

## Human mandibles and maxillae with tooth extraction signs of the Late–Final Jomon period from the Daimyojin site, Okuwa Village

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### Abstract

Intentional tooth extraction, practiced in the Japanese Islands during the Jomon period, is considered a symbolic act reflecting social affiliation. This paper examines 17 human jawbones, likely recovered during the 1962 excavation at the Daimyojin site in Nagano Prefecture, and belonging to the Late–Final Jomon period. Anatomical observations confirmed that all specimens were human and showed signs of both tooth loss and burning. Alveolar socket closure was most frequent in the canines, suggesting intentional extraction. These specimens provide additional evidence of symbolic bodily modification during the Jomon period, shedding light on social practices within Jomon culture.

### 要旨

縄文時代の日本列島の人々の間では、意図的な抜歯行為がみられ、社会的な所属を象徴するものであった可能性が考えられている。本稿では、長野県の大明神遺跡より1962年に発掘され、縄文時代後・晩期に属するとみられる17点のヒトの顎骨を調査した。観察により、各標本において、人骨の特徴を有することが確認され、加えて、生前における歯の脱落（歯槽閉鎖）や、被熱の痕跡が認められた。歯槽の閉鎖は犬歯に最も多く見られ、意図的な抜歯が示唆された。これらの標本は、縄文時代における象徴的な身体改変のさらなる証拠を提供し、縄文文化における社会的慣習の理解に貢献するものである。

### Introduction

Tooth extraction customs refer to the deliberate removal of healthy teeth for ritualistic purposes. These practices are believed to have begun appearing globally from the Neolithic period onward and are commonly associated with societies that had transitioned into tribal structures (Funahashi, 2010). Consequently, ritual tooth extraction has often been studied in terms of social organization and its complexity (Funahashi, 2010). In Japan, such customs have been identified from the Early Jomon period and are believed to have reached their peak during the Final Jomon period (e.g., Funahashi, 2010; Yamada, 2019). The teeth targeted for extraction, typically incisors and canines, are those visible to others, suggesting that the display of their absence itself may have held meaning (Yamada, 2019). Therefore, ritual tooth extraction in the Jomon period likely functioned as a symbolic act to affirm social affiliation and demonstrate conformity within a group. In this context, human remains showing signs of tooth extraction are of material significance, as they suggest that such cultural symbolic acts may have extended to even physical loss.

This paper presents several human skeletal remains with signs of tooth loss, excavated from the Daimyojin

site in Okuwa Village in the Kiso region, Nagano Prefecture. The site is situated on a flat area (35°41'08.6"N, 137°39'32.9"E) along the right bank of the upper Kiso River, in a mountainous region. Excavations conducted in 1962 and 1984–1985 revealed artifacts and features primarily attributed to the Late–Final Jomon period.

In the 1962 excavation, stone assemblages were detected in both the northeastern and southwestern parts of the excavation area, and pottery and lithics were collected. Additionally, in the southwestern stone assemblage, burned and fragmented bones were found scattered across an area of about 3 m<sup>2</sup>, extending to the bottom of the stone assemblage. Among these bone fragments, thirteen jawbones with signs of tooth extraction have been reported (Higuchi, 1983).

In the 1984–1985 excavation, ten stone assemblages, believed to belong to the Late–Final Jomon period, were discovered. In this investigation as well, pottery, lithics, and burned faunal remains, including human bones, have been reported. The human skeletal remains, including various anatomical regions, were attributed to at least two individuals (Shinya *et al.*, 1988). However, jawbones with signs of tooth extraction have not been reported in this excavation.

The human remains excavated in 1962 had been in the possession of the excavator but were subsequently lost. However, in recent years, the whereabouts of mandibles and maxillae with signs of tooth extraction, which are believed to have been recovered from the Daimyojin site, have been confirmed, and the specimens have been transferred to the Okuwa Village Museum of History and Folklore (Fig. 1). Although a photograph of a mandible has previously been published (Higuchi *et al.*, 1986), detailed information was unclear. Therefore, in this paper, direct observation was conducted, and several well-preserved specimens are illustrated.

### Materials and methods

The jawbones, which have been transferred to the Okuwa Village Museum of History and Folklore, are 17 specimens and are stored in a box (Fig. 1). Identification of animal species and skeletal elements of each specimen



**Fig. 1** Human mandibles and maxillae, likely recovered during the 1962 excavation at the Daimyojin site.

was conducted through visual inspection and morphological comparison with the human bone models (The 3B Scientific Skull Kit A290) and published morphological references (France, 2009; White *et al.*, 2011), and the presences of ante mortem tooth loss were assessed based on the closure of the alveolar socket. If the socket is closed, it indicates that the person continued to live after the tooth loss.

