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Frequency of mandibular tori in prehistoric and historic Japanese island populations

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ABSTRACT

The frequency and development of mandibular tori are distributed unevenly geographically and among fossil hominids, archaeological skeletal samples, and present-day populations. This suggests that tori frequencies may be influenced by both genetic and non-genetic factors. In order to clarify chronological changes in the frequencies of mandibular tori, the frequencies of tori in prehistoric and historic populations on the main island of the Japanese archipelago were examined. A total of 971 skeletal samples ranging from the Jomon to early-modern age were examined. The frequencies of mandibular tori were highest in the Jomon populations, but lower in the Yayoi, Kofun, Kamakura, Muromachi, Edo, and early modern populations. In addition, the frequencies tended to decrease over time. Among the Jomon populations, the frequencies were lower in Southwest Jomon (Chugoku district) and Central Jomon (Aichi Prefecture), and higher in East Jomon (Kanto district) and Northeast Jomon (Tohoku district). These results suggest that the development of mandibular tori could be influenced by both genetic and non-genetic factors (specifically diet) factors.

1. Introduction

A mandibular torus is a bony protuberance on the lingual surface of the mandible generally found in the premolar region above the linea mylohyoidea (Figs. 1 and 2). It is an exostosis typically formed by hypertrophy of the compact bone and sometimes of the spongy bone (Thoma and Goldman, 1960). Mandibular tori have been found in fossil hominids, archaeological skeletal samples (Appendix 1), and present-day populations (Appendix 2), and anthropologists have noted that the frequency of tori differ among populations. As reported in previous studies, tori have frequently (50–100%) been found in Aleuts (Hrdlicka, 1940; Moorrees, 1957; Ossenberg, 1981; Dodo and Ishida, 1987), Kodiaks (Ossenberg, 1981), Koniags (Hrdlicka, 1940), Eskimos (Hooton, 1918), Alaska Eskimos (Hrdlicka, 1940; Ossenberg, 1981; Dodo and Ishida, 1987), Canada Eskimos (Dodo and Ishida, 1987), Eskimos and Norsemen in Greenland (Sellevold, 1980), Lapps (Hrdlicka, 1940), Nordic people in Iceland (Hooton, 1918; Richter and Eliasson, 2008), North American Indians (Ossenberg, 1981), Japanese (Sakai, 1954; Dodo, 1974; Nakazawa et al., 1995; Sugihara et al., 2003; Igarashi et al., 2008), Portuguese (Galera et al., 1996), Thais (Sirirungrojying and Kerdpon, 1999), Vietnamese (Taddei, 2004), Black South Africans (Ihunwo and Phukubye, 2006), iron age people in Scotland (Brothwell and Powers, 1967; Wells, 1974), pre-Medieval people in Ireland (Brothwell, 1967), and Pliocene hominids from in Ethiopia (White and Johanson, 1982). On the other hand, in these high frequency areas, the following populations with low frequencies of tori were also found: Aleuts (Hrdlicka, 1940; Moorrees, 1951; Moorrees et al., 1952; Moorrees, 1957), Alaska Eskimos (Hrdlicka, 1940; Mayhall et al., 1970; Dodo and Ishida, 1987), Canada Eskimos (Mayhall, 1968; Mayhall and Mayhall, 1970; Jarvis and Gorlin, 1972), Swedish in Greenland (Mellquiast and Sandberg, 1939), schoolchildren in Iceland (Axelsson and Hedegard, 1981), North American Indians (Ossenberg, 1981), Japanese (Hrdlicka, 1940; Sakai, 1954; Dodo, 1974; Mouri, 1976; Dodo and Ishida, 1987; Ohno et al., 1988; Taniguchi et al., 1999), and Vietnamese (Nair et al., 1996). In the populations in Central America, South America, the South Pacific, and the Middle and Near East, the frequencies of tori were low (Appendix). This uneven distribution suggests that tori frequencies may be influenced by both genetic and non-genetic factors alike.

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Fig. 1. Developed mandibular torus (Class 3) of a present-day Japanese male in his 40s.

The frequency and development of tori might be judged differently due to differences in the judging standards. In previous studies, judging standards were not unified. Therefore, to set up a universal judging standard, Igarashi et al. (2008) established a classification system for the development of tori in which it is influenced by both genetic and non-genetic factors.

