

Comparative Study of the Crown Cusp Areas in the Maxillary Second Molars of the Jomon People

Hirofumi Matsumura

Department of Anthropology, National Science Museum 3–23–1
Hyakunincho, Shinjuku-ku, Tokyo, 169–0073 Japan
E-mail: matumura@kahaku.go.jp

Abstract Crown cusp areas of the maxillary second molar are described for the Jomon people, and compared within the Jomon groups, then with the modern Japanese and Hokkaido Ainu. The relative hypocone area slightly varies within the late Jomon groups, while there was no significant difference between the average late Jomon, modern Japanese and Ainu. However, the early Jomon people possess the larger relative hypocone area than the late Jomon people, suggesting that they retained rather primitive feature in the upper second molar compared to the later Jomon people. On the contrary to the existence of such inter- and intra-population variability in the hypocone size, significant difference was not found in the relative metacone area within the Jomon people or between the Jomon, Japanese and Ainu.

Key words: Maxillary molar, Crown cusp area, Metacone, Hypocone, Jomon.

Introduction

The protocone, paracone, metacone and hypocone are the four principal cusps which comprise the occlusal surface of the maxillary molar in the hominid teeth (Fig. 1). The relative cusp size of the hypocone, the distal-lingual cusp, had attracted considerable attentions in determining the evolutionary stages and population relationships of the hominid species (Dahlberg, 1953). The size of the hypocone reduces through the process of long-term human evolution, and it is well known that the cusp size in the second molar varies among modern human populations. Dahlberg (1949) classified the relative size of the hypocone into four categories (Dahlberg's Plaque). This standard of classification has often used for population characterization. On the other hand, Hanihara *et al.* (1970) and Yamada *et al.* (1988) applied the quantitative method to the hypocone size measurement, and demonstrated its characteristics in the Japanese samples.

In regard to the Neolithic Jomon people in Japan, one of their dental characteristics is the possessing of the smaller upper second molars compared to the modern Japanese (Matsumura, 1989). Thus, the question arisen to whether the upper second molars of the Jomon people have smaller distal cusps in relative size than those of the

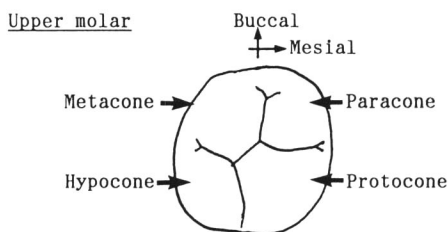


Fig. 1. Principal cusps of the maxillary right molar.

modern Japanese. In order to answer to this question, present study describes the distal cusp areas in the upper second molars of the Jomon specimens, and compared the traits within the Jomon groups, and with the modern Japanese. In addition, the comparison was made with the Hokkaido Ainu who has smaller upper second molars like the Jomon people.

Materials and Methods

Materials used in the present study are maxillary second molars of the Jomon specimens, modern Japanese and Hokkaido Ainu. The late Jomon specimens, dating to the Middle to Final Jomon periods (ca. 5,000 BP–2,300 BP), are from the Hokkaido, Tohoku, Kanto, Tokai and Sanyo regions. The early Jomon specimens are of the Early to Middle Jomon period (ca. 6,000 BP–5,000 BP) from various sites in Japan. These Jomon specimens, as well as the modern Japanese from the Kanto region and Hokkaido Ainu, are from same skeletal series used in else study (Matsumura, 1989, 2000).

In order to measure the cusp area, the same method used in the else study (Matsumura *et al.*, 1992) was adopted. The occlusal pictures were taken with a single-lens reflex camera with bellows focusing attachment and lens ($f=105$ mm) (Fig. 2). Then, the tooth sample was positioned in the standard plane where its cervical line was perpendicular to the optical axis of the lens. The photograph was enlarged five times the normal size (Fig. 3), then the cusp boundaries were traced using the digitizer (0.1 mm of accuracy) and each cusp area was computed. The absolute and relative cusp areas to the total cusp area were calculated for each molar. Since Hanihara *et al.* (1970) found normal distribution in the cusp areas of the upper molar class, significant test of difference between the samples were carried out by using the Analysis of Variance (ANOVA) and the Student's *t*-test.

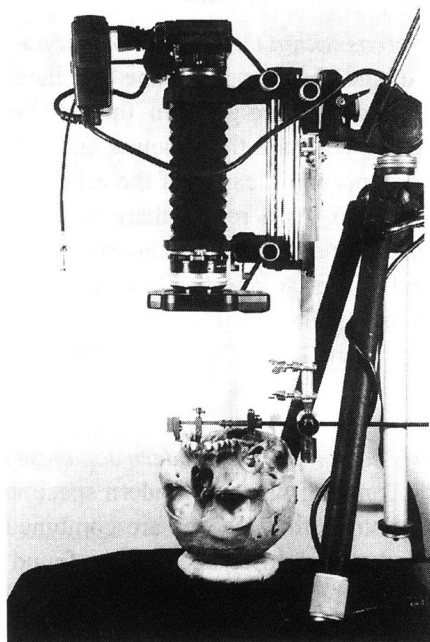


Fig. 2. Specimen set to take a photograph of the maxillary molar.