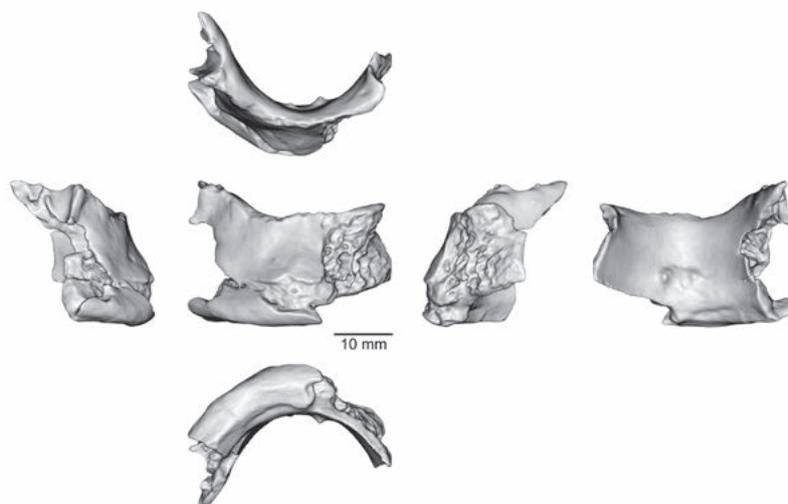
However, it is difficult to determine with certainty whether the tooth loss was due to customary extraction based only on the condition of the alveolar socket, and therefore, it is more appropriate to examine the issue from multiple perspectives. Since tooth loss and subsequent socket closure can also result from pathological causes, the criteria proposed by Hattori *et al.* (1996) were taken into account, and the following features, which can be easily observed with the naked eye, were examined. Firstly, the height of the alveolar bone is consistent with that of the adjacent teeth, with no evidence of bone resorption caused by periodontal disease. Secondly, there is no indication that the tooth was lost due to trauma or pathological causes such as caries, periodontitis, or alveolar abscess. Finally, the alveolar crest at the tooth-loss site exhibits a knife-edge shape. These features suggest the possibility of intentional tooth extraction.

The well-preserved specimens were 3D scanned using a scanner (Revopint Miraco Plus) to record their shape, and the open-source software CloudCompare (CloudCompare 2.13, 2024) was used to draw orthographic views of the specimens. Specimen numbers were arbitrarily assigned by the authors according to storage order (Fig. 1).

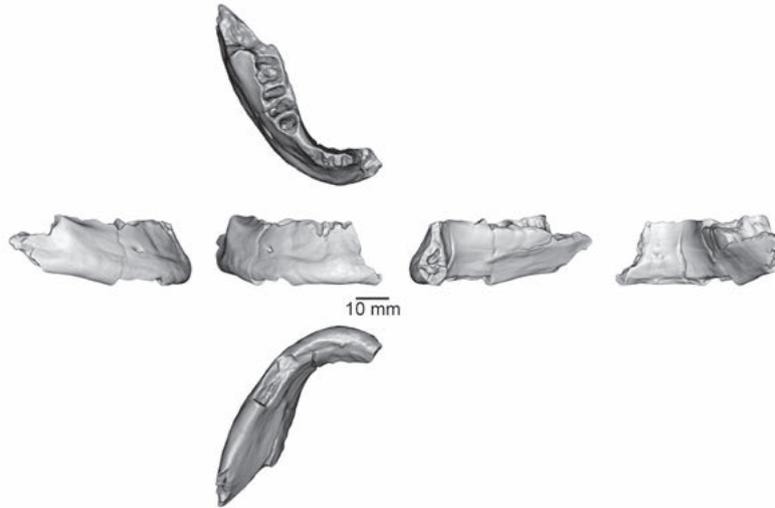
## Results

All 17 specimens exhibited characteristics of human bone (*Homo sapiens*), comprising 12 mandibles and 5 maxillae. Each specimen showed a grayish white coloration and visible cracking, suggesting exposure to high temperature (Fernandez-Jalvo and Andrews, 2016). No teeth were preserved in the specimens, and no refittable fragments were found. The minimum number of individuals was estimated to be nine, based on the presence of mental protuberances of the mandibles. 3D scanned specimens are shown in Figures 2–8. The conditions of the alveolar sockets, whether open or closed, for each jawbone are summarized in Table 1.

