlands of Peru. Fewer examples come from other regions, such as the central coast or northern highlands of Peru, the Titicaca Basin of Peru and Bolivia, or the south central highlands of Bolivia (Hjortsjö, 1972; Stewart, 1958; Verano, 2003). Four examples have been identified from the Titicaca Basin, specifically from the Island of the Sun, a large island located near the northern-most portion of the Copacabana Peninsula of Bolivia (Fig. 1) (Bandelier, 1904; Torres-Rouff, 2013). At Kea Kollu Chicho, a Middle and Upper Formative (1300 BC–AD 200) site on the Island of the Sun, Bandelier (1904) and Torres-Rouff (2013) recorded four trepanned individuals. All of these surgeries were performed by a method called scraping and demonstrated varying degrees of healing and survival. Unfortunately, these crania were collected by Bandelier in 1895 without post-cranial remains and from poorly documented contexts, making conclusions about when and why these individuals were trepanned uncertain.

This case study presents three trepanned crania from the nearby Copacabana Peninsula in the Titicaca Basin of Bolivia in order to address the antiquity and technique of trepanation in this region. These crania originate from two sites on the peninsula and are associated with the Early Horizon (800 BC–AD 200) and Late Intermediate Period (AD 1000–1250). The discovery and documentation of these crania confirm the presence and continued practice of trepanation in the lake basin over time.

2. Trepanation in the Andes

There are four well-documented types of trepanation in the prehispanic Andes: scraping, linear cutting, boring and cutting, and circular grooving (Verano, 2003; Verano and Finger, 2009). These surgeries were likely performed with tools made from obsidian or metal. Covers or plaques made of metal or bone and herbal poultices (as found with mummified remains in the Peruvian highlands) may have been used in post-operative treatment (Andrushko and

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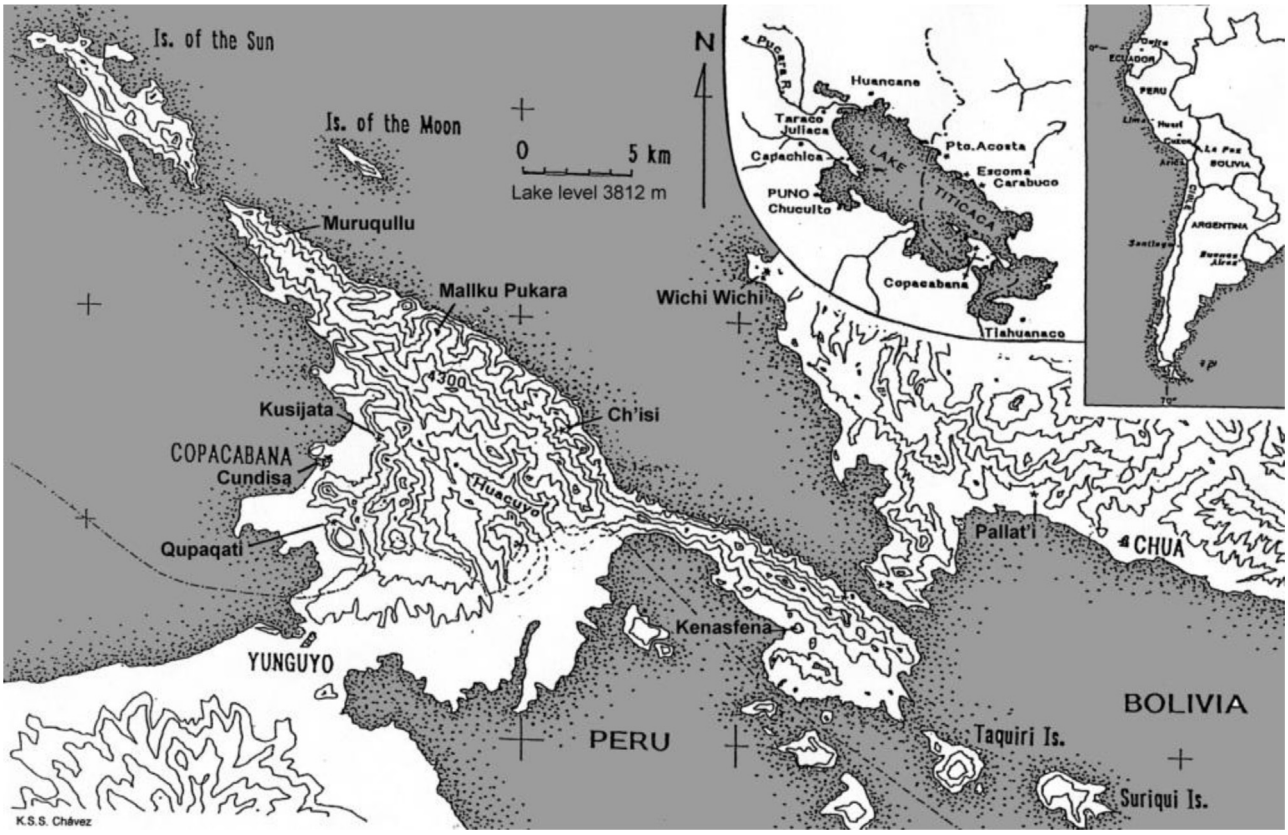

