Archives of Oral Biology 67 (2016) 15–21

Contents lists available at ScienceDirect

Archives of Oral Biology

journal homepage: www.elsevier.com/locate/aob

Morphological analysis of the occlusal surface of maxillary molars in Koreans

Hong-Il Yoo[b,1], Dong-Wook Yang[a,1], Mi-Yeon Lee[a], Min-Seok Kim[a], Sun-Hun Kim[a,*]

[a] Department of Oral Anatomy, School of Dentistry, Chonnam National University, 77 Yongbong-ro, Buk-gu, Gwangju 500-757, South Korea
[b] Department of Anatomy and Neuroscience, College of Medicine, Eulji University, 77 Gyeryong-ro 771 beon-gil, Jung-Gu, Daejeon 34824, South Korea

ARTICLE INFO

Article history:
Received 21 May 2015
Received in revised form 29 December 2015
Accepted 28 February 2016

Keywords:
Maxillary molars
Cusps
Dimorphism
Races
Hypocone reduction

ABSTRACT

Objective: To determine the diameter of the crown, total crown area, individual cusp area, and occlusal table area in Korean maxillary permanent molars, as well as dental characteristics relevant to the hypocone reduction trait.
Materials and methods: Subjects included 121 dental school students in Korea (81 men and 40 women). A digital image analysis system was used for measurements and we relied on visual scoring to assign categories of hypocone expression.
Results: The mean crown dimension was larger in the first molar (M1) than in the second molar (M2). Regarding differences according to gender, the crown diameter, total crown area, and individual cusp area were significantly larger in the men than in the women. The mean occlusal table area ratios were 61% for M1 and 57% for M2, and these ratios increased in proportion to the total crown area. With respect to the hypocone and other features of the maxillary molars, differences between the men and women were more prominent for M1 than for M2. The M2 hypocone tended to be smaller than the M1 hypocone, and hypocone reduction was inversely related to the cusp area of the protocone. The protocone area may be considered a reliable parameter for comparing race and/or gender differences in maxillary molars.
Conclusion: This study concerning characteristics of the maxillary molar occlusal surface in Koreans provides useful information for comparative studies among human races.

1. Introduction

The ontogeny and morphology of the human dentition provide basic information about oral anatomy. Many studies in dental anthropology have focused on the differences in size and morphology between the sexes or among races (Corruccini, 1979; Garn, Lewis, Swindler, & Kerewsky, 1967; Jensen, Kai-Jen Yen, Moorrees, & Thomsen, 1957; Reid, van Reenen, & Groeneveld, 1991; Sofaer, Chung, Niswander, & Runck, 1971). The crown dimensions of human permanent molars have proved useful in the identification of specific individuals (Macaluso, 2010), and crown diameters have been widely used in studies assessing sex and/or racial differences, the phylogeny of fossils, and systematics between humans and apes (Bailey, 2004; Fiorenza, Benazzi, Viola, Kullmer, & Schrenk, 2011; Gingerich, 1974; Lukacs & Pal, 2013; Quam, Bailey, & Wood, 2009; Wood & Engleman, 1988). Moreover, it is easy to compare total crown areas on dental casts, a technique that has been used to evaluate gender-related tendencies toward crown reduction (Kondo & Townsend, 2004; Kondo, Townsend, & Yamada, 2005;Macho & Moggi-Cecchi, 1992).

Crowns of maxillary molars generally consist of four major cusps: the mesiobuccal cusp (MBC), or paracone (Pa); the mesiolingual cusp (MLC), or protocone (Pr); the distobuccal cusp (DBC), or metacone (Me); and the distolingual cusp (DLC), or hypocone (Hy) (Nelson & Ash, 2003). The protocone is the largest cusp that emerges with the paracone (Kraus, Jordan, & Abrams, 1969) and is reported to have a reciprocal relationship with hypocone reduction (Takahashi, Kondo, Townsend, & Kanazawa, 2007). The paracone is the most stable cusp because it is the first cusp to develop. Meanwhile, the hypocone tends to exhibit significant gender-related dimorphism because it is the smallest and latest cusp to develop ontogenetically (Jernvall, 2000; Kondo et al., 2005; Morita, Yano, Nagaoka, Abe, & Nakatsukasa, 2014).

Recent advances in standardized digital photography and image processing techniques have enabled researchers to study tooth dimorphism more extensively (Gu, Wang, & Ni, 2015; Polychronis, Christou, Mavragani, & Halazonetis, 2013). Nevertheless, the traits of maxillary molars, including those related to gender differences and racial characteristics among Koreans, remain to be

* Corresponding author.
E-mail address: ksh@jnu.ac.kr (S.-H. Kim).
[1] These authors contributed to this work equally.

http://dx.doi.org/10.1016/j.archoralbio.2016.02.020
0003-9969/

determined. Therefore, we undertook this study to establish systemic anatomical data on permanent maxillary molars and to examine occlusal surface traits (Takahashi et al., 2007; Townsend, Richards, & Hughes, 2003).