Fig. 3. Picture taken for the occlusal surface of the maxillary left molar.

Results

Variation of relative cusp areas within the late Jomon people

The basic statistics of the absolute metacone and hypocone areas in the upper second molars of the Jomon groups are given in Table 1. The relative cusp areas are shown in Table 2. In order to compare the absolute and relative cusp areas between the five regional Jomon groups, significance of the differences were tested using the Analysis of Variance (ANOVA). As a result, there was no significant difference in both the absolute and relative metacone areas in either sex. On the other hand, the hypocone areas significantly differ among the Jomon females. The Sanyo Jomon females, which mainly consist of the specimens from the Tsugumo site in Okayama Prefecture, possess significantly larger hypocone than the other regional Jomon groups.

Comparisons with the early Jomon people, modern Japanese and Ainu

To compare the early Jomon group and modern specimens, the late Jomon samples are pooled and data from both the sexes are combined. The reason is that, as shown in Table 3, significant sexual difference was not found in any cusps in the population samples used in this study. The result of comparisons is given in Table 4, indicating that the early Jomon samples are significantly different from the late Jomon samples. There is no significant difference in the relative metacone area. The relative hypocone area of the late Jomon sample also does not differ from those of the Hokkaido Ainu and modern Japanese. Significant difference was evident only in comparison with the early Jomon sample. The relative hypocone area of the early Jomon sample was larger than the late Jomon.

Discussion

It is well known that the Jomon dentition is considerably smaller in the tooth crown diameters compared to the modern Japanese. In detailed comparison of the maxillary tooth class, especially, smallness of the Jomon dentition is stressed in the second molars, as well as in the canines and premolars (Matsumura, 1989). The present study examined whether the upper second molars of the Jomon people have smaller distal cusps in relative size than those of the modern Japanese. According to the Dahlberg's four-category-classification, however, the hypocone size reduction in the upper second molar of the Jomon people was not so prominent as expected. Frequency of absence of the hypocone was 7.7% in the late Jomon sample and was 12.7% in the modern Japanese (Matsumura, 1995). Though this difference is found to be not significant, the absence of hypocone is rather frequently observed in the modern Japanese with the large crown size compared to the Jomon people with the smaller crown size. Although slight regional differences was observed in the hypocone size

Table 1. Absolute cusp areas of the maxillary second molars in the Jomon people, Hokkaido Ainu and modern Japanese, and results of comparison within the late Jomon groups.

Males	Total Crown Area			Metacone			ANOVA*			Hypocone			ANOVA*
	n	M (mm ²)		SD	n	M (mm ²)		SD	ANOVA*	n	M (mm ²)		ANOVA*
Late Jomon	112	80.3	8.9		112	17.3	3.5			112	10.8	5.1	
(Hokkaido)	8	76.3	5.9		8	19.5	8.6			8	7.3	4.9	
(Tohoku)	7	80.6	8.8		7	17.3	3.7			7	9.8	4.7	
(Kanto)	30	80.0	8.7		30	16.5	2.5			30	11.7	5.1	
(Tokai)	46	81.1	9.6		46	17.6	3.0			46	11.3	5.3	
(Sanyo)	21	80.3	8.8		21	17.0	2.8			21	10.4	4.5	
Early Jomon	8	87.4	5.8		8	18.9	2.1			8	15.0	3.4	
Hokkaido Ainu	17	78.5	9.7		17	17.1	3.2			17	8.6	5.8	
Modern Japanese	29	85.8	8.0		29	18.4	3.4			29	11.2	5.4	
Females	Total Crown Area			Metacone			ANOVA*			Hypocone			ANOVA*
	n	M (mm ²)		SD	n	M (mm ²)		SD	ANOVA*	n	M (mm ²)		ANOVA*
Late Jomon	98	74.9	8.0		98	15.8	2.6			98	7.5	5.2	
(Hokkaido)	8	75.1	9.6		8	15.9	3.9			8	6.9	4.6	
(Tohoku)	6	72.5	5.8		6	15.3	1.9			6	4.7	3.0	
(Kanto)	17	74.7	9.6		17	15.0	3.2			17	6.8	4.8	
(Tokai)	47	74.8	7.7		47	16.3	2.4			47	6.9	5.4	
(Sanyo)	20	76.1	7.5		20	15.6	2.0			20	10.6	4.8	
Early Jomon	7	75.9	4.9		7	15.5	2.8			7	10.5	5.6	
Hokkaido Ainu	17	76.1	8.6		17	15.8	2.7			17	9.8	7.4	
Modern Japanese	26	82.7	7.6		26	17.5	3.2			26	10.2	3.8	

* ANOVA: Analysis of Variance, ns: not significant.

