

Occlusal Surface Analysis of Mandibular Premolars in Koreans

Hong-Il Yoo, Ha-Yeon Park, Sun-Hun Kim

Department of Oral Anatomy, School of Dentistry, Chonnam National University

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Abstract : The aim of this study was to investigate the characteristics of mandibular premolars regarding size and morphology in Koreans. Moreover, comparisons of gender difference in mandibular premolars were examined to expand anatomical database in Koreans.

Data was obtained from students in School of Dentistry, Chonnam National University, Gwangju, Korea. The total number of participants was 66 (33 men and 33 women) and dental casts were fabricated. A total of nine items was investigated using a digital measuring software. Five measurements were performed including intercuspal distance (ID), buccolingual diameter (BL), mesiodistal diameter (MD), total crown area, and each cusp area. One item as each cusp area ratio was calculated, and three items were observed including the number of lingual cusp, occlusal groove patterns, and mesiolingual developmental groove. Comparison measurements were analyzed using paired *t*-tests, independent *t*-tests and Pearson correlation tests.

Average values in mandibular second premolars were larger than first premolars in most of measurements with a significance with the exception of mesiodistal diameter ($p=0.223$). Overall average values were significantly higher in male than in female except intercuspal distance ($p=0.607$) and lingual cusp area ($p=0.070$) in mandibular premolars. The presence of mesiolingual developmental grooves in the first premolars was 59.1% (male 51.5%, female 66.7%). The most common occlusal groove patterns of the second premolar were a Y pattern, followed in order by H and U patterns.

These results provide valuable morphological characteristics of mandibular premolars in Koreans.

Keywords : Mandibular premolar, Koreans, Morphology

Introduction

A study of dental anatomy requires knowledge about morphology of the various teeth in the human dentition and investigation of how the shape, structure, and function of the teeth are related to each other in the same and

contralateral sides [1]. Correct identification of single human teeth which were performed in intraoral and/or extraoral examination have great importance for two fields. The first is the clinical dentistry which depends on correct identification of the tooth for accurate diagnosis. The latter is the forensic odontology which demands the prudent identification of teeth at postmortem, whether these are found in jaw fragments or in isolation [2].

To analyze characteristics of tooth morphology, advanced digital photography and powerful computer programs made it possible to study on difference of tooth morphology in detail. Although there are many studies regarding tooth morphology from many countries and

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Correspondence to : Sun Hun Kim (Department of Oral Anatomy, School of Dentistry, Chonnam National University, 77 Yongbong-ro, Buk-gu, Gwangju 500-757, Korea)

E-mail : ksh@jnu.ac.kr

periods [3-8], there is lack of studies on tooth morphology and systematic correlations in Koreans yet. Recent study demonstrated that mandibular molars of Korean have smaller size and more dimorphism than other races [9]. However, it is not intensively investigated on the premolars of Korean. In the present study, analysis on dental anatomy of mandibular premolars was performed by adopting various measurements including crown diameter, shape of crown and occlusal groove, and areas of each crown. Moreover, characteristics between mandibular first and mandibular second premolars, or between genders were studied to comprehend and accumulate basic data on dental anatomy in Koreans.

Materials and Methods

1. Sampling and dental casts

The total number of participants was 78, consisting of 38 males and 40 females who were students at Chonnam National University School of Dentistry, Gwangju, Korea. Their average age was 28. Among them, 12 participants (5 males and 7 females) were excluded from experiments for several reasons including restoration, severe attrition, extraction for orthodontic treatment, missing tooth, and abnormal tooth. After excluding all kinds of exceptions, total number of participants was 66 consisting of 33 males and 33 females. Dental casts were made with dental stone (GC Co., Tokyo, Japan) after taking impression of participants' teeth. To make clear surface of tooth, air bubble from each casts were carefully removed.

2. Photograph and measurements of occlusal surface

To take an image of the occlusal surfaces of mandibular first premolars and second premolars in dental casts, digital camera (Canon Powershot A640, Canon Co., Japan) was used. Each dental cast was shot 40 cm away from the occlusal surface perpendicular to the laboratory floor. AxioVision LE Rel 4.4 software (Carl Zeiss GmbH, Jena, Germany) was used to measure diameters and area of premolars. Diameters and areas were measured by 0.01 mm and 0.01 mm².

