Introduction

In the current standard high-school history textbook used in Japan, the Jomon period is described as having extended from about 12000 to 2300 years ago, in a natural environment that was largely the same as it is today. This was the economic stage of food gathering, and Jomon pottery was used. Group sizes were about 20–30 people, and even if there was a leader, no real difference in status or wealth was seen. Generally, during the Jomon period, people were poor, and socially, they enjoyed equality. This probably matches the image of the Jomon period that many people have. However, in contemporary Jomon studies, this image is not generally recognized and the period is now seen as a complex hunter-gatherer society with a high degree of cultural content. Of course, this change in outlook reflects new discoveries about the relative positions of graves, the presence or absence therein of accessories and grave goods, head orientations of corpses, types of tooth extraction, and so on. In recent years, research using anthropological information—both physical and biological—obtained from excavated human bones has begun to elucidate the social structures of that time. This approach is called bioarchaeology. In the analysis of the social structure of the Jomon period, bioarchaeology has three principal uses: to reconstruct burial subgroups by \(^{14}\text{C}\) dating of human bones; to estimate genetic relationships between adjacent human bones; and to estimate the proportion of migrants in the overall population. Here, I review the analysis of the cemetery of the Odake shell-mound as an example of bioarchaeological research while touching on the history of archaeological research of Jomon social structure.

Key words: bioarchaeology, Jomon period, social structure

History of Jomon studies

Grand theories, such as the materialistic view of history and the view that divides it into developmental stages, which are considered obsolete in many areas of cultural study, still occupy the center of the study of Japanese history. The thesis that the social structure changes in an evolutionary pattern from matrilineal to patrilineal is generally seen, and archaeological research is conducted that applies this orientation to Japanese history. As a result, the questions of the type of kinship (matrilineal, bilateral, or patrilineal) a past human society had and of the type of structure within the group (equality, hierarchy, or class) become central to the discussion. These remain open historical problems in the study of Jomon societies.

In elucidating the social structure of the Jomon period from this point of view, graves and burial systems, as mirrors of society, are fundamental targets for analyses. This approach is called bioarchaeology. In the analysis of the social structure of the Jomon period, bioarchaeology has three principal uses: to reconstruct burial subgroups by \(^{14}\text{C}\) dating of human bones; to estimate genetic relationships between adjacent human bones; and to estimate the proportion of migrants in the overall population. Here, I review the analysis of the cemetery of the Odake shell-mound as an example of bioarchaeological research while touching on the history of archaeological research of Jomon social structure.

Key words: bioarchaeology, Jomon period, social structure

Abstract Archaeological study of the social structure of the Jomon period has advanced through discoveries about the relative positions of graves, the presence or absence therein of accessories and grave goods, head orientations of corpses, types of tooth extraction, and so on. In recent years, research using anthropological information—both physical and biological—obtained from excavated human bones has begun to elucidate the social structures of that time. This approach is called bioarchaeology. In the analysis of the social structure of the Jomon period, bioarchaeology has three principal uses: to reconstruct burial subgroups by \(^{14}\text{C}\) dating of human bones; to estimate genetic relationships between adjacent human bones; and to estimate the proportion of migrants in the overall population. Here, I review the analysis of the cemetery of the Odake shell-mound as an example of bioarchaeological research while touching on the history of archaeological research of Jomon social structure.

Key words: bioarchaeology, Jomon period, social structure

Review

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children were buried in pottery coffins might have been due to a view that compared pottery to women, and he considered that Jomon society was matrilineal (Okamoto, 1956).

Kensaku Hayashi focused on the direction of the head orientation of the buried corpses and concluded that it reflected the structure of the group that occupied the settlement. Furthermore, he argued that cemeteries were divided according to a plan (Hayashi, 1977) and hypothesized that divisions within cemeteries were made by the family (Hayashi, 1979). Certainly, in cemeteries of the Jomon period, corpses are concentrated in certain areas called maison shogun (burial subgroups). Hayashi thought that these burial subgroups were made up of people belonging to a single family.