Fig. 1. Map of the Copacabana Peninsula with important archaeological sites and modern cities marked.

Verano, 2008; Kurin, 2013; Verano and Andrushko, 2010). However, most examples are found without such artifacts.

The earliest trepanations were executed by scraping. This method involved slowly removing external layers of bone by scraping the skull with a tool until the vault was penetrated. The external aperture tended to be beveled outward. Scraping trepanations generally had the highest rates of healing and survival (Andrushko and Verano, 2008; Kurin, 2013; Stewart, 1958).

Linear cutting likely developed after scraping. Also called crosscut sawing or rectangular intersecting incisions, the method involved making straight, deep cuts to remove a rectangular piece of bone. Saw or cutmarks surrounding the excised portion of bone often persist post-operation (Verano, 2003). This technique was less common and had lower rates of survival than other methods (Andrushko and Verano, 2008; Kurin, 2013).

Boring and cutting involved drilling a perimeter of small holes and subsequently removing the central piece of bone. Drill bit size varied over time, between locations, and sometimes even on the same trepanned individual. This technique necessitated more skill than other types as one had to know where to place boreholes and the appropriate drill depth to avoid damaging internal structures such as the brain or intracranial blood vessels. Evidence for practicing this technique on crania after death has been found near Andahuaylas, Peru (Kurin, 2013). As measured by survival, this technique was moderately successful (Kurin, 2013; Verano, 2003).

The final method was circular grooving or circular cutting. This involved prying a small, circular area of bone from the cranium, creating a smooth-walled circular furrow. These trepanations tended to be smaller in size than other types and had relatively high rates of survival. This technique was most commonly practiced during the Late Horizon (AD 1400–1532) in southern highland Peru (Andrushko and Verano, 2008; Verano, 2003).

3. Materials and methods

Recent bioarchaeological analyses have identified three trepanned individuals from two sites (Ch'isi and Cundisa) on the Copacabana Peninsula, Bolivia. Ch'isi was located on the western portion of the peninsula and was primarily occupied through the latter half of the Early Horizon (800 BC–AD 200) (Fig. 1). The remains of 52 Early Horizon individuals were excavated from this site in 1994 and 1995 under the direction of Karen Mohr Chávez. This included one trepanned individual. The site was again used for burial during the Late Intermediate Period (AD 1000–1250). A second trepanned individual was found among the nine Late Intermediate Period individuals.

Cundisa, located in modern day Copacabana (Fig. 1), was continuously occupied from the Preceramic period (5000–1500 BC) through Spanish colonization and into the modern day (Chávez, 2008). Excavations directed by Stanislavia Chávez in 2008 and 2009 revealed burials associated with Late Horizon (AD 1476–1534), Middle Horizon (AD 600–1000), and Early Horizon grave goods. Amongst these burials, there was one trepanned individual. Unfortunately, this individual was recovered from an area of the site disturbed by modern construction, making its temporal association somewhat unclear. Qalasasaya ceramics (800 BC–AD 100) were uncovered nearby; the correlation between the pottery and burial suggests that this individual also dates to the Early Horizon.