A total of nine measurements was set as followings: (1) intercuspal distance (ID) as the distance from buccal cusp tip to lingual cusp tip. (2) Buccolingual diameter (BL) as

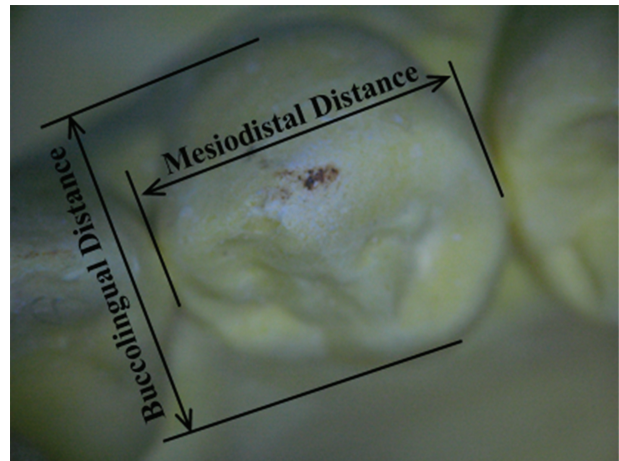


Fig. 1. MD and BL measurement.

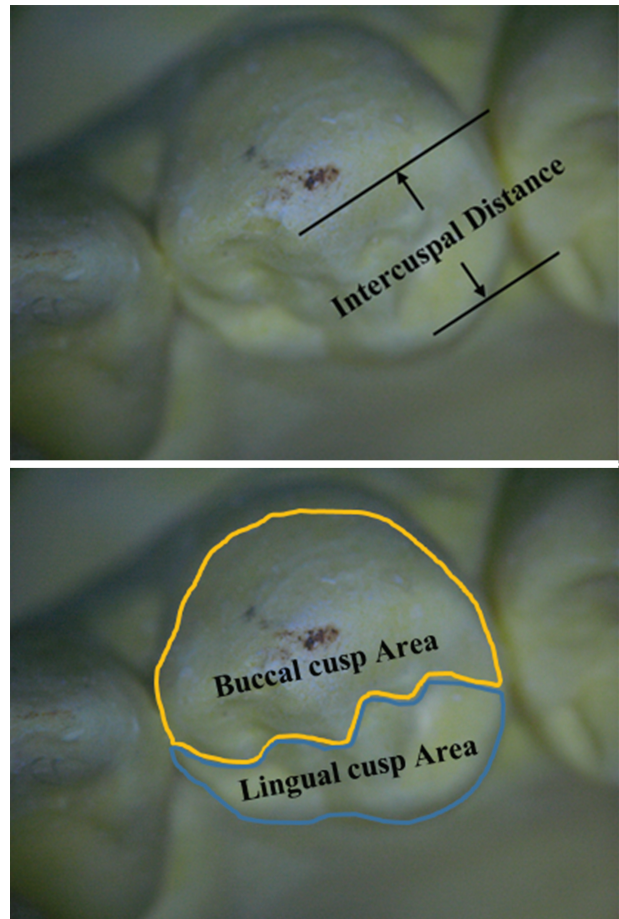


Fig. 2. ID, BC and LC area measurement.

the perpendicular distance between two tangential line of the most prominent point of buccal and lingual sides of crown. (3) Mesiodistal diameter (MD) as the perpen-

dicular distance between two tangential line of the most prominent point of mesial and distal sides of crown (Fig. 1). (4) Each cusp area as the division of buccal cusp area (BC area) and lingual cusp area (LC area) was based on the central developmental groove like other previous studies [7,10]. (5) Total crown area as the sum of all cusp areas. (6) Buccal cusp ratio (BC ratio) and lingual cusp ratio (LC ratio) as the buccal cusp area per total crown area and lingual cusp area per total crown area were calculated, respectively (Fig. 2). (7) The number of lingual cusp from no cusp to two cusps was observed. (8) Mesi-lingual developmental groove was checked whether it exist or absent only in mandibular first premolars (Fig. 3). (9) Patterns of occlusal surface which divided H shape, Y shape or U shape regarding to cusp number were also investigated only in mandibular second premolars (Fig. 4).