Hideji Harunari divided tooth extraction patterns commonly seen in Jomon remains into two types: one that removed the lower incisors and the upper canines (4I type) and another that removed the lower canines and upper canines (2C type). Harunari reported that people with the 4I type patterns were the original inhabitants of their settlement and those of the 2C type were newcomers from other settlements who joined the settlement through marriage (Harunari, 1973, 1979, 1980). Tooth extraction would have been a visible symbol to the buried person and to those around him during life. Thus, it probably reflects his/her social background. If Harunari’s hypothesis is correct, combining the type of tooth extraction and identification by sex, it is possible to hypothesize whether the settlement had a matrilineal or patrilineal organization. Harunari applied this method to archaeological sites with human bones all over Japan and found that the Jomon society changed from matrilineal to bilateral and finally patrilineal. For 40 years, Harunari’s tooth extraction hypothesis had significant influence on the public perception of social organization in the Jomon period. Since then, although other work has been conducted that seems to confirm or refute Harunari’s hypothesis, biological information is increasingly frequently used to examine the social structure of the Jomon period. For example, Yoshiyuki Tanaka developed a theory of Jomon society using measurements of the crown of the tooth, and Kyoko Funahashi interpreted Jomon society through the age at which tooth extraction conducted, and a whole series of works have been made as extension of Harunari’s studies (Yamada, 1997, 2014, 2015; Tanaka and Doi, 1988; Funahashi, 2003).

Harunari’s hypothesis was based on the premise that both 4I and 2C type human bones were buried in the same period. However, Soichiro Kusaka found a large time lag between the burial times of 4I and 2C type human skeletons excavated from the Inariyama shell-mound in Aichi Prefecture, a discovery that challenged the premise of the Harunari hypothesis (Kusaka et al., 2018). This discrepancy underlined the importance of $^{14}$C dating of excavated human bones, and it is now widely recognized that bioarchaeological verification is essential for archaeological interpretations.

Regardless of the determination of exact times, the archaeological methods used to investigate the burial system of Jomon society, including the work of Hayashi and Harunari, are too simplified. Basically, human bones are grouped in relation to their relative spatiotemporal arrangements, and they are cross-analyzed with burial attributes, such as sex, tooth extraction type, head orientation, and the presence or absence of accessories and burial goods; then, these specimens all together are considered a descent group. However, from recent research, based on the results of excavations, such as at the Karinba site in Hokkaido, it has been claimed that a stratified society existed during the Jomon period. And it has also been asserted that the belief that Jomon society was poor and therefore egalitarian, widely seen in conventional social research on the Jomon period, has its roots in prejudice derived from the curse of the progressive view of history (Kosugi, 1991). Therefore, it is not sufficient to understand the aforementioned differences simply in terms of descent groups (Yamada, 2014). To discuss differences found at burial sites and in individual graves, it must be established, as accurately as possible, on what principles the cemetery was constructed and what temporal transitions it had undergone. For this, it is necessary to propose a reasonable hypothesis and test it.

**Methodological development of Jomon social research by bioarchaeology**

Bioarchaeology is suited to this investigation. In Europe and America, this method has been systematized by Larsen, Katzenberg, Saunders, and others (Larsen, 1997; Katzenberg and Saunders, 2000). A good archaeological hypothesis is the key to successful bioarchaeological research. First, let us describe how to construct one.

The information that can be obtained from a grave is called the burial attribute (Yamada, 2014). The attributes brought into the grave can be classified according to the occasion of the addition. Attributes added when the buried person was still alive may have a different meaning from those added when the burial was performed after death, and those added when the corpse was buried. These attributes are called premortem additional attributes and postmortem additional attributes, respectively. The archaeologically observable attributes can be classified as follows.

Premortem additional attributes are roughly classified into two types. Type 1 attributes are performed directly on the body and are irreversible; these include tooth extraction and body modification. Type 2 attributes are removable or reversible, including accessories, hair dyeing, and body painting. Biological information drawn from the human bones, such as sex and age, observable traces of disease or injury on bones, the dietary reconstruction based on carbon/nitrogen isotope ratios, and human mobility reconstructed by strontium isotopes, kinship relations described by DNA analysis, the estimated number of pregnancies, and radiocarbon dating directly conducted on human bones should be counted as type 1 premortem additional attributes.

Postmortem attributes are roughly classified into three types. Type 1 attributes are those added to the grave itself, such as the position of the grave, its shape, scale, and axial direction, its upper structure, and the coffin type. Type 2 attributes are those added to the corpse itself, such as the burial posture, head orientation, face orientation, corpse damage, intentional group burial, and so on. Type 3 attributes are added during the funeral ritual itself, such as grave goods, holding stones, covering pottery, clothing or accessories.
sprayed red pigment, and so on. In addition, these attributes can be categorized as visible and invisible, i.e. those that can be visually confirmed even after burial and those that are hidden by burial soil and cannot be visually confirmed from the outside, respectively.