Age and sex were estimated from dental and skeletal material, according to standard methods (Bass, 1995; Buikstra and Ubelaker, 1994). Juengst used tooth eruption and wear as the primary indicators of age for all individuals. Juengst also considered cranial suture closure, the appearance of the pubic symphysis (when present), and fusion of the epiphyses of long bones (when present) to corroborate and narrow age ranges from dental age estimates. Sex was

Fig. 2. Healed trepanation defect on the left parietal of Individual 1.

estimated for each adult individual based on cranial and pelvic elements. Female pelvis tend to be wider overall and marked by the presence and appearance of the following features: the subpubic concavity, the ischiopubic ramus, the ventral arch, the greater sciatic notch, the pelvic outlet, and the preauricular sulcus. Two individuals did not have preserved pelvic remains; for these individuals, Juengst estimated sex based on cranial features, including the supraorbital margin, superciliary arches, nuchal crest, and mastoid process, according to standards in Buikstra and Ubelaker (1994) and Bass (1995). These two individuals were assigned "probable male" designations because they lacked pelvic elements but had cranial features that suggested male sex.

Trepanations were recorded following methods established in Verano (2003). First, location, size of the trepanation, and side of the cranium were recorded. Method of trepanation (scraping, linear cutting, boring and cutting, or circular grooving) was identified based on the shape and size of the trepanation and associated cutmarks, boreholes, or other evidence of tool use. Associated trauma was recorded as an indicator of potential motivation for trepanation. Finally, healing was recorded as none (sharp or clean edges, no bone remodeling), partial (some new bone growth evident), or fully healed (rounded edges, extensive remodeling).

4. Results

The first trepanned individual (CH P26C-AB) was from the Early Horizon occupation of Ch'isi. Radiocarbon dates from this tomb extended from 400 BC to AD 100. Individual 1 was a 25–30-year-old probable male represented by a mostly complete skull, and a partially complete post-cranial skeleton. This individual had two trepanations, one on the left parietal (Fig. 2) and one on the right lambdoidal suture (Fig. 3). Both were examples of linear cutting. The trepanation on the left parietal was quite large, measuring approximately 4.5 cm × 3.5 cm in maximum dimensions. There were visible but well-healed cutmarks on two sides of the trepanned area (Fig. 4), likely related to removal of skin and musculature prior to bone removal. The trepanation on the lambdoidal suture was small, measuring 1.5 cm × 2 cm. There were no visible cutmarks associated. Slight pitting surrounded the smaller defect (Fig. 3), indicating remodeling. Both trepanations were well-healed, with smoothed edges.

The second trepanned individual (CU T114 IN1) originated from the Early Horizon occupation of Cundisa (800 BC–AD 100). Individual 2 was a 14–16-year-old probable male with a large depressed fracture and a partial linear cutting trepanation on the left parietal (Fig. 5). No other trauma or pathology was noted on this individual, although many postcranial elements were missing. The depressed fracture measured 4.56 cm × 4.97 cm and involved two radiating fracture lines, one of which crossed the lambdoidal suture. Deep cutmarks were made superior to the fracture, related to the portion of the bone that was removed (Fig. 6). These cutmarks are also associated with a small fracture line, possibly created from the force of the cuts. Shallower cutmarks are evident on the inferior border of the fracture, although no bone was removed (Fig. 7). These are likely related to removal of skin and muscle on top of the bone. No signs of healing were evident.

The third trepanned individual (CH TC IN 8) was from the Late Intermediate Period context at Ch'isi (AD 1000–1250). Individual 3 was a 35–45-year-old adult female with a boring and cutting trepanation on the posterior right parietal (Fig. 8). In addition to the trepanation, this individual had a healed nasal fracture (Fig. 9). The trepanation on Individual 3 measured 1.82 cm in average diameter and was not associated with any cutmarks. There were boreholes around the edges of the defect and this surgery showed evidence for long-term healing (Table 1).

5. Discussion

These cases of trepanation provide new and important information about the nature and development of trepanation in the Andes. First, from these crania, we can observe two types of trepanation: linear cutting and boring and cutting. Individuals 1 and 2 are both examples of linear cutting. Linear cutting is the least frequently identified trepanation technique in studies from the