3. Statistical analysis

Statistical analysis including the distribution of vari-

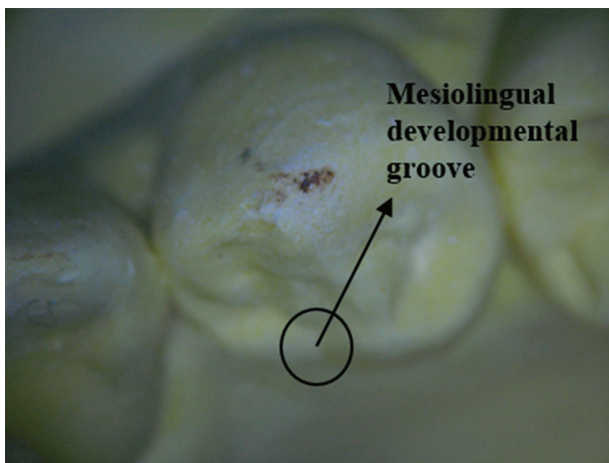


Fig. 3. Mesiolingual developmental groove measurement.

ables was performed with PASW Statistics 18.0 program (IBM-SPSS Corporation, Armonk, NY, USA). Difference between mandibular first premolars and second premolars was analyzed by using paired *t*-tests. Difference between genders and correlation between each measurements was analyzed by independent *t*-tests and Pearson's correlation tests respectively. Each analysis was conducted with 95% confidence interval and significant difference of $p < 0.05$.

Results

1. Comparison with mandibular first and second premolars

Basic descriptive measurements of crown diameter, cusp area, ratio of buccal or lingual cusp to total cusp area of mandibular first and second premolars are listed in Table 1.

1) Crown diameter

Average intercuspal diameter (ID) of mandibular first and second premolars were 4.27 ± 0.49 mm, 4.78 ± 0.46 mm, respectively. Mesiodistal diameter (MD) were 6.56 ± 0.49 mm, 6.66 ± 0.48 mm, buccolingual diameter (BL) were 7.12 ± 0.56 mm, 7.51 ± 0.52 mm in mandibular first premolars and second premolars, respectively. Mandibular second premolars had significantly larger measurements than first premolars in crown diameter, especially in ID and BL. MD between mandibular first and second premolars did not show significant difference, although mean value of MD of mandibular second premolars was larger than first premolars. In terms of gender, male had significantly larger measurements in mandibular second premolars than first premolars except MD (Table 2). Also, female had significantly larger crown diameter in second

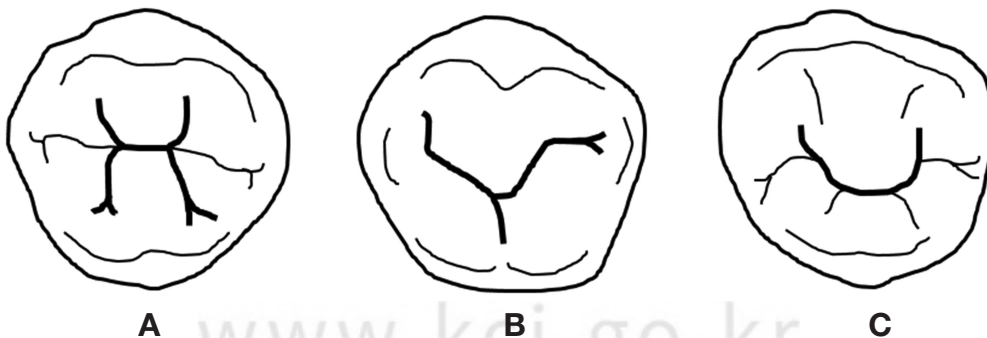


Fig. 4. Occlusal groove pattern of mandibular second premolar. A: H pattern, B: Y pattern, C: U pattern.