The pre-mortem attributes acquired during life would have been recognized by the subject and others, and they clearly indicate an aspect of the position or state of the person, such as sex, age, status, descent, origin, and presence or absence of illness, among others. In particular, type 1 pre-mortem additional attributes, such as body modifications, always show the consciousness of the person or others throughout his or her life. However, type 2 post-mortem attributes may have been brought to the grave or added on a special occasion. As only a few accessories and grave goods are typically excavated from any given grave, it can be assumed that it is extremely dangerous to derive an entire social structure using their presence or absence alone. To restore the social structure, we must determine what these attributes correspond to. Post-mortem attributes are added by those who performed the burial and may be defined by the buried person’s life position, descent, origin, ability, and so on, while also reflecting the burial person’s will and judgment of magical response to the cause of death and the view of the after-life. Therefore, it must be recognized that any derivation of a social structure using only post-mortem additional attributes will always involve some ambiguity.

Post-mortem attributes can be broadly classified into the following two types in relation to the person doing the burial (the burial person).

Visible attributes are what the grave-digger and others can see after burial. This includes burial position, head orientation (assuming appropriate superstructure), standing stones, earthen graves, tombstones, grave goods on the ground, and so on. Many of these are not attributes directly added to the body.

Invisible attributes are what cannot be seen by contemporaries after the burial. Burial posture, head orientation (in the absence of appropriate superstructure), accessories, burial goods in the pottery, sprayed red pigment, shell pebbles, stone flakes, white sand, wrappings for the body (the coffin, a bag, or something similar), damage to the body, and so on. Many of these are added directly to the body.

The phenotypes of these two major attributes may differ, depending on the sex, age, cause of death, descent, origin, kinship, status, and abilities of the buried person. For example, visible attributes can bring the memory of the dead to mind by looking at them, even after burial. Therefore, as a general tendency, visible attributes are more likely to express the social reality of the deceased, including descent, origin, and status. It is also possible that the individual causes of death and magical responses to other worldviews were performed on the corpse itself.

Using this categorization of attributes, a methodological model of the Jomon period grave systems and social research can be established. Moreover, considering the above attributes, the methodological limit points can be identified. For example, the following archaeological models could be established.

**Primary model**: Analysis of pre-mortem attributes and post-mortem attributes (visible and invisible). This can be done when all the aforementioned burial attributes are available for study. If this is realized, it will be possible to use the individual features of each burial to develop an analysis of social structure, including descent, class, and aspects of spiritual culture, such as a view of other worlds.

**Secondary model**: Analysis using only one post-mortem attribute. This corresponds to cases where investigations consider only the position and shape of the grave or perhaps the presence or absence of grave goods, for example. Various interpretations are possible, but their validity cannot be assumed to be high.

### How to use biological information for archaeological analyses

Biological methods can support archaeological analyses in three main types of cases. The first is the extraction of burial subgroups by dating human bones, the second estimates genetic relationships between adjacent burials, and the third estimates immigration. I will review some examples on the Jomon social structures in the following section.

#### Extraction of burial subgroups by dating human bones

The time of a burial is often determined by the type of accessory and pottery associated with the burials. Few burial items are found in the Jomon period, so pottery shards excavated from a burial pit or pottery excavated from around it are often used to estimate the cultural period. However, as this is an uncertain method, it is desirable to date the human bone itself and examine its consistency with the pottery type at the same time.

For example, in a 2010 survey of the Ikawazu shell-mound in Aichi Prefecture, six human bones buried in a narrow area were excavated (Figure 1) (Sagisaka, 2015). It was inferred that these human bones constituted one burial subgroup. In addition, Gokanmori and Mamizuka types of pottery from the end of the Jomon period were excavated from around the bones, and the period of these human bones was also estimated to be from the time of Gokanmori to Mamizuka types. Gokanmori pottery is dated 2845–2755 cal BP, and Mamizuka pottery is dated 2695–2355 cal BP (Kobayashi, 2017). On the other hand, according to the direct radiocarbon dating on each burial, it was concluded that five of six bodies were buried around 2700–2400 cal BP, and the last one was buried from 2500 to 2300 cal BP, indicating a limited range (Figure 2) (Yoneda, 2014). In this case, as the burial date and the period of the pottery may be the same, the six human bones are considered to form one burial subgroup. In the next stage of the research, it will be possible to investigate the relationships between these individuals. We also succeeded in extracting burial subgroups from the cemetery at the Tsugumo shell-mound in Okayama Prefecture (Yamada et al., 2020). Thus, dating of an excavated bone is an effective method of extracting burial subgroups from a set of graves.