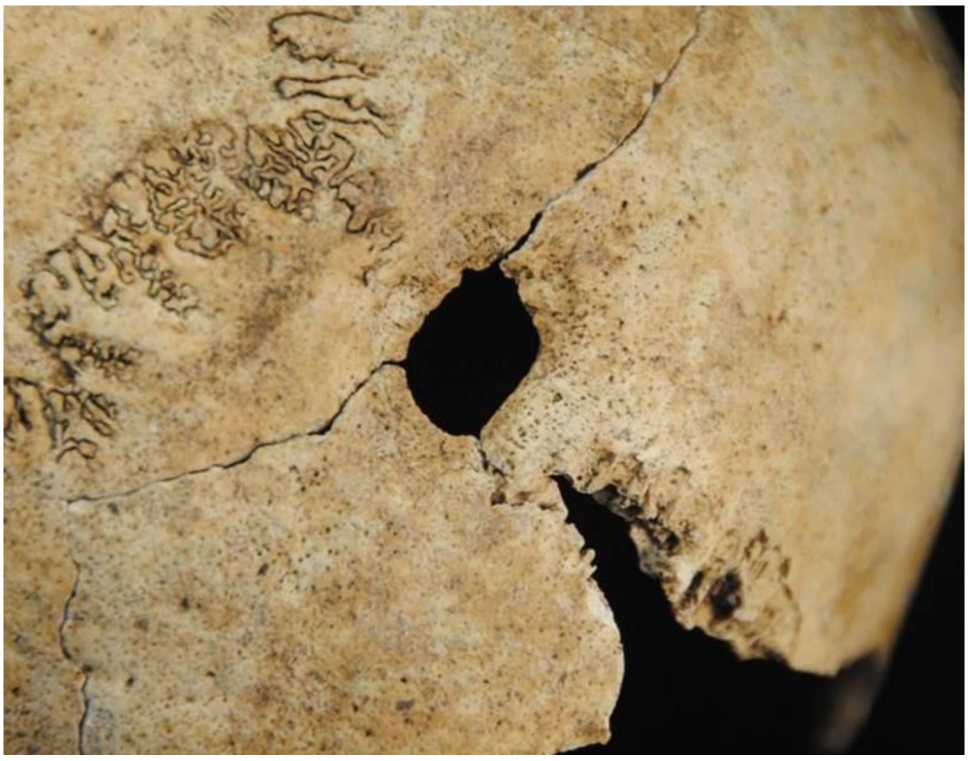

Fig. 3. Healed trepanation crossing the lambdoidal suture of Individual 1, with pitting surrounding the defect.

southern highlands of Peru (Andrushko and Verano, 2008; Kurin, 2013) but was more commonly practiced in the central highlands of Peru (Tello, 1913). These are the only two examples of linear cutting trepanation from the Titicaca Basin of Peru and Bolivia; the other four examples from Bandelier's collection were executed by scraping. These two skulls thus contribute to the literature on linear cutting trepanation in the lake basin and throughout the Andes more broadly.