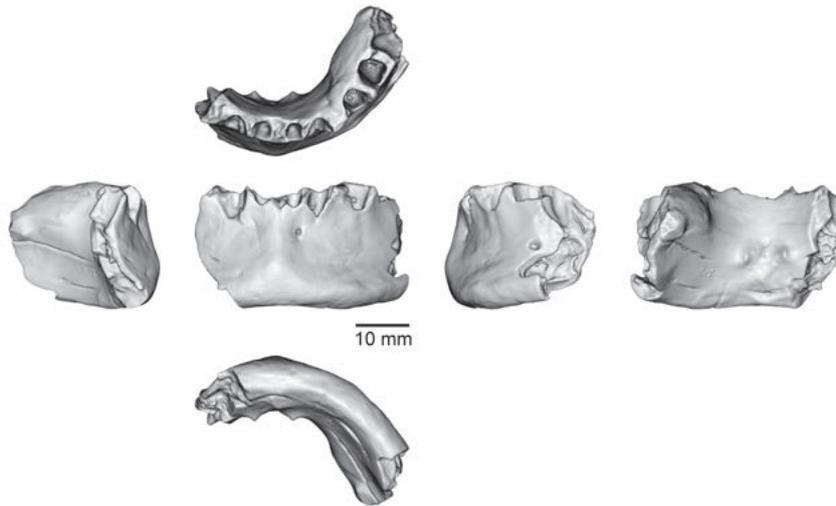
Among the 5 maxillae, closed alveoli were observed in at least two canine sockets of the maxillae. Among the mandibles, all eight canine sockets (100%) showed closure, along with 3 of 7 first premolar sockets (approximately 43%), and at least 9 of 28 incisor sockets (approximately 32%). In contrast, none of the 15 sockets for second



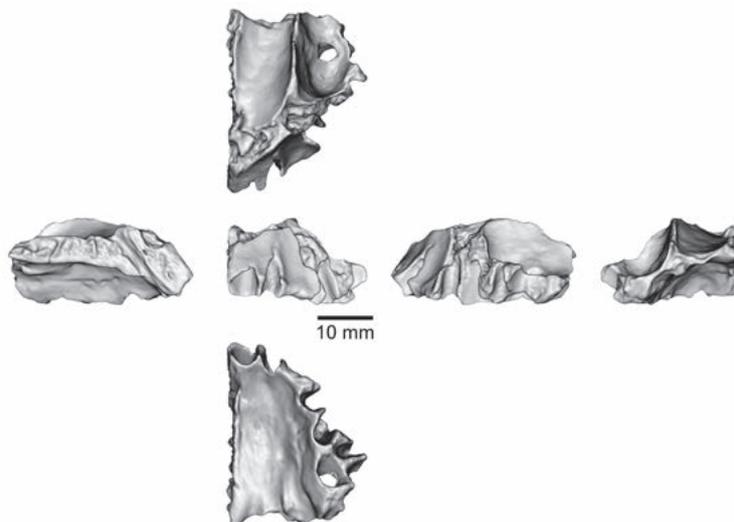
**Fig. 2** Orthographic projections of specimen No. 1 from six cardinal directions.



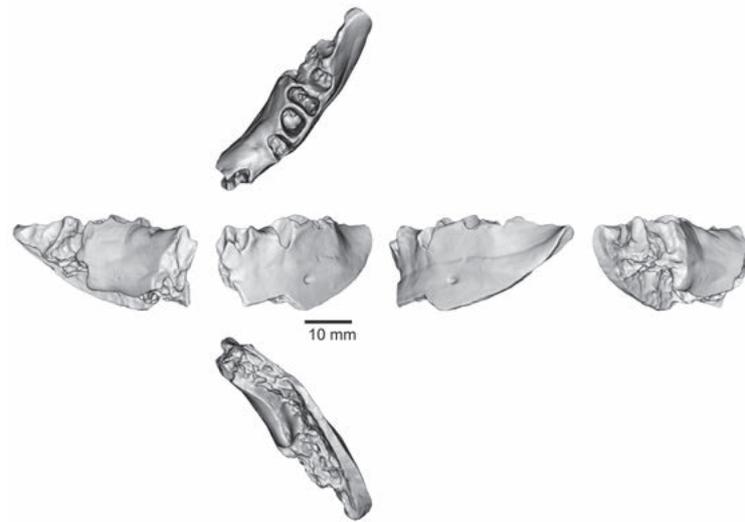
**Fig. 3** Orthographic projections of specimen No. 2 from six cardinal directions.