#### Estimating the genetic relationships between adjacent human bones

If two human bones are found side by side, or if two hu-
Man bones are excavated from the same grave, archaeologists often assume that they are related. However, this is only a hypothesis and needs to be tested. Until the analysis of nuclear DNA became possible, the relationship between adjacent human bones was assessed using non-metric cranial trait variants, such as metopism, that could be observed on the skull. Assessing the relationships between human bones using non-metric traits is common in bioar-

Figure 1. Burial subgroup from the Ikawazu shell-mound in a 2010 survey.

Figure 2. $^{14}$C dating of skeletons from the Ikawazu shell-mound in a 2010 survey.
In Japan, for example, an archaeological excavation at point C in the Hobi shell-mound, Aichi Prefecture, in 1941 showed 15 human bones in one burial subgroup (Figure 3). It is probable that these bones were buried in the middle of the late Jomon, judging from the accompanying pottery. It should be noted that among these bones, four individuals exhibited metopism (Yamada, 2014). In modern humans, the incidence of metopism is less than about 7.0% (Dodo, 1981). Therefore, by probability alone, the chance of metopism occurring in four randomly selected human individuals is 0.0024% to the fifth power, or vanishingly improbable. Considering that trait variants in cranial morphology are a genetic trait, we can assume that the burial subgroup of Hobi shell-mound Point C included people with a genetic connection. The group of 15 people, some of whom were genetically related, was probably a family group including up to three generations (Yamada, 2014). In addition, the Nakazuma shell-mound in Ibaraki Prefecture and the Hikozaki shell-mound in Okayama Prefecture are cases where human bones that shared non-metric variations, such as metopism and hypoglossal canal bridging, were included in a single burial subgroup. As mentioned earlier, to prove there actually is a genetic or kinship relationship among human bones in the burial subgroup, it is necessary to study the nuclear DNA. However, if abnormal epicanthic suture, such as metopism and os Inca, are observed in multiple human bones within a single burial subgroup, it can be presumed that the burial subgroup contains genetically related individuals. An example of the relationship between human bones buried in close proximity verified using nuclear DNA is seen in the Isoma rock-shelter site in Wakayama Prefecture in the Kofun period (Adachi et al., 2021). This method is already being put to practical use.

**Estimating migrants to the resident group of the villages**

It is possible to identify migrants from another settlement by analyzing food habits established using carbon and nitrogen isotope ratios and the analysis of strontium isotopes. Individuals with outlying carbon and nitrogen isotope ratios are likely to represent migrants from other places. In such cases, marriage can be assumed to be a socially recognized migration opportunity within a group. If the sex of the migrants is biased toward either men or women, it can be presumed that the host group receives that sex at marriage and, thus, shows lineage through the other sex, i.e. it is matrilineal or patrilineal, respectively.

Soichiro Kusaka and his colleagues analyzed the strontium isotopes of bones excavated from the Yoshigo shell-mound in Aichi Prefecture to determine which individuals might have been migrants to the settlement (Kusaka et al., 2009; Kusaka, 2012). In all, 14 of the 39 human bones excavated from the Yoshigo shell-mound were identified as migrants (Figure 4). Both 4I and 2C type tooth extractions were included in estimated migrants, which does not support Harunari’s hypothesis. Furthermore, both male and female migrants were found. From this, it seems probable that the people who lived at the Yoshigo shell-mound could have constituted a bilateral society, in which both men and women entered or left at the time of marriage.
An example of bioarchaeological investigation of a Jomon site

Here, I present an analysis of the cemetery at the Odake shell-mound, Toyama Prefecture, as an example of analyzing the social structure at one archaeological site by adopting multiple methods (Yamada, 2015). To that end, I posit a hypothesis.

To begin with, it should be established whether the graves belonged to one settlement alone or whether multiple settlements were involved in its formation. At the Odake shell-mound, 91 human bones from the Early Jomon period have been excavated, and ten pit-house dwellings were confirmed at about the same time. The floor space of the pit dwelling varied from about 42 to about 6.3 m², and if one person needs about 3 m² to live in, about 2–13 people could live in each building. Thus, it can be calculated that about 57 people could live in the confirmed pit-houses. These houses spread outside the survey area, but relative to the extent of the ruins, it is highly possibly that there were nearly twice as many pit-houses at this site. Since the scales of both the estimated total population and the number of human bones excavated from the cemetery are not so different and they are well-balanced, I assume that the cemetery at the Odake shell-mound was related to a single settlement, i.e. the people who lived at the site (the Odake people). The graves at the Odake shell-mound are disturbed, and many of them cannot provide the burial attributes necessary for a grave system analysis, such as their upper structure and scale. In addition, in many cases, the human bone itself is damaged or bones of other individuals are mixed in because of disturbance, so the burial attributes that can be examined are limited. However, on the other hand, physicochemical analysis was conducted, including carbon and nitrogen isotope analyses, mitochondrial DNA (mtDNA) analyses, and radiocarbon dating.

