Case Study

Point taken: An unusual case of incisor agenesis and mandibular trauma in Early Bronze Age Siberia

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ARTICLE INFO

Article history:
Received 20 December 2013
Received in revised form 15 April 2014
Accepted 22 April 2014

Keywords:
Dental agenesis
Perimortem trauma
Violence
Computed tomography
Middle Holocene
Hunter-fisher-gatherers
Baikal

ABSTRACT

This paper focuses on the mandible of an adult male individual (radiocarbon dated to 4420–3995 cal BP) from the Early Bronze Age Cis-Baikal cemetery of Ust’-Ida I (Siberia, Russian Federation). The mandible contains two features of interest: (1) bilaterally missing central incisors, and (2) the tip of a lithic projectile point embedded in the symphyseal region. Despite the absent teeth, the mandible presents a dental arcade without diastemata, appearing normal and complete on first glance. Three different levels of CT (computed tomography) imaging—ranging from clinical to synchrotron-based—were employed in order to establish the aetiology behind the missing dentition, whether subsequent to the projectile trauma or entirely unrelated to it. Results indicate that the mandible exhibits two highly unusual but unrelated features: probable bilateral agenesis of the central incisors and perimortem trauma to the mental symphysis. In addition, the embedded tip was successfully matched via digital imaging to photographs of a broken projectile point, an artefact recovered from the facial region of the skeleton.

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1. Introduction

Among archaeological human remains, absent or missing teeth typically reflect agenesis, impaction, or antemortem loss, conditions that can be difficult to distinguish on the basis of external appearance alone (Hillson, 1996:113; Ortner, 2003:597; Pietsuweysky and Douglas, 1993; Regezi et al., 2000:147–148). Agenesis is the congenital absence of teeth, and impaction is their failure to erupt (Hillson, 1996:113). While the external appearance of the two may be similar, the former can be easily distinguished from the latter via bone imaging techniques (Ortner, 2003:597). Antemortem loss, on the other hand, is tooth loss during life, typically secondary to dental disease, cultural practices such as ablation (intentional removal), or trauma (e.g., Lukacs, 2007; Pietsuweysky and Douglas, 1993). Subsequent resorption of alveolar bone and/or migration of adjacent teeth can further complicate diagnoses (Hillson, 1996:113), particularly when macroscopic methods alone are employed.

Here we present an unusual case of missing mandibular incisors from the Early Bronze Age cemetery of Ust’-Ida I (Burial 48), located in Siberia’s Cis-Baikal. The mandible in question exhibits two features of interest: (1) bilaterally absent central incisors, and (2) the tip of a projectile point embedded in the symphysis. This paper examines the aetiology behind the absent incisors—and, in particular, any potential relationship between their absence and the projectile trauma—and demonstrates the effectiveness of CT imaging technology in diagnosing unusual skeletal and dental conditions.

2. Materials and methods

Ust’-Ida I is a middle Holocene hunter-gather cemetery located along the Angara River in the Cis-Baikal region of Siberia, Russian Federation (Fig. 1). While it comprises both Late Neolithic (LN) and Early Bronze Age (EBA) interments, these represent two horizons of the same cultural complex dating to 6000/5800–4000 cal. BP (Weber and Bettinger, 2010; Weber et al., 2011). In total, 67 individuals were excavated from Ust’-Ida I between 1986 and 1994. Burial 48 was recovered in 1994 and directly radiocarbon dated to

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http://dx.doi.org/10.1016/j.ijpp.2014.04.004
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4420–3995 cal. BP (TO-10308: 3830 ± 70 BP; Weber et al., 2006), placing it in the latter part of the EBA. Grave accompaniments included a large (7.5 cm) nephrite disc, dozens of small decorative beads, and four projectile points, one of which had a broken tip and was lying in the left orbit (Fig. 2). These artefacts and their associations (including those positioned on or around the cranium) are not atypical of EBA male grave goods, which often include hunting and fishing paraphernalia (Okladnikov, 1950, 1955).