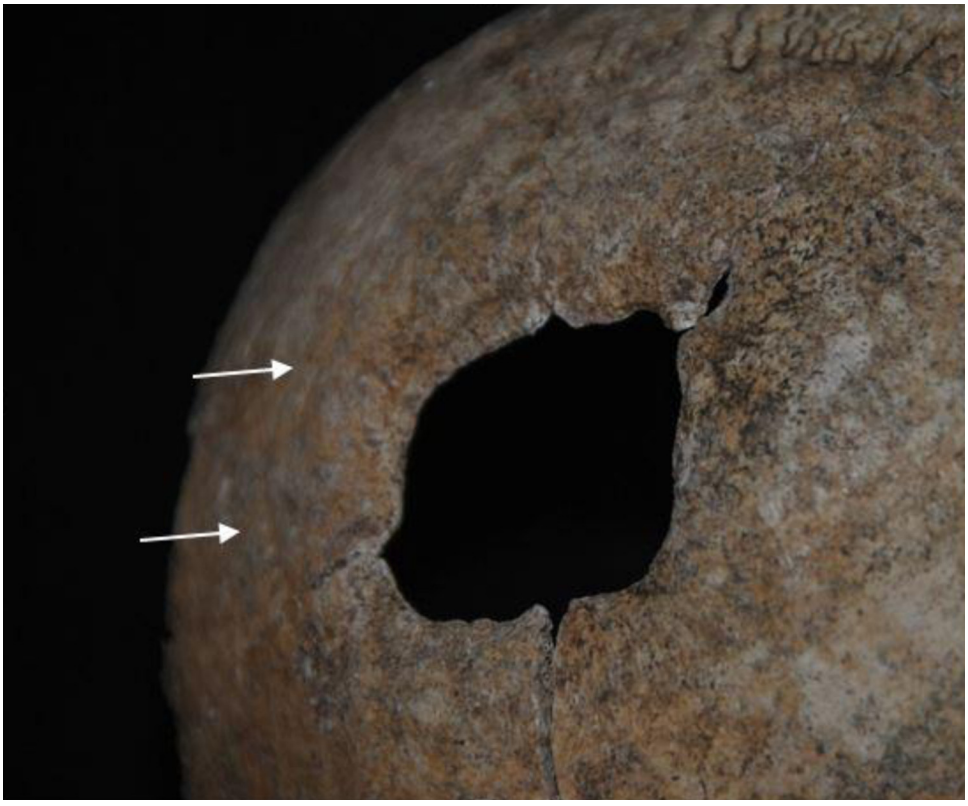

Fig. 4. Healed cutmarks surrounding the parietal trepanation on Individual 1 (marked with white arrows).

Fig. 5. Unhealed trepanation and depressed fracture on the left parietal of Individual 2.

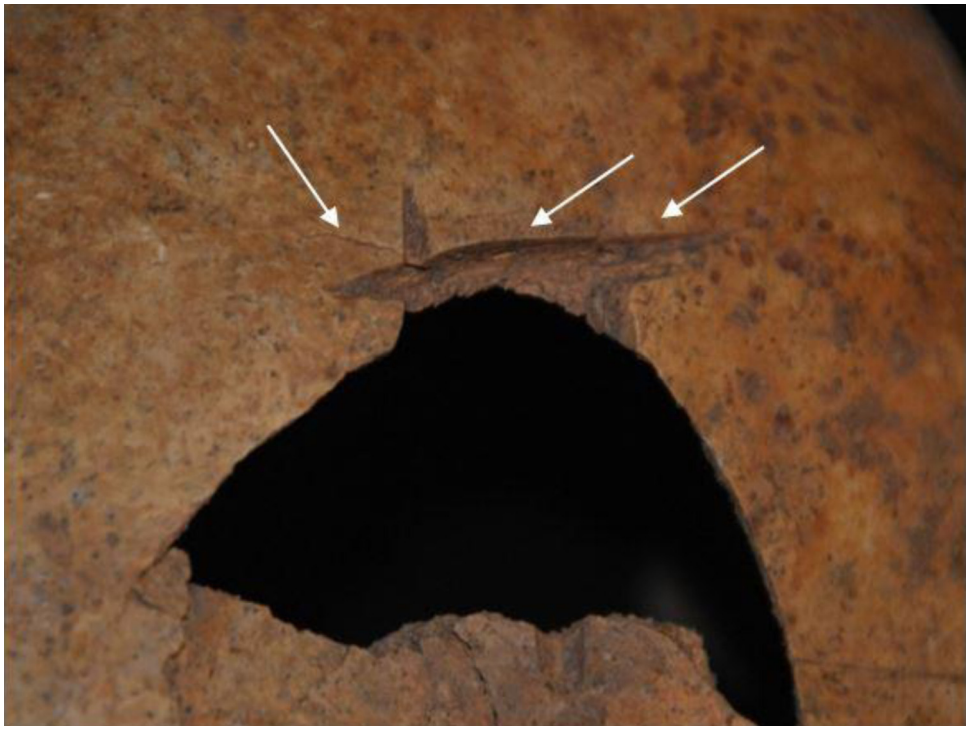

Fig. 6. Deep cutmarks (marked with arrows on the right) superior to Individual 2's trepanation and small radiating fracture line (marked with arrows on the left).

Table 1
Three trepanned individuals from the Copacabana Peninsula.

Site and time period	Individual number	Age	Sex	Trepanation location	Other trauma?
Ch'isi, 400 BC–AD 100	1	25–30	Male	Left parietal, right lamdoidal suture	No
Cundisa, 800 BC–AD 100	2	14–16	Probable male	Left parietal	No
Ch'isi, AD 1000–1250	3	35–45	Female	Right parietal	Yes – healed nasal fracture