Extraction of burial subgroups by dating human bones

The cemetery at the Odake shell-mound can be roughly divided into four periods: phase I to phase IV (Table 1). However, burials likely took place continuously (Hayase and Ohara, 2014). The upper structures of the grave and the presence or absence of grave goods could not be confirmed. Therefore, only the relative positional relationships of the graves and the head orientations can be used for the analysis of the social structure.

Transition of burial subgroups in the Odake shell-mound

The distribution of human bones excavated from the Odake shell-mound fall into several corpse groups. The corpse group simply means that the corpses are spatially organized. Figure 5 shows the distribution of the corpse groups at each phase. Those corpse groups surrounded by a solid line are most likely cohesive groups, and those joined by a broken line may have spread outside the survey area or have an original attribution that is lost because of disturbance. However, the corpse groups a–r were not independent of each other. Considering the fate of the corpse groups from Figure 5, they seem to be divided into about eight genealogies. These eight genealogies of the corpse groups probably correspond to the burial subgroup. Table 2 shows the correspondence between the corpse groups and the burial subgroups at each phase. Among these, burial subgroups 1 and 3 were proactively present throughout almost all phases, and some of them existed only in phase I, such as burial subgroup 4, and then disappeared. Therefore, I would like to focus on burial subgroups 1 and 3.

Analysis by head orientation

The head orientation is regulated in burial subgroup 1 in the range from west–northwest to south between no. 19 (N63°W) and no. 20 (N177°W). Within this burial subgroup, the head orientation was regulated to some extent, centering on the west side. However, grave no. 64 had the orientation N117°E, which is almost the opposite of the others (reverse position). In addition, it had a slightly different burial attribute from the others, with a large stone on the head or chest. Further, this individual was unusual among the inhabitants at the Odake shell-mounds. Thus, no. 64 is somewhat atypical of burial subgroup 1. In burial subgroup 3, there are two sets of head orientation, that between no. 76 (N63°W) and no. 3 (N139°W) (cluster I), and between no. 2 (N68°E) and no. 51 (N82°E) (cluster II). The two have a dichotomous appearance. Cluster I features many cases of corpse groups c and j, and cluster II shows cases of corpse groups o and p. Part of cluster I is slightly older than cluster II, and there may be a time lag in the head orientation in this subgroup. It is very interesting to note that a large stone was placed on the head or chest in a burial in cluster II, no. 30, and an exceptional head orientation was seen in no. 41.

Analysis of burial posture

In burial subgroup 1, there were ten cases in which the burial posture is supine and flexed, one case in which the left side is lain upon and flexed, and four cases in which the right side is lain upon and flexed. In burial subgroup 3, there were eight cases of supine and flexed burial, and two cases of left side lain upon and flexed burials. It is interesting that only burial subgroup 1 has many cases of the lower right side lain and flexed burial. This burial posture is limited to women and children. The reason for the frequent occurrence of such burial postures in a particular burial subgroup is unknown,
Table 1. The attributes of skeletons excavated from the Odake shell-mound