2. Materials and methods

2.1. Subjects

Volunteers for this study were recruited from among the dental students of the Chonnam National University School of Dentistry in South Korea, which is representative of the Korean population. Among the initial 200 volunteers, 121 subjects met the selection criteria (81 men and 40 women). Their average age was 30 years (men = 31.25 ± 2.76; women = 27.34 ± 2.65). Samples of the maxillary M1 and M2 were chosen based on the following criteria: (1) intact morphology with no restorations or prostheses, (2) no apparent evidence of attrition or erosion, (3) the presence of both right and left molars, (4) no apparent tilting or displacement, and (5) no damage or distortion of the molars during fabrication of the dental casts. Two of the authors (Yoo and Yang) investigated the samples with either the naked eye or a magnifier and agreed on their selections. Moreover, molars on each side were compared to rule out samples that did not fulfill these five criteria.

2.2. Dental cast fabrication and standard photography

Impressions of the maxilla were obtained using alginate (Cavex, Haarlem, The Netherlands), and dental casts were made using dental white stone (GC Dental, Tokyo, Japan). To standardize cast fabrication, the stone was poured immediately after all the impressions had been taken at room temperature and humidity to minimize changes in the alginate. Also, mixing times and the ratios of water to alginate and water to stone were controlled to ensure consistency. Standard photographs of the occlusal surfaces of maxillary M1 and M2 were obtained using a digital camera (PowerShot A640, Canon, Tokyo, Japan). Using a dental surveyor, we added bases to the dental casts and mounted the bases parallel to the floor so the occlusal tables of both maxillary right and left molars would be parallel. Also, to standardize the camera position when taking photos using a stereoscope (Zeiss Stemi 2000-C, Carl Zeiss, Jena, Germany), the bases of dental casts were positioned parallel to the floor.

2.3. Dental cast measurements

2.3.1. Determination of experimental measurements

A total of eight measurements were made based on standard photographic views: (1) the buccolingual (BL) diameter—l side of the crown; (2) the mesiodistal (MD) diameter—the perpendicular distance between the most prominent point on either the mesial or the distal side; (3) the occlusal table area (OCC)—the area within the line of four cusp tips and the marginal ridges; (4) the protocone area (Pr)—the mesiolingual cusp area; (5) the paracone area (Pa)—the mesiobuccal cusp area; (6) the metacone area (Me)—the distobuccal cusp area; (7) the hypocone area (Hy)—the distolingual cusp area, and (8) the total crown area—the sum of all the cusp areas (Fig. 1).

2.3.2. Dental cast measurements

All measurements were performed with the use of AxioVision LE Release 4.4 software (Carl Zeiss). Diameters and areas were measured by the unit of 0.01 mm and 0.01 mm^2, respectively. An interobserver comparison test was performed (by Yoo and Yang) to analyze measurement errors. In addition, we calculated the relative ratios of the occlusal table area (ROCC) and of the four individual cusp areas to the total crown area, as were the ratios of the buccolingual-to-mesiodistal (BL/MD) diameters of each crown.

2.3.3. Visual scoring of hypocone reduction

For visual scoring of hypocone reduction, we adopted a four-category classification system, proposed by Takahashi et al. (2007) adapted from the six-grade Arizona State University Dental Anthropology System (ASUDAS) of Turner, Nicholand, and Scott (1991) (Fig. 2). Hypocone reduction was classified as follows: (1) Category 0 (ASUDAS grade 0)—no hypocone, (2) Category 1 (ASUDAS grades 1 and 2)—a hypocone capsule has formed on a distal marginal ridge, (3) Category 2 (ASUDAS grade 3)—hypocone is distally reduced and triangular, and (4) Category 3 (ASUDAS grades 4 and 5)—hypocone is large and prominently quadrilateral.

2.4. Statistical analysis

Interobserver errors of measurements obtained with the image analysis system were analyzed using the method described by Bailey, Pilbrow, and Wood (2004). A serial procedure of standard photography and measurements on dental casts was repeated by the second operator using 30 randomly chosen casts (about 25% of the total dental casts). Differences between the first and second determination were analyzed by technical errors of measurement, which were calculated using the equation, Error $= \sqrt{\frac{\sum d^2}{2N}}$ (Zar, 2010). Descriptive statistics were analyzed with the PASW Statistics 18 software program (IBM-SPSS, Armonk, NY, USA). Differences in mean values among measurements were tested by two-tailed *t*-tests. Cusp area differences among category groups according to M2 hypocone size were analyzed by one-way ANOVA. Chi-square tests were performed to determine correlations between gender and each hypocone category group (for both M1 and M2). Pearson's correlation test for measurement

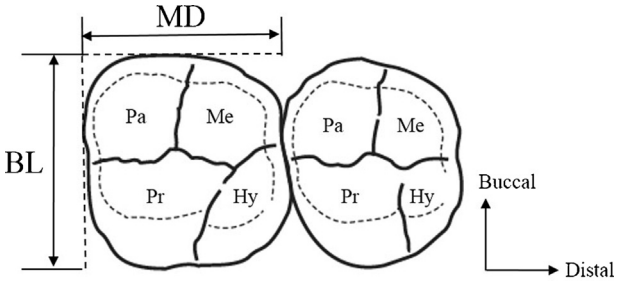

Fig. 1. A schematic diagram of crown measurements (Takahashi et al., 2007). Molar cusps are separated by major grooves on the occlusal surface. Occlusal table areas were defined as the inner area of the circle that connects the cusps and the marginal ridge (a dashed line). MD, mesiodistal crown diameter; BL, buccolingual crown diameter; Pa, paracone; Pr, protocone; Me, metacone; Hy, hypocone.