Table 1. Descriptive statistics of mandibular first and second premolars

		N	Mean	S.D	t-test			
					t	p-value	Confidence interval (95%)	
							Min.	Max.
Crown diameter (mm)	ID (P1)	66	4.27	0.49	-6.12	0.000**	-0.671	-0.343
	ID (P2)	66	4.78	0.46				
	MD (P1)	66	6.56	0.49	-1.22	0.223	-0.622	-0.267
	MD (P2)	66	6.66	0.48				
	BL (P1)	66	7.12	0.56	-4.18	0.000**	-0.579	-0.207
	BL (P2)	66	7.51	0.52				
Area (mm ²)	BC area (P1)	66	22.42	3.42	-2.19	0.030*	-2.556	-0.130
	BC area (P2)	66	23.76	3.61				
	LC area (P1)	66	13.85	2.77	-5.79	0.000**	-3.636	-1.784
	LC area (P2)	66	16.56	2.59				
	Crown area (P1)	66	36.27	5.35	-4.36	0.000**	-5.892	-2.215
	Crown area (P2)	66	40.32	5.32				
Area ratio	BC ratio (P1)	66	0.61	0.04	4.24	0.000**	0.016	0.043
	BC ratio (P2)	66	0.58	0.03				
	LC ratio (P1)	66	0.38	0.04	-4.24	0.000**	-0.043	-0.016
	LC ratio (P2)	66	0.41	0.03				

ID: intercuspal distance, MD: mesiodistal diameter, BL: buccolingual diameter, BC area: buccal cusp area, LC area: lingual cusp area, BC ratio: buccal cusp ratio to total crown area, LC ratio: lingual cusp ratio to total crown area, F: female, M: male, S.D standard deviation. * $p < 0.05$, ** $p < 0.01$

Table 2. Comparison of mandibular first and second premolars in male

		N	Mean	S.D	t-test			
					t	p-value	Confidence interval (95%)	
							Min.	Max.
Crown diameter (mm)	ID (P1)	33	4.32	0.42	-4.57	0.000**	-0.663	-0.260
	ID (P2)	33	4.78	0.38				
	MD (P1)	33	6.68	0.50	-0.57	0.570	-0.297	0.165
	MD (P2)	33	6.74	0.43				
	BL (P1)	33	7.25	0.56	-2.36	0.021*	-0.607	-0.051
	BL (P2)	33	7.58	0.56				
Area (mm ²)	BC area (P1)	33	22.81	3.95	-2.33	0.023*	-4.222	-0.325
	BC area (P2)	33	25.09	3.97				
	LC area (P1)	33	14.96	2.61	-2.21	0.030*	-2.738	-0.143
	LC area (P2)	33	16.40	2.65				
	Crown area (P1)	33	37.77	5.57	-2.65	0.010*	-6.515	-0.914
	Crown area (P2)	33	41.49	5.80				
Area ratio	BC ratio (P1)	33	0.60	0.04	-0.100	0.913	-0.021	0.018
	BC ratio (P2)	33	0.60	0.03				
	LC ratio (P1)	33	0.39	0.04	0.10	0.913	-0.188	0.021
	LC ratio (P2)	33	0.39	0.03				

ID: Intercuspal distance, MD: mesiodistal diameter, BL: buccolingual diameter, BC area: buccal cusp area, LC area: lingual cusp area, BC ratio: buccal cusp ratio to total crown area, LC ratio: lingual cusp ratio to total crown area, F: female, M: male, S.D standard deviation. * $p < 0.05$, ** $p < 0.01$

premolars than first premolar except MD ($p = 0.240$) (Table 3).

2) Cusp area and area ratio

Buccal cusp (BC) areas of mandibular first and second premolars were $22.42 \pm 3.42 \text{ mm}^2$ and 23.76 ± 3.61

mm^2 , respectively. Lingual cusp (LC) areas were $13.85 \pm 2.77 \text{ mm}^2$, $16.56 \pm 2.59 \text{ mm}^2$, and total crown areas were $36.27 \pm 5.35 \text{ mm}^2$, $40.32 \pm 5.32 \text{ mm}^2$ in mandibular first premolars and second premolars, respectively (Table 1). Mandibular second premolars were significantly larger than first premolars