| No. | Sex       | Age  | Burial posture | Burial form | Head orientation | Accessories | Grave goods | Large stone placed on the corpse | Phase | Corpse group | Burial subgroup | Tooth extraction | Remarks                                      |
|-----|-----------|------|----------------|-------------|------------------|-------------|-------------|-----------------------------|-------|--------------|-----------------|-----------------|----------------------------------------------|
| 74  | Unknown   | About 1 | Lower right side lying; flexed | Single; primary | N81W             |             |             | 1             | I     | a            | I               |                  | Disturbed                                   |
| 44  | Unknown   | About 10 | Lower right side lying; flexed | Single; primary | N109W            |             |             | 1             | I     | a            | I               |                  | Abnormal attrition                            |
| 42  | Male      | Old   | Supine; flexed | Single; primary | N74W             | Grindstone 1 | Present     | I             | II    | g            | I               | Carbon–nitrogen isotope ratio is the same as salmon |
| 16  | Female?   | Adult | Jointed; secondary |              |                  |             |             | II            | g     | I            | I               | Both upper second incisors, the hip joint was wide open and may have been wrapped in an organic bag |
| 61  | Female    | Adult | Lower right side lying; flexed | Single; primary | N152W            | Present     | II          | g            | I     |              | I               |                  | Abnormal attrition                            |
| 46  | Male      | Adult | Supine; flexed | Single; primary | N87W             |             |             | II            | g     | I            | I               |                  | Disturbed                                   |
| 64  | Male      | Juvenile | Supine; flexed | Single; primary | N117E            | Present     | II          | h            | I     |              | I               |                  | Disturbed                                   |
| 20  | Female?   | Adult | Lower right side lying; flexed | Single; primary | N177W            |             |             | II            | h     | I            | I               |                  | Abnormal attrition                            |
| 47  | Male?     | Adult | Supine; flexed | Single; secondary |                |             | II          | h            | I     |              | I               |                  | Abnormal attrition                            |
| 67  | Male      | Juvenile | Supine; flexed | Single; primary | N82W             |             |             | II          | h     | I            | I               |                  | Abnormal attrition                            |
| 1   | Male      | Juvenile | Supine; flexed | Single; primary | Present         | III         | i           | I            | I     |              | I               |                  | Abnormal attrition                            |
| 35  | Female?   | Adult | Single; secondary | Small pottery | Present?         | III         | i           | I            | I     |              | I               |                  | Abnormal attrition                            |
| 34  | Male      | Adult | Upper left side lying; flexed | Single; primary | (W)             |             | III         | i            | I     |              | I               |                  | Abnormal attrition                            |
| 38  | Male      | Mature | Supine; flexed | Single?, primary | N93W            |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 14  | Male      | Adult | Supine; flexed | Single?, primary | (S)             |          | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 36  | Male      | Adult | Supine; flexed | Single; primary | Stone weight 2   |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 63  | Male      | Mature | Supine; flexed | Single; secondary |                |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 18  | Male      | Old   | Upper left side lying; flexed | Single; primary | (N)             |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 39  | Female    | Adult | Lower right side lying; flexed | Single; primary | N164W            |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 19  | Male      | Juvenile | Supine; flexed | Single?, primary | N63W            |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 75  | Male      | Adult | Upper left side lying; flexed | Single?, primary | N140E            | Necklace 1  | Stone knife 1 | IV         | m     | I            | I               |                  | Abnormal attrition                            |
| 79  | Unknown   | about 10 | Lower right side lying; flexed | Single?, primary | N140E            | Necklace 1  | Stone knife 1 | IV         | m     | I            | I               |                  | Abnormal attrition                            |
| 31  | Unknown   | Adult  | Upper left side lying; flexed | Single; primary | (E)             |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 29  | Female    | Adult  | Upper left side lying; flexed | Single; primary | N140E            | Necklace 1  | Stone knife 1 | IV         | m     | I            | I               |                  | Abnormal attrition                            |
| 27  | Female    | Juvenile | Supine; flexed | Single; primary | Stone weight 2   |             | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 15  | Male      | Adult  | Upper left side lying; flexed | Single; primary | N63W             | Scrape 1    |             | I           | c     | 3            | I               |                  | Abnormal attrition                            |
| 33  | Male      | Adult  | Upper left side lying; flexed | Single; primary | N85W             |             | I           | c           | 3     |              | I               |                  | Abnormal attrition                            |
| 76  | Male      | Mature | Supine; flexed | Single; primary | Ground stone axes 2 | Present | III         | i           | I     |              | I               |                  | Abnormal attrition                            |
| 72  | Unknown   | about 5 | Supine; flexed | Single; primary | Necklace 1      |             | I           | c           | 3     |              | I               |                  | Abnormal attrition                            |
| 52  | Unknown   | Unknown |                |              |                 |             | III         | j           | 3     |              | I               |                  | Disturbed                                   |
| 53  | Male      | Adult  |                |              |                 |             | III         | j           | 3     |              | I               |                  | Disturbed                                   |
| 41  | Male      | Adult  | Supine; flexed | Single; primary | (N)             | Present     | III         | j           | 3     | ear exostosis | I               |                  | Disturbed                                   |
| 41  | Male      | Adult  | Supine; flexed | Single; primary | (N)             | Present     | III         | j           | 3     | ear exostosis | I               |                  | Disturbed                                   |
but in this burial group, probably a small family group, there may have been some reasons for women and children to be buried in this way. This is suggestive in considering the attribution of children who seemed to belong to the original descent group.