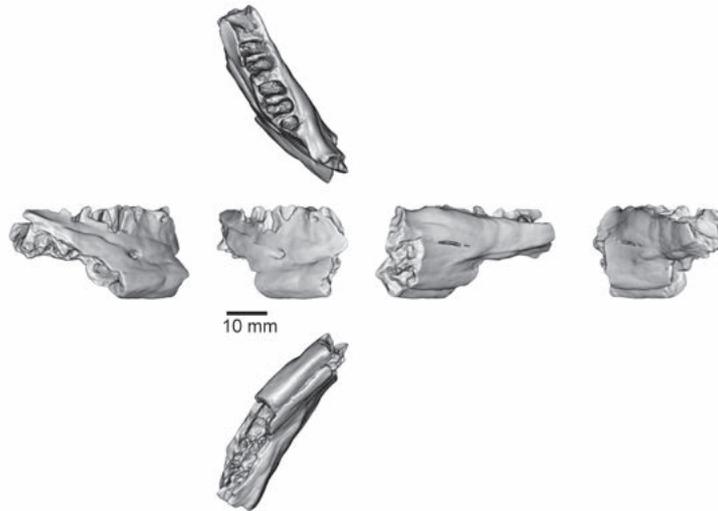
**Fig. 4** Orthographic projections of specimen No. 3 from six cardinal directions.



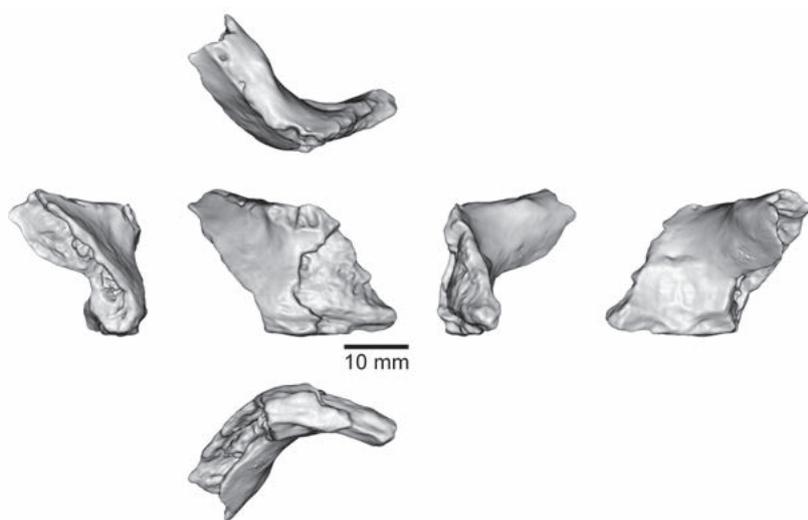
**Fig. 5** Orthographic projections of specimen No. 10 from six cardinal directions.



**Fig. 6** Orthographic projections of specimen No. 11 from six cardinal directions.



**Fig. 7** Orthographic projections of specimen No. 16 from six cardinal directions.



**Fig. 8** Orthographic projections of specimen No. 17 from six cardinal directions.

**Table 1** Alveolar socket conditions of mandibles and maxillae from the Daimyojin site. I: incisor; C: canine; P: premolar; M: molar; y: present; n: absent; NA: not applicable.