Table 2. Relative cusp areas of the maxirally second molars in the Jomon people, Hokkaido Ainu and modern Japanese, and results of comparison within the late Jomon groups.

Males	Metacone			ANOVA*	Hypocone			ANOVA*
	n	M (%)	SD		n	M (%)	SD	
Late Jomon	112	21.3	2.4	ns	112	13.2	5.7	ns
(Hokkaido)	8	21.6	0.9		8	9.4	5.5	
(Tohoku)	7	21.3	2.3		7	11.8	4.5	
(Kanto)	30	20.6	2.1		30	14.4	5.8	
(Tokai)	46	21.7	2.5		46	13.6	5.6	
(Sanyo)	21	21.3	2.9		21	12.7	5.1	
Early Jomon	8	21.7	2.4		8	17.1	3.9	
Hokkaido Ainu	17	21.8	2.6		17	10.9	7.1	
Modern Japanese	29	21.4	3.6		29	13.1	6.1	

Females	Metacone			ANOVA*	Hypocone			ANOVA*
	n	M (%)	SD		n	M (%)	SD	
Late Jomon	98	21.2	2.7	ns	98	9.8	6.5	P<0.05
(Hokkaido)	8	21.3	2.7		8	8.7	4.9	
(Tohoku) [†]	6	21.1	4.5		6	6.4	3.8	
(Kanto)	17	20.0	2.3		17	9.1	6.1	
(Tokai)	47	21.8	2.7		47	8.9	6.7	
(Sanyo)	20	20.5	2.4		20	13.9	6.0	
Early Jomon	7	20.3	2.5		7	13.6	6.9	
Hokkaido Ainu	17	20.9	3.4		17	12.3	8.2	
Modern Japanese	26	21.2	3.2		26	12.2	4.4	

* ANOVA: Analysis of Variance, ns: not significant.

Table 3. Results of comparison of the relative cusp areas in the maxirally second molars between the sexes.

	Metacone	Hypocone
Early Jomon	ns	ns
Late Jomon	ns	ns
Hokkaido Ainu	ns	ns
Modern Japanese	ns	ns

ns: not significant by the *t*-test.

Table 4. Results of comparison of the relative cusp areas in the maxillary second molars between the Jomon, Hokkaido Ainu and modern Japanese (Both the sexes combined).

	Late Jomon (Metacone Area)	Late Jomon (Hypocone Area)
Early Jomon	ns	$P < 0.05$
Hokkaido Ainu	ns	ns
Modern Japanese	ns	ns

ns: not significant by the *t*-test.

among the late Jomon groups, the average relative hypocone area of the pooled samples was very close to the modern Japanese. Therefore, it is concluded that the small upper second molar of the late Jomon people does not associated with the significant reduction of the relative hypocone area.

The comparison with the early Jomon sample demonstrated the significant temporal difference within the Jomon lineage. The early Jomon people possess the larger relative hypocone area compared to the late Jomon people. This suggests that the earlier Jomon people retain rather primitive feature in the upper second molars than the later Jomon people.

On the contrary to the existence of inter- and intra-population variability in the hypocone size, there was no significant difference in the relative metacone area within the Jomon people, or between the Jomon, Japanese and Ainu. Thus, the invariability of the metacone size between the population samples indicates that the metacone is morphologically more stable than the hypocone.

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References

- Dahlberg, A. A., 1949. The dentition of the American Indian. The Phys. Anthrop. Amer. Indian. The Viking Fund, New York. pp. 138–176.
- Dahlberg, A. A., 1953. Concept of occlusion in physical anthropology and comparative anatomy. *J. Am. Dent. Assoc.*, **46**: 530–535.
- Hanihara, K., M. Tamada and T. Tanaka, 1970. Quantitative analysis of the hypocone in the human upper molars. *J. Anthropol. Soc. Nippon*, **78**: 200–207.
- Matsumura, H., 1989. Geographical variation of the dental measurements in the Jomon people. *J. An-*

throp. Soc., Nippon, **97**: 494–512.

Matsumura, H. 1995. Dental characteristics affinities of the prehistoric to modern Japanese with the East Asians, American natives and Australo-Melanesians. *Anthropol. Sci.*, **103**: 235–261.

Matsumura, H., 2000. Dental metric variations between the periods, sites and individuals of the Neolithic Jomon people in the Setouchi, Tokai and Kanto regions, Japan. *Mem. Natn. Sci. Mus., Tokyo*, **32**: 175–187.

Matsumura, H., M. Nakatsukasa and H. Ishida, 1992. Comparative study of crown cusp areas in the upper and lower molars of African apes. *Bull. Natn. Sci. Mus., Tokyo*, **D18**: 1–15.

Yamada, H., K. Kawamoto, S. Takada, Y. Hotta, J. Chen and T. Sakai, 1988. Numerical study of distolingual crown portion on the basis of hypocone variability in upper molars. *J. Growth*, **27**: 63–74. (In Japanese with English summary.)