Burial practice of using a large stone

One characteristic burial at the Odake shell-mound involves putting a large stone on the head or chest. This practice was first identified long ago, probably in a survey of the Kou site in Osaka Prefecture in 1917 (Hamada, 1918), and has since been found in a range of archaeological sites of the Early Jomon period. The most distinctive feature of this type of burial is the placement of head-sized pebbles and flat stones on the body of the buried person, especially on the head or chest. Thus, this is a special case of burial. This may have been done to prevent the dead from reviving and doing harm (Hasebe, 1920; Koganei, 1923). At the Odake shell-mound, all cases buried with a large stone are adult males, but this tendency is not observed at other sites. Therefore, it is likely that this practice had a specific origin.

Social structure of Odake people

Here, I focused on individual no. 32 as an outlier. Dietary analysis from carbon and nitrogen isotopes shows that no. 32 had a distinct dietary habit, biased toward C3 plants (Yoneda, 2014) (Figure 6). In addition, mtDNA analysis revealed that the mtDNA haplotype of no. 32 belongs to G2, a rare type among Odake shell-mounds (or rather, the only case that could be analyzed) (Shinoda, 2014). Furthermore, special attrition of the lower right second premolar was confirmed in no. 32 (Sakaue et al., 2014). The enamel part of that tooth was very rounded and worn. Perhaps the other teeth were worn as well. Such special attrition can only be confirmed in no. 61 among the Odake people, and it is a rare case. In addition, this special attrition likely arose from