While most right side long bones (much of the humerus, the radius, ulna, femur, tibia, and fibula) were absent postmortem, Burial 48 was well preserved and otherwise relatively complete, including the cranium and mandible with a nearly full set of dentition. Missing teeth included all four maxillary incisors (all absent postmortem, except for the right lateral incisor, which was absent antemortem; Supplemental Fig. S1), the right maxillary third molar (possible agenesis, with no discernible wear facets on the distal crown of the adjacent second molar; Fig. S1), and both mandibular central incisors (the subjects of this paper). A conservative age at death estimate of 30–40 years was based on the morphology of the pubic symphysis and auricular surface, as well as palatal and ektocranial suture closure (Brooks and Suchey, 1990; Mann et al., 1987; Meindl and Lovejoy, 1985, 1989). Sex was assessed as male by non-metric cranial and pelvic indicators (as outlined by Buikstra

Fig. 1. Map of Cis-Baikal, Siberia, with location of Ust’-Ida I and other cemeteries mentioned in the text.

Fig. 2. Burial 48 skull and grave goods in situ in the grave pit. Note the broken projectile point lying flat on the floor of the left orbit, with its base oriented more or less anteriorly and its (broken) tip oriented more or less posteriorly, or into the eye. The projectile tip embedded in the mandible cannot be discerned in this image.
and Ubelaker, 1994:16–21). Other than on the mandible, no pathological or traumatic conditions were observed on the skeleton, including the left orbit where the broken projectile had been recovered.

Supplementary Fig. S1 related to this article can be found, in the online version, at doi:10.1016/j.ijpp.2014.04.004.

Only two mandibular incisors were present, positioned adjacent to one another with their mesial aspects meeting along the midline (Figs. 3 and 4). Their crowns were angled slightly mesially, being separated by a distance of 4 mm at their cementoenamel junctions (CEJ), but abutting against one another with their mesioincisal edges so that interproximal wear facets had formed. Dental wear was moderate, i.e., stage 5 using the Smith (1984) method (Fig. 4). The incisors were identified as lateral, rather than central, because of their distinctive distally twisted (relative to their roots) and fan-shaped asymmetrical crowns (Fig. 3; Hillson, 1996: 21; Scheid, 2007:161–162).

The tip of a lithic projectile point was embedded in the mental symphysis, just right of the midline and 7 mm inferior to the alveolar margin (Fig. 3). The projectile had broken so that its observable surface was more or less flush with the external surface of the bone. The visible portion of it measured approximately 7.5 mm wide and 1.9 mm thick. While there was no discernible evidence of bone remodelling around the projectile point, postmortem exfoliation and root etching of the cortical bone made it difficult to state this definitively. Conventional plain film radiographs, taken at the Irkutsk City Hospital (Irkutsk, Russian Federation) in 2012, were also inconclusive (Fig. 5), as the projectile point exhibited X-ray absorption similar to that of the surrounding bone. Based on these initial assessments, we were unable to confidently conclude whether the projectile injury represented an antemortem or perimortem traumatic event, or to ascertain its association, if any, with the missing central incisors. Using CT (computed tomography) imaging technology to complement morphological analyses and better understand the unique features of the mandible, we proposed three hypotheses to explain the missing teeth: (1) a congenital defect such as agenesis or impaction unrelated to the projectile trauma, (2) antemortem loss unrelated to the projectile injury, and (3) antemortem loss resulting directly from the projectile trauma.

Clinical CT was performed at the Royal University Hospital in Saskatoon (Canada) using a GE LightSpeed QXI scanner with 0.3125 mm × 0.3125 mm × 0.625 mm voxels. 186 slices were reconstructed on site using commercial GE software. High-Resolution Peripheral Quantitative CT (HRpQCT), which is capable of resolving individual trabeculae, was then performed to examine the bone around the impact site for indicators of trauma or missing dentition. HRpQCT was performed at the University of Saskatchewan using a Scanco Medical XtremeCT system with an isotropic 41 μm³ voxel size. 2926 slices were reconstructed on site using the commercial Scanco software. Finally, Synchrotron Radiation micro-CT (SRµCT) was performed at a resolution capable of detecting cortical bone porosity in order to test for signs of damage or remodelling. SRµCT was performed at the BioMedical Imaging and Therapy (BMIT) beamline at the Canadian Light Source synchrotron at 20 μm³ and 10 μm³ voxel sizes. All scans were visualized using Amira (Visualization Sciences Group, Burlington, MA) and images created using volume rendering techniques.

