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Prehistoric diet and mortuary practices in the Jomon period: Isotopic evidence from human skeletal remains from the Yoshigo shell mound

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ABSTRACT

Carbon and nitrogen stable isotope analysis of human bone collagen is a useful tool for clarifying the diet of prehistoric populations. The people of the Jomon period have been shown to have had a highly varied diet; however, the reasons for this dietary variation remain unclear. Therefore, the objectives of the present study were to clarify the factors that affected dietary variation among the Jomon people during the Late/Final Jomon period through stable isotope analysis of human skeletal remains from the Yoshigo shell mound in Japan, and to investigate the association between diet, sex, and mortuary variables. The carbon and nitrogen stable isotope ratios of 123 individuals from the Yoshigo shell mound were evaluated. The results indicated that the Jomon people consumed both terrestrial and marine resources with varying degrees of dependence. In addition, the following two groups were identified based on burial posture and position in the shell layer: early and late occupation groups. A comparison of these groups revealed that dependence on marine resources might have temporally decreased. Remains buried in clusters in the eastern and southern parts of the cemetery yielded low and high nitrogen isotope ratios, respectively. Associations were found between diet and burial posture in the east cluster and between diet and both sex and ornaments in the south cluster. These results suggest the presence of an association between diet and mortuary variables relative to burial clusters.

1. Introduction

Carbon and nitrogen stable isotope analysis of human bone collagen is a useful tool for clarifying the diet of prehistoric populations (Ambrose and DeNiro, 1986; Chisholm et al., 1982; Craig et al., 2009; Hedges et al., 2008; Schulting et al., 2008; Walker and DeNiro, 1986). Carbon and nitrogen, which are the primary elements constituting animal tissue, contain stable isotopes. The composition of animal tissue reflects that animal's dietary intake; for example, laboratory experiments have shown that the composition of body protein largely reflects dietary protein intake (Ambrose and Norr, 1993; Tieszen and Fagre, 1993). Therefore, stable isotope ratios in human skeletal remains can be measured to estimate the proportion of terrestrial and marine protein intake among ancient peoples. As the turnover time of bone collagen is slow (Libby et al., 1964; Stenhouse and Baxter, 1979; Hedges et al., 2007), stable isotope data can reveal the average diet of an individual for about 10 years before death. Carbon stable isotope analysis is generally used to characterize diets from C_3 (plants adapted to temperate ecosystems, including most vegetables, fruits, and wheat) versus C_4 (plants adapted to hot, arid ecosystems, including millet, maize, and sugarcane) ecosystems (Pate, 1995) or, from environments without C_4 plants, and between marine and terrestrial ecosystems (Chisholm et al., 1982; Schoeninger et al., 1983; Tauber, 1983). Nitrogen stable isotopes can be used to characterize the trophic level of an individual because body tissue shows a 3 to 6‰ enrichment in $\delta^{15}N$ relative to diet (Minagawa and Wada, 1984; Schoeninger and DeNiro, 1984; O'Connell et al., 2012). A combined analysis of carbon and nitrogen isotope ratios in human bone collagen can therefore be used to reconstruct prehistoric diets.

The Jomon period in the Japanese Archipelago lasted from 16,500 to 2300 years BP. The Jomon people were hunter-gatherers who effectively exploited marine and/or terrestrial resources and made cord-marked pottery (Kobayashi et al., 2004). The cultivation of soybeans and adzuki beans is thought to have been started from the Early Jomon period (Lee et al., 2011; Obata et al., 2011; Nakayama, 2010); however, these plants were not the main sources of subsistence for the Jomon people (Nakayama, 2009), and rice agriculture was not introduced until the subsequent Yayoi period (Kobayashi et al., 2004). Investigating the diet of the Jomon people can provide an understanding of how they exploited a wide variety of seasonal wild food resources and adapted to their surrounding environment for subsistence (Akazawa, 1986).

Stable isotope analysis of human skeletal remains from the Jomon period in Japan has been conducted in previous studies (Koike, 2000; Minagawa, 2001; Yoneda et al., 2004; Kusaka et al., 2008, 2010), and dietary variation over time and by region has been recognized

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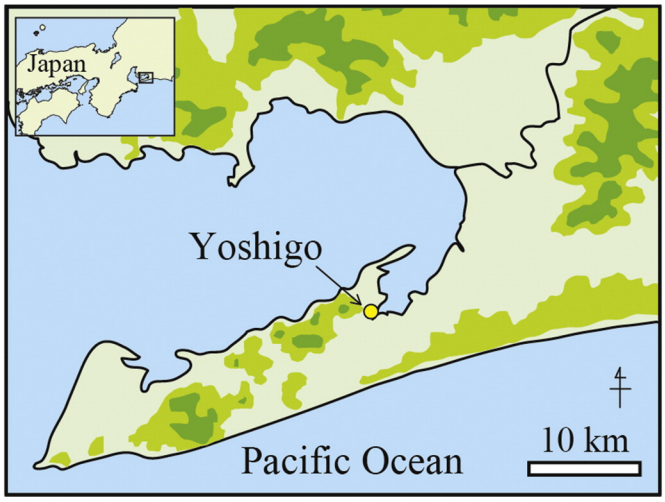

Fig. 1. Map of the Yoshigo shell mound in Aichi Prefecture, Japan.

(Minagawa, 2001). In addition, several studies have investigated differences in isotope ratios between sexes (Koike, 2000) and dietary differences in relation to tooth ablation patterns (Kusaka et al., 2008, 2010). Although individual dietary differences among ancient populations have been investigated, it remains unclear whether diet is associated with mortuary variables such as burial posture, ornaments, and spatial distribution within cemeteries.