The importance of genetic factors in the development of tori has been emphasized in previous studies based on the frequencies of tori in genetically different populations living in similar environments (Sellevold, 1980), the incidence of tori development in families (Suzuki and Sakai, 1960; Johnson et al., 1965; Alvesalo and Kari, 1972), and in individuals with various sex chromosome abnormalities (Alvesalo, 1997; Lahdesmaki and Alvesalo, 2004; Alvesalo, 2009). Ossenberg (1981) reviewed previously published data and concluded that a threshold model could explain the trait's phenotypic behaviors better than a single gene model. Based on a threshold model, Eggen (1989) concluded that in Norwegians, tori are influenced both by genetic and environmental factors such as bruxism.

Other studies have stressed non-genetic factors as the cause of tori. Factors such as coarse diet (Mayhall, 1970; Eggen and Natvig, 1991), parafunctional activities (Kerdpon and Sirirungrojying, 1999; Sugihara et al., 2003), temporomandibular disorder (Clifford et al., 1996; Sirirungrojying and Kerdpon, 1999), the number of teeth (Eggen and Natvig, 1986), the degree of dental attrition (Pechenkina and Benfer, 2002), the area of occlusion contact (Nakazawa et al., 1995; Nakazawa, 1997; Kamouchi et al., 2000), the degree of dental crowding (Takano, 2000), and bite force (Cagirankaya et al., 2005) were shown to be linked with torus development.

Fig. 2. Developed mandibular torus (Class 2) of a Jomon person.

Based on these observations, to analyze the correlations between the development of tori and non-genetic factors, Igarashi et al. (2008) selected the number of teeth, the degree of dental attrition, and the degree of crowding as non-genetic factors because they can easily be examined on the mandible of plaster casts or skeletal samples. Igarashi et al. (2008) examined the correlation between these factors and the development of tori in present-day Japanese, and concluded that the development of mandibular tori was correlated to age, the number of teeth, the degree of crowding, and the degree of dental attrition, while the number of teeth, the degree of crowding, and the degree of dental attrition were independent of age.

In this study, to analyze the extent of chronological change and geographical distribution in the frequency of tori from the Jomon to the early modern era, and to gather insight into the etiologies of mandibular tori, the frequencies of mandibular tori in the populations on the main island of the Japanese archipelago were examined.

The extent of chronological change in the frequency of tori in the populations on the main island of the Japanese archipelago has previously been examined (Ohzeki and Igarashi, 2007). However, in that study, samples were only obtained from the populations in the following three eras: Jomon, Kamakura, and early modern. In the present study, samples were obtained from the populations in the following seven eras: Jomon, Yayoi, Kofun, Kamakura, Muromachi, Edo and early modern. The number of samples in the Jomon and Kofun populations increased, and the addition of the Yayoi, Kofun, Muromachi, and Edo eras resulted in an increase of the total sample number. Moreover, in Ohzeki and Igarashi (2007), individuals under 18 years old were included in the analyses. Although Igarashi (2013) reported that mandibular tori were found in individuals who were over 11 years old, the frequencies were low; these steadily increased until the age of 18 years. After that, the total frequencies of tori did not increase, even though developed tori increased into the 50s. Therefore, to estimate the frequency of tori of adult populations, we should only use samples from individuals who are 18 years old and over. In the present study, only individuals who were judged to be 18 and over were examined.

2. Materials and methods

A total of 971 skeletal remains were examined. Table 1 shows the number of samples in each era, the sites or prefectures from which skeletal remains were derived, and the laboratories where the samples were stored. Regarding the Jomon population, the sites from where the samples were excavated covered a large area. For this reason, the Jomon people were divided into the following four subgroups according to area: Southwest Jomon (Chugoku district); Central Jomon (Aichi Prefecture); East Jomon (Kanto district); and Northeast Jomon (Tohoku district) (Fig. 3). Analyses were done both on the total Jomon population and on the individual Jomon subgroups. All samples were observed by the author. Some samples in the Jomon, Kamakura, and early-modern eras were also examined in a previous study (Ohzeki and Igarashi, 2007), but these samples were reexamined by the author.