3. Results and discussion

Clinical CT imaging (Fig. 6) revealed that there were no unerupted incisors or partial crypts present, but was unable to easily distinguish the projectile from the surrounding bone. HRpQCT (Figs. 6 and 7) was not only able to discern individual trabeculae, but also to differentiate more clearly the projectile from the bone and to reaffirmed that unerupted incisors and/or partial crypts were not present in any form. SRµCT, the most advanced of the CT techniques, was able to visualize individual trabeculae and vascular

Fig. 3. Anterior view of mandible with embedded projectile tip in the symphysis and missing central incisors. The right molars had been removed postmortem for chemical analyses.

Fig. 4. Superior view of mandible with embedded projectile tip in the symphysis and missing central incisors.

Fig. 5. Conventional plain film radiograph of mandible, anterior view (taken at the Irkutsk City Hospital, Irkutsk, Russian Federation). Note that most teeth had been removed from the mandible (postmortem) for ease of transport. The projectile tip is difficult to identify in this image.
canals in the cortex and to discriminate easily between the bone and projectile, allowing the latter to be segmented (Figs. 8 and 9). SRμCT images clearly revealed the perimortem nature of the traumatic lesion, including fragmented trabeculae and deformed and crushed vascular channels. There was no evidence whatsoever of bony reaction or remodelling indicative of an antemortem injury. Furthermore, extensive damage was observed on the projectile tip itself—specifically hairline fractures oriented more or less perpendicularly to the presumed trajectory (Figs. 8 and 9)—suggesting that it had shattered on impact, a finding not inconsistent with experimental evidence (e.g., Dockall, 1997; Odell and Cowan, 1986; Smith et al., 2007). These results confirmed that the Burial 48 mandible exhibited two unusual but unrelated features: (1) bilateral agenesis or early-life antemortem loss of the central incisors and (2) perimortem projectile trauma.

Differentiating between early-life antemortem tooth loss—whether the result of cultural practices such as ablation, dental disease, or trauma—and agenesis can be difficult. Over time, alveolar sockets and root fragments can completely resorb and adjacent teeth can migrate mesially, partially obstructing gaps in the tooth row. No evidence of intentional tooth removal has ever been documented in the middle Holocene Cis-Baikal and, as a result, we considered ablation to be a highly unlikely explanation in the present case. While tooth loss can also result from dental disease and trauma (intentional or accidental), these scenarios were not readily supported for three reasons. First, there were, effectively, no spaces in the mandibular tooth row, other than a slightly widened (∼2 mm) gap between the CEJ of the two lateral incisors (Fig. 3). Second, interproximal and occlusal wear facets on all mandibular and maxillary teeth, including the mesial crowns of
the lateral mandibular incisors (Fig. 4), were consistent with one another and indicative of tight interdental spacing for (similarly) extended periods of time. Had the two central incisors been lost antemortem, even early in life, it is unlikely that mesial drift could have closed such a large gap—equivalent to two teeth—in the tooth row and so tightly as to account for the pronounced interproximal facets. Third, other than one case of antemortem loss involving the right lateral maxillary incisor (Fig. S1), there was no evidence of dental disease or excessive wear that might have caused tooth loss (Merbs, 1968; Milner and Larsen, 1991).