The spatial distribution of burials within cemeteries may provide evidence about sex, kinship, and other social status indicators (Shennan, 1975; Pearson and Pearson, 1999). More than 300 skeletal remains from the Jomon period have been excavated from the Yoshigo shell mound in Japan, which is more than any other site. Grave clusters in the Yoshigo shell mound were previously analyzed by Harunari (1979), and the Yoshigo skeletal remains are therefore suitable for analysis regarding the association between diet and spatial distribution in the cemetery (Kiyono, 1969). Harunari (1979) revealed that segments of each cluster, which included both males and females, were associated with tooth ablation patterns.

Ritual tooth ablation was found among the Yoshigo skeletal remains. Tooth ablation patterns are an important indicator of social organization and an expression of rites of passage and identity (Harunari, 1979). Tooth ablation patterns may also provide information on moiety (Harunari, 2013; Tanaka, 1998) and descent groups (Yamada, 2008). Dietary differences in relation to tooth ablation patterns have been found among the Inariyama (Kusaka et al., 2008), but not among the Ikawazu, Koh, or Tsukumo skeletal remains (Kusaka et al., 2015). Gaining an understanding of differences in tooth ablation patterns would help identify any associations they may have with diet.

Burial posture and ornaments are also important mortuary variables to consider when investigating past societies. Most of the skeletal remains during the Jomon period were in flexed burial positions. Individuals in extended burial positions, who were considered to belong to a later period, were excavated from the upper layer of shell mound (Kiyono, 1969; Nakayama, 1952; Maeda, 2000). Individuals with ornaments held particular social positions in a population; since these persons may have consumed special foods, an association may be found between diet and these mortuary variables.

Therefore, the objectives of this study were to clarify the factors that affected dietary variation among the Jomon people during the Late/Final Jomon period through stable isotope analysis of human skeletal remains from the Yoshigo shell mound in Aichi Prefecture, Japan, and to analyze the association between stable isotope ratios and sex, spatial distribution in the cemetery, and burial ornaments in order to clarify social organization in the Jomon period.

2. Materials and methods

2.1. Materials

The Yoshigo shell mound is located in the Atsumi Peninsula of Tahara city, Aichi Prefecture (Fig. 1). In an excavation of the Yoshigo shell mound conducted in 1922 and 1923, >300 human skeletal remains from the Late to Final Jomon period were found based on the chronology of Jomon pottery types (Yamanouchi, 1952; Kiyono, 1969). The radiocarbon dates of two shells from the Yoshigo shell mound were 2870 ± 250 and 2800 ± 600 uncalibrated years BP (Watanabe, 1966). The radiocarbon dating on three Yoshigo individuals ranged from ca. 3200–2800 cal BP (Kusaka et al., 2009). The lower and upper layers were found in the eastern part of the shell mound, and the proportion of extended burial posture was high in the upper layer (Kiyono, 1969). The burial posture changed from flexed to extended during the Late-Final Jomon period (Maeda, 2000). Therefore, the eastern part of the cemetery might include more individuals buried in a later period (Kiyono, 1969). To exclude this chronological effect, we divided samples into Early and Late groups based on burial posture and position in the shell layer. The individuals who were in an extended burial position and/or excavated from the upper layer of the shell mound were categorized into the late group, and all others were categorized into the early group.

The materials were stored in the Physical Anthropology Laboratory at Kyoto University. For this study, we newly analyzed carbon and nitrogen stable isotope ratios of samples from 108 human skeletal remains. A total of 146 samples, including published data from 38 individuals (Kusaka et al., 2008), were evaluated. Archaeological information,

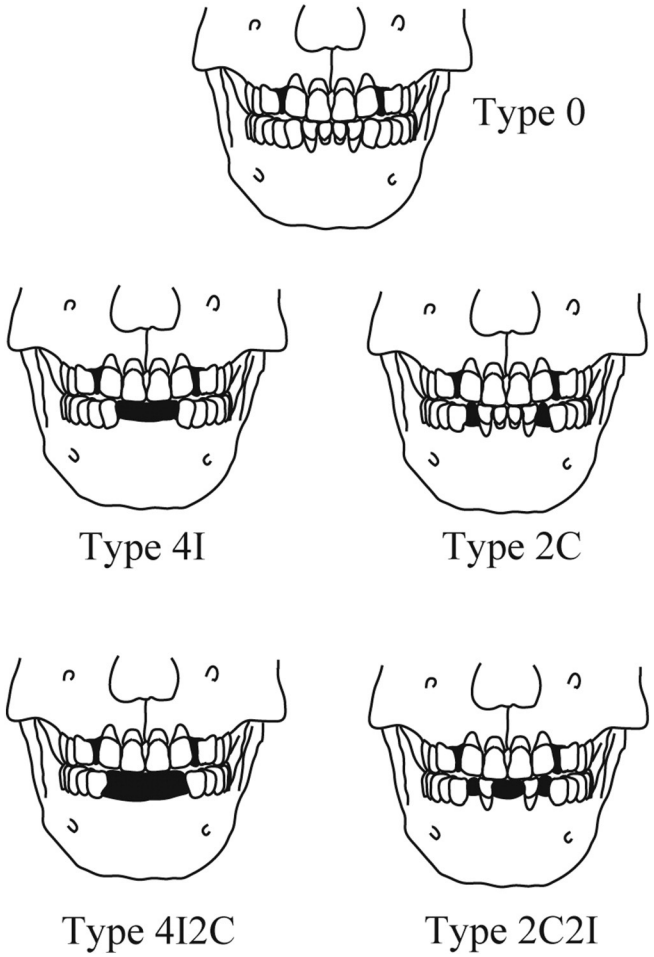

Fig. 2. Types of ritual tooth ablation (modified from Harunari, 1973).