| No. | Sex | Age | Burial posture | Burial form | Head orientation | Accessories | Grave goods | Large stone placed on the corpse | Phase | Corpse group | Burial subgroup | Tooth extraction | Remarks |
|-----|-----|-----|----------------|-------------|-----------------|-------------|-------------|-----------------------------|-------|--------------|----------------|----------------|---------|
| 55  | Female? | Juvenile |  |  |  |  |  |  | III | j | 3 | Disturbed |
| 65  | Unknown | about 5 |  |  |  |  |  |  | III | j | 3 | Disturbed |
| 70  | Male | Old | Supine; flexed | Single; primary | N111W |  |  |  | III | j | 3 |  |
| 50  | Male | Adult | lower left side lying; flexed | Single; primary | N16W | Stone knife 1, ground stone axe 1 |  | III | j | 3 |  |
| 32  | Male? | Adult | Single; primary | (N) |  |  |  |  | III | j | 3 |  |
| 49  | Unknown | Unknown |  |  |  |  |  |  | III | j | 3 | Disturbed |
| 6   | Male | Adult |  |  |  |  |  |  | III | j | 3 | Disturbed |
| 5   | Male | Mature |  |  |  |  |  |  | IV | o | 3 | Disturbed |
| 56  | Unknown | Unknown | Single; primary | (W) |  |  |  | IV | o | 3 | Disturbed |
| 51  | Male | Mature | Supine; flexed | Single; primary | N82E |  |  | IV | o | 3 | Disturbed |
| 4   | Male | Mature |  |  |  |  |  |  | IV | o | 3 | Disturbed |
| 10  | Male? | Adult |  |  |  |  |  |  | IV | o | 3 | Disturbed |
| 2   | Male | Adult | Supine; flexed | Single; primary | N68E |  |  | IV | o | 3 |  |
| 30  | Male | Juvenile | Supine; flexed | Single; primary | N150W | Present | IV | o | 3 |  |
| 22  | Unknown | Unknown |  |  |  |  |  |  | IV | o | 3 | Disturbed |
| 3   | Female | Juvenile | Supine; flexed | Single; primary |  |  | IV | p | 3 |  |
| 9   | Female | Mature | Supine; extended? | Single?; primary | N71E |  |  | IV | p | 3 | Disturbed |
| 8   | Unknown | Unknown |  |  |  |  |  | IV | p | 3 | Disturbed |
| 7   | Male | Juvenile | Supine | Single; primary | ? |  | IV | p | 3 |  |
| 45  | Male | Juvenile | Supine; flexed | Single; primary | N102W |  |  | I | d | 4 |  |
| 58  | Female? | Adult | Supine; flexed | Single; primary | ? |  |  | I | d | 4 |  |
| 59  | Female | Old | Lower left side lying; flexed | Single; primary | N42W |  |  | I | d | 4 |  |
| 68  | Male | Old | Supine; flexed | Single; primary | N67W | Stone knife 1, bone accessory | I | d | 4 |  |
| 11  | Female | Old | Supine; flexed | Single; primary | (E) |  |  | III | l | 7 |  |
| 12  | Male | Mature | Lower left side lying; flexed | Single; primary | N13W | Ground stone 1, ground stone axes 7 | Present | III | l | 7 |  |
| 4   | Male | Mature | Single; secondary |  |  |  |  | III | l | 7 | Disturbed |
| 13  | Male | Mature | Single; secondary |  |  |  |  | III | l | 7 |  |
performing specialized work that involved using the teeth as a tool, such as leather tanning, and is often observed in early Jomon human bones. The fact that it is not seen in other excavated human bones may mean that the Odake people did not do much work using their teeth. The fact that this kind of special attrition can be observed only for no. 32 may mean that his lifestyle differed from that of the Odake people. What can we conclude from the burial attributes of this bone? Normally, it is said that bone tissue is replaced in about ten years. This means that if a person has recently moved from another community, the stable carbon–nitrogen isotope ratio will indicate the diet from the earlier place of habitation. For example, the dietary habits of no. 32, which were biased toward C3 plants, are reminiscent of diets in mountainous areas, such as the case of the Kitamura site in Nagano Prefecture (Akazawa et al., 1993). Therefore, no. 32 could be thought of as a person from a mountain village who was not born and raised at the Odake shell-mound. Kenichi Machida points out the suggestive fact that a large number of Moroiso-type pottery pieces were brought in from the moun-
tainerous areas of the Kanto region (Gunma Prefecture and elsewhere) and a large number of obsidian artefacts produced in Nagano Prefecture were excavated at the Odake shell-mound (Machida, 2014). It is also known that no. 32 belongs to the corpse group j of phase III, i.e. burial subgroup 3. If the burial subgroup means a small family group, as I understand, no. 32 was likely a member of the family buried in subgroup 3. As an opportunity for a people of different origins to become part of the family, marriage is the most obvious reason. Perhaps no. 32 came from the mountains for marriage. Furthermore, it can be assumed that skeleton no. 32 is a male because of the size of the mastoid. Judging from the fact that the male comes in at the time of marriage, it is highly possible that the people of Odake ran a matrilineral society. Similarly, other males who may have external elements include no. 28 and no. 41. No. 28 had both upper second incisors extracted. There is no such custom in the Hokuriku region in the Early Jomon period. In this period, similar tooth extraction customs were performed in some areas, e.g. the area around Sendai Bay in Miyagi. Checking from the burial posture, it can be assumed that no. 28 had enough space to open the hip joint at the time of body decay; unlike other cases, it is assumed that he was buried in an organic bag (e.g. one made of skin). Ear exostosis has been confirmed in no. 41. In the Jomon period, ear exostosis occurred frequently among those who did dive fishing on the Sanriku coast, particularly Oofunato Bay (Hasebe, 1925). As fish and shellfish, such as the turban shell, which are thought to have been collected mainly through diving, have also been excavated from the Odake shell-mound, it is assumed that similar work was being carried out in the nearby sea. However, ear exostosis cannot be observed in other human bones. Human bone no. 41 may indicate an foreigner. If this individual was a migrant from the coastal area of the Tohoku region, some exotic relics, such as amber and Daigi-type pottery from the region, may have been related to this migrant.

In addition, no. 45 had a special dietary habit, namely, ingesting more marine products than the average inhabitant of the Odake shell-mound (Yoneda, 2014). Tooth extraction was confirmed in the upper left second incisor (the right side is unknown because of damage). Like no. 28, it is suggested that this case was male. The head orientation of no. 64 is of the so-called inverted type in the burial subgroup, and it cannot be ruled out that this person might be an outpatient. Yoneda indicated that men had a greater range of variability in their dietary habits (Yoneda, 2014), which may be due to their varied origins. A maternal society is the easiest to imagine fitting these phenomena, i.e. a social structure in which men marry into a group. From this point of view, I conclude that the Odake people had a maternal society, featuring matrilocal residence. This allows us to infer the reason why male corpses had a large stone placed on them. It seems likely that this was done for the burial of foreigners and those who married into the group. This and the above points are noted here for future bioarchaeological studies.

**Conclusion**

I have described research methods and practical examples of Jomon society through a collaboration between archaeology and physical anthropology. Bioarchaeological methods are already becoming indispensable for the study of Jomon society using graves and human skeletons. Drawing on these results, this paper presents a hypothesis on ideal social structures from some archaeological sites. Bioarchaeology has not fully developed in Japan unless we pose such archaeological hypotheses and test them using appropriate biological methods. The future of bioarchaeology will only be opened through the joint research of archaeology and physical anthropology.

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