Agenesis, therefore, seems to be the most likely explanation not only because the others are less plausible, but also because several other cases of reduced or congenitally absent teeth have been documented in the region. In fact, of approximately 100 other LNEBA individuals with preserved dentition and/or alveolar bone from three distinct cemeteries (Ust’-Ida I, Khuzhir-Nuge XIV, and Kurma XI; Fig. 1), six cases of reduced maxillary incisors (including one supernumerary pegged incisor; Supplemental Fig. S2), two cases of reduced molars, at least six cases of third molar agenesis, and one case of maxillary premolar agenesis have been recorded (Lieverse, 2005; Lieverse et al., 2007, 2012). Dental anomalies such as agenesis and microdontia appear to be closely linked, likely through shared genetic mechanisms (Grahnen, 1956; Garib et al., 2009; Garn and Lewis, 1970; Peck et al., 1996), so their documentation elsewhere in the population is consistent with the agenesis interpretation.

Supplementary Fig. S2 related to this article can be found, in the online version, at doi:10.1016/j.ijpp.2014.04.004.

After the third molars (with prevalence rates as high as 70%; Dahlberg, 1951; John et al., 2012), the permanent teeth most frequently affected by agenesis are the mandibular second premolars (~3%), maxillary second premolars (~1.5–2%), and maxillary lateral incisors (~1.5%); Baum and Cohen, 1971; Brothwell et al., 1963; Grahnen, 1956; Mattheeuws et al., 2004; Polder et al., 2004; Rose, 1966). Involvement of the mandibular incisors is extremely rare (0.17–0.35%) among European populations (Polder et al., 2004), especially when the anomaly is expressed bilaterally, but appears to be somewhat more common (1.1–4.0%) for modern East Asian groups (Davis, 1987; Dechkuukharn, et al., 1990, cited in Nelsen et al., 2001; Niswander and Sujaku, 1963). Among East Asian samples, lateral mandibular incisors are more likely to be absent than central ones (Nik-Hussein, 1989; Niswander and Sujaku, 1963).

Mandibular incisor agenesis has been reported occasionally in the clinical literature (e.g., Nagaveni and Umashankara, 2009; Newman, 1967; Newman and Newman, 1998; Pannu et al., 2011), but archaeological cases are almost unknown. Of four archaeological reports of mandibular incisor agenesis (Nelsen et al., 2001; Ortner, 2003: 600–601; Rougier et al., 2006; Sejersen et al., 1995), only one—that of an immature Neanderthal—represents bilateral absence, albeit of unidentified teeth (Rougier et al., 2006). While the other three instances involve anatomically modern humans, none are bilateral and all are considerably more recent than and geographically removed from Ust’-Ida I. Therefore, Burial 48 likely represents one of the earliest cases, worldwide, of bilateral agenesis involving the central mandibular incisors, and the first documented case in prehistoric Siberia. It is the only known example in the LN-EBA Cis-Baikal, among some 107 individuals with preserved permanent mandibular incisors (teeth and/or alveolar bone) recovered from three distinct cemeteries (Ust’-Ida I, Khuzhir-Nuge XIV, and Kurma XI; Fig. 1).

The second feature of interest is the perimortem projectile point injury to the mental symphysis. Both sharp-force injuries—such as those caused by projectile points—and craniofacial trauma in general are typically interpreted as evidence for violence (Jurmain, 2005:186–188; Jurmain et al., 2009). The ultimate mechanisms behind ancient injuries can never be known for certain (Judd and Redfern, 2012), but both the location and causative implement employed in the present case strongly indicate intentional, rather than accidental, trauma. While the injury was perimortem, its location on the mandible indicates that it was likely not a fatal blow. Whatever other perimortem insults may have contributed to this individual’s death, no direct evidence of them was observed on the rest of the skeleton.