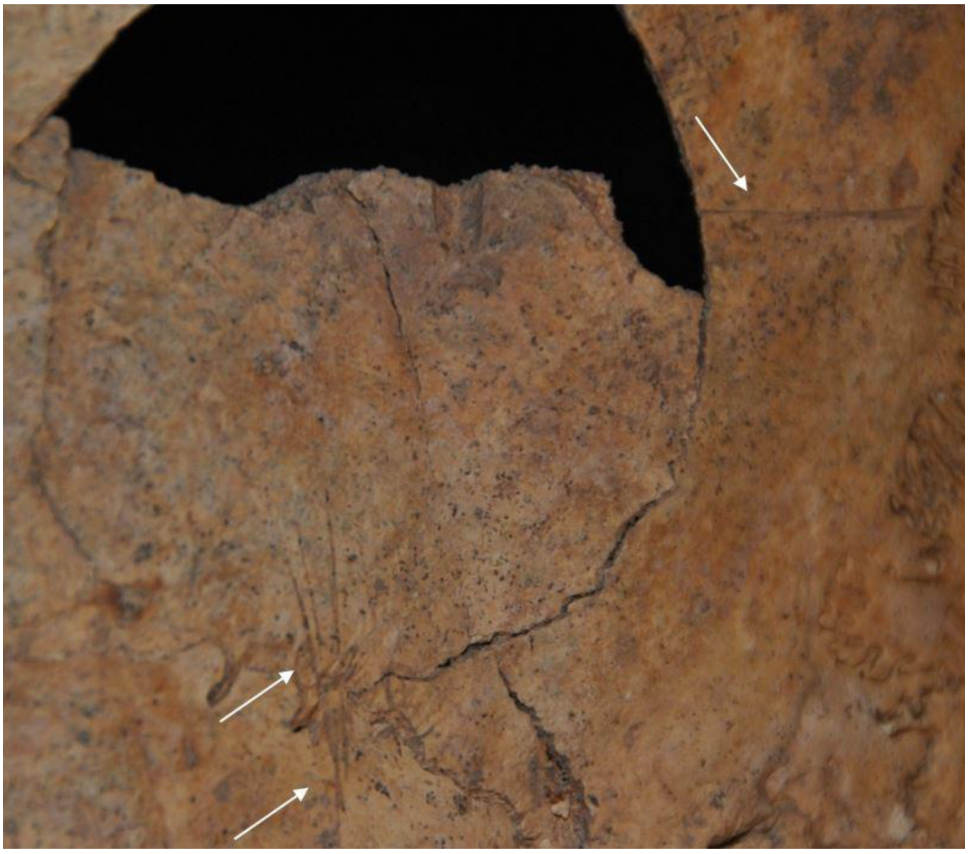

Fig. 7. Shallow cutmarks surrounding Individual 2's trepanation and depressed fracture (marked with white arrows).

Fig. 8. Healed trepanation on the posterior right parietal of Individual 3.

Fig. 9. Healed nasal fractures on Individual 3.

Individual 3's trepanation was an example of boring and cutting. This technique was commonly practiced in the central Peruvian highlands during the Late Intermediate Period and may have been introduced to the Titicaca Basin during this time. Trade between Cusco, Peru, and the Titicaca Basin of Bolivia has been documented since Early Horizon times (1500 BC–AD 200) (Burger et al., 2000; Stanish et al., 2002); these connections would have been well-established by the Late Intermediate Period. It is likely that medical knowledge also traveled along these routes. Alternatively, Individual 3 may have herself moved from the southern highlands of Peru into the Titicaca Basin, following her surgery. In either case, the example of boring and cutting trepanation in the Titicaca Basin during the Late Intermediate Period underscores the movement of goods, people, and ideas around the Andes at this time.

All three trepanned individuals also suffered blunt force cranial trauma associated with their surgeries. Blunt force trauma to the cranium can create intra-cranial bleeding, which can ultimately impair brain function and cause death. Trepanation allows intracranial fluids to drain, releasing pressure on the brain (Nerlich et al., 2003). While this does not eliminate the possibility that trepanation was practiced for other reasons, it seems that in some cases, trepanation was used as a medical treatment.

Two of the three trepanned individuals survived their surgeries. The amount of bone remodeling displayed on Individuals 1 and 3 suggests that they may have lived for many years after their trepanations (Nerlich et al., 2003). Given this, it seems that trepanation in the lake basin was an effective treatment in some cases.

Finally, two of these individuals pre-date the other well-preserved and clearly dated examples from the Titicaca Basin by at least 500 years (c. AD 100). While these surgeries post-date examples from Paracas (Tello, 1913), they were certainly early for the Titicaca Basin and South Central Andes (Verano, 2003). This may indicate an independent invention of trepanation techniques or relatively fast spread of knowledge and skillful technique into the south-central highlands. The presence of these early trepanned individuals confirms the practice of trepanation in the lake basin during the Early Horizon.

6. Conclusion

Based on these patterns, this case study adds important new data to our understanding of trepanation in the Andes. The contribution of these three individuals nearly doubles the known sample of trepanned skulls for this region and time period, adding to a growing literature on Andean trepanation more broadly. Second, two trepanation techniques (linear cutting and boring and cutting) were practiced in the Titicaca Basin. The examples of linear cutting are the first documented in the lake basin during the Early Horizon. The variation in techniques over time suggests long-distance movement of people and ideas around the prehispanic Andes. Third, two of these individual survived their surgeries, indicating the effectiveness of the intervention as measure by survival. Finally, these cases provide concrete data to confirm that trepanation was practiced in the Titicaca Basin of Bolivia during the Early Horizon.

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References

Andrushko, V.A., Verano, J.W., 2008. Prehistoric Trepanation in the Cusco Region of Peru: A View into an Ancient Andean Practice. Am. J. Phys. Anthropol. 137, 4–13.

Bandelier, A.F., 1904. Aboriginal trephining in Bolivia. Am. Anth. 6 (4), 440–446.

Bass, W.M., 1995. Human Osteology, 5th ed. Missouri Archaeological Society Inc., Columbia.

Buikstra, J.E., Ubelaker, D.H. (Eds.), 1994. Standard for Data Collection from Human Skeletal Remains. Arkansas Archaeological Survey Research Series No. 44., Fayetteville.

Burger, R.L., Mohr Chávez, K.L., Chávez, S.J., 2000. Through the glass darkly: prehispanic obsidian procurement and exchange in Southern Peru and Northern Bolivia. J. World Prehist. 14 (3), 267–362.

Chávez, S.J., 2008. Resumen de Los Trabajos Arqueologicos del Proyecto Yaya-Mama en el Sitio de Cundisa, Copacabana. Chachapuma December.

Hjortsjö, C.-H., 1972. Anthropological investigations of an artificially deformed and trepanned cranium from Niño Korin, La Paz Bolivia. In: Wasseń, S.H. (Ed.), A Medicineman's Implements and Plants in a Tiahuanacoid Tomb in Highland Bolivia. Etnologiska Studier 32. Elanders Boktryckeri Aktiebolag, Göteborg, pp. 145–158.

Kurin, D.S., 2013. Trepanation in South-Central Peru during the early late intermediate period (ca. AD 1000–1250). Am. J. Phys. Anthropol. 152, 484–494.

Nerlich, A., Peschel, O., Zink, A., Rosing, F.W., 2003. Pathology of trepanation. In: Arnott, R., Finger, S., Smith, C.U.M. (Eds.), Trepanation. Swets & Zeitlinger Publishers, Lisse, The Netherlands, pp. 43–51.

Stanish, C., Berger, R.L., Cipolla, L.M., Glascock, M.D., Quelima, E., 2002. Evidence for early long-distance obsidian exchange and watercraft use from the Southern Lake Titicaca Basin of Bolivia and Peru. Lat. Am. Ant. 13 (4), 444–454.

Stewart, T.D., 1958. Stone Age Skull Surgery: A General Review, With Emphasis on the New World. Annual Report of the Smithsonian Inst, 1957. Publication: 4314., pp. 469–491.

Tello, J.C.,1913. Prehistoric trephining among the Jauyos of Peru. In: International Congress of Americanists, Proceedings of the XVIII Session, 1912. Harrison and Sons, London.

Torres-Rouff, C., 2013. Human skeletal remains from Bandeliers 1895 expedition to the island of the Sun. In: Vranich, A., Levine, A.R. (Eds.), Advances in Titicaca Basin Archaeology-2. Cotsen Institure of Archaeology, Los Angeles, pp. 181–187.

Verano, J.W., 2003. Trepanation in prehistoric South America. In: Arnott, R., Finger, S., Smith, C.U.M. (Eds.), Trepanation. Swets & Zeitlinger Publishers, Lisse, The Netherlands, pp. 223–236.

Verano, J.W., Andrushko, V.A., 2010. Cranioplasty in Ancient Peru: a critical review of the evidence, and a unique case from the Cuzco Area. Int. J. Osteoarch. 20, 269–279.

Verano, J.W., Finger, S., 2009. Ancient trepanation. Handb. Clin. Neurol. 95, 3–14.