No.	Element	ID	Mass (g)	Right										Left				Mental protuberance	Remarks			
				M3	M2	M1	P4 (P2)	P3 (P1)	C	I2	I1	I1	I2	C	P3 (P1)	P4 (P2)	M1			M2	M3	
1	Mandible	None	4.0	x	x	x	(O)	O	O	O	O	O	O	O	x	x	x	x	x	x	y	
2	Mandible	8-2	13.8	x	●	●	O	O	●	●	●	●	●	x	x	x	x	x	x	x	y	11,2 were also extracted (?)
3	Mandible	75	9.6	x	x	x	x	x	●	●	●	●	●	●	O	x	x	x	x	x	y	
4	Maxilla	64	2.2	x	x	x	●	(O)	●	●	●	●	●	x	x	x	x	x	x	x	NA	
5	Maxilla	67	0.7	x	x	x	x	x	x	●	●	●	●	(O)	x	x	x	x	x	x	NA	
6	Mandible	2	5.1	x	x	x	x	(O)	●	●	●	●	●	x	x	x	x	x	x	x	y	
7	Mandible	77	2.9	x	x	x	x	(O)	●	●	●	●	●	x	x	x	x	x	x	x	y	
8	Maxilla	65	0.8	x	x	x	x	x	x	x	x	x	x	(O)	x	x	x	x	x	x	NA	
9	Mandible	74	3.3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	●	n	
10	Maxilla	63	3.1	x	x	x	x	x	x	x	x	x	x	x	O	●	●	●	●	●	NA	
11	Mandible	84	5.9	x	x	x	x	x	x	x	x	x	x	x	O	●	●	●	●	●	n	
12	Maxilla	66	2.1	x	x	x	x	x	x	x	x	x	x	x	O	●	●	●	●	●	NA	Slightly weathered (?)
13	Mandible	80	2.9	x	x	x	x	x	O	O	O	O	O	x	x	x	x	x	x	x	y	
14	Mandible	76	6.9	x	x	x	●	O	●	●	●	●	●	x	x	x	x	x	x	x	y	
15	Mandible	83	2.6	x	x	x	x	x	x	x	x	x	x	x	O	●	●	●	●	●	y	
16	Mandible	82	8.6	x	●	●	O	O	x	x	x	x	x	x	x	x	x	x	x	x	n	
17	Mandible	81	3.6	x	x	x	O	O	O	O	O	O	O	x	x	x	x	x	x	x	y	11,2 sockets slightly remain

● Alveolar socket remaining after tooth loss

O Closed alveolar socket, possibly indicating previous extraction (ante mortem tooth loss)

(O) Possible closed alveolar socket

x Diagnosis not possible due to bone destruction

premolar–second molar teeth (0%) exhibited closure. Notably, in specimen No. 2, although the incisor sockets were intact, the sockets were smaller compared to those of specimen No. 3, suggesting possible ante-mortem tooth loss.

The alveolar bones in the observed cases of closure showed heights comparable to those of the adjacent teeth, and the alveolar crests were to some extent reduced in thickness. At least in the alveolar closure sites of specimens No. 1 and 2, the alveolar crests were clearly thinned to a knife-edge form. The surfaces of the alveolar bones did not exhibit a spongy appearance, which is characteristic of tooth loss caused by severe periodontal disease (Funahashi, 2010: pp. 88–89).

### **Discussion and conclusion**

Specimen No. 2 closely resembles the mandible previously published in a photograph (Higuchi *et al.*, 1986: p. 22), supporting the attribution of all specimens to the Daimyojin site. The total number of specimens analyzed in this study exceeds previous reports by four (Higuchi, 1983), possibly due to ambiguous alveolar closure observed in six specimens (No. 4–9).

In the observed cases of alveolar closure among the 17 specimens, the height of the alveolar bone was consistent with that of the adjacent teeth, and the alveolar crest appeared thinned. No spongy structure was observed on the surface of the alveolar bone, and thus it was considered unlikely that the tooth loss resulted from pathological causes (Hattori *et al.*, 1996; Funahashi, 2010: pp. 88–89). However, in cases (Nos. 1, 13, and 17) where alveolar closure was observed in multiple teeth, including the incisors, the possibility of tooth loss due to trauma cannot be overlooked. In addition, closed alveolar sockets were observed in the canines, first premolars, and incisors, with the canine sockets showing a 100% closure rate. The above observations, together with the concentration of closed alveoli in specific tooth positions, suggest that the teeth were likely intentionally extracted.

Although the mandibles and maxillae with signs of tooth extraction were stored together in a single box, it remains unclear to what extent jawbones without extraction signs or other skeletal elements were originally recovered. Therefore, it is not possible to estimate the experience rate of intentional tooth extraction within the population at the Daimyojin site.

In the Kiso region, other examples of human skeletal remains of the Jomon period are known, including those from the Matsubari site and the Shibagaito site (Nishizawa, 1982; Shigehara *et al.*, 2019). However, at present, the Daimyojin site remains the only case in the region where multiple jawbones exhibiting clear evidence of tooth extraction have been confirmed, making it a valuable source of data. The whereabouts of other materials excavated during the 1962 excavation, which were originally associated with these specimens, remain unknown, and their rediscovery is expected.

### **Acknowledgements**

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