Projectile injuries to the craniofacial region are known but relatively uncommon in the archaeological literature, most being to the calvaria (Becker, 1952; Etxeberria and Herrasti, 2007; Geber, 2012; Gordon, 2013; Guilaine and Zammit, 2001; Jurmain and Bellifemine, 1997; Lambert, 1997; Owens, 2007; Schulting, 2012; Smith, 2003; Watson et al., 2012). The head/neck region accounts for 25% of embedded projectile injuries noted by Lambert (1997) for prehistoric California, though other studies provide lower figures, 7–15% (Bill, 1862; Milner, 2005; Smith et al., 2007). Dentofacial projectile injuries specifically are even more rare in the archaeological record (e.g., Erdal, 2012; Jurmain et al., 2009; Pahl, 1983), perhaps reflecting the fact that, unless other injuries are received at the same time, many may not be lethal. Additionally, the face and head may be deliberately shielded from projectiles. In the middle Holocene Cis-Baikal, violent trauma was not particularly common, being documented on only three individuals (including this one) out of approximately 120 with relatively well-preserved skeletal remains excavated from three different LN-EBA cemeteries (Ust’-Ida I, Kurma XI, and Khuzhir-Nuge XIV; Fig. 1). Two of these three cases were perimortem.

Because there was no evidence of damage to the bone adjacent to the broken point found in the left orbit (Fig. 2), it is possible that it was placed intentionally on the left side of the face as a grave accompaniment prior to interment. On the other hand, the absence of bone damage does not negate the possibility that the broken point pierced the eye of the deceased at or around the time...
of death, representing an additional blow. Regardless of the context surrounding its deposition, the question was raised of whether the point tip embedded in the mandible and the broken projectile were, in fact, two pieces of the same artefact. Not only was the colour and type of stone similar, both being light grey chert, but the measurements of the two potentially conjoining ends were almost identical: 7.46 mm versus 7.5 mm in width and 1.87 mm versus 1.9 mm in thickness, for the broken end of the point and the visible end of the embedded tip, respectively (Figs. 3 and 10).

The broken point could not be transported out of Russia for imaging, so photographs of it were digitally merged with segmented images of the embedded tip obtained via SRµCT (Fig. 10). While the refit was not perfect, the overall dimensions and colour matched well. Several small fragments were missing, likely having been lost when the point tip shattered upon impact (Figs. 8 and 9). Indeed, the terminal end of the embedded tip is asymmetrical, suggesting that one or more fragments had spalled off around the same time. Despite the imperfect fit, we are quite confident that these represent two parts of a single projectile measuring 29.2 mm in length. The complete point, exhibiting oval convex edges and a concave base (Fig. 10), is typical of EBA projectiles in this part of Siberia (Okladnikov, 1950, 1955).

4. Summary and conclusions

The challenges presented by the Burial 48 mandible have allowed us to demonstrate the effectiveness of CT imaging technology—and synchrotron-based imaging, in particular—in helping to diagnose and better understand otherwise ambiguous skeletal and dental conditions. In this case, we identified two unusual but unrelated features on the same bone: probable bilateral incisor agenesis and perimortem trauma. The agenesis is one of the earliest cases involving the central mandibular incisors documented thus far, and the first in prehistoric Siberia. While exploring the geographical distribution and prevalence of dental agenesis is beyond the scope of this paper, we hope that its presentation will contribute to the growing body of literature on dental agenesis in general and mandibular incisor agenesis in particular.

The second feature examined, the embedded projectile tip, represents an almost certain deliberate assault that occurred at or around the time of death. Synchrotron CT imaging revealed that the tip had shattered upon impact and, furthermore, allowed us to digitally segment the fractured tip from the bone and successfully merge it with images of a broken projectile point recovered with the deceased.

Acknowledgements

This research is part of the Baikal-Hokkaido Archaeology Project (BHAP) based at the University of Alberta (Edmonton, Canada) and funded largely by the Social Sciences and Humanities Research Council of Canada (Grant No. 412-2011-1001). Thank you to Dr. George Belev, beamline scientist at the BioMedical Imaging and Therapy (BMIT) Beamline of the Canadian Light Source, for his assistance with the SRµCT, and to Chantal Kawaiik for assistance with the HR-pQCT imaging. Isaac Pratt is a Fellow in the Canadian Institutes of Health Research Training grant in Health Research Using Synchrotron Techniques (CIHR-THRUST). Finally, thanks go to Dr. Andrea Waters-Rist (Leiden University), Ms. Megan Clarke (University of Saskatchewan), and the associate editor and anonymous reviewers for their kind assistance with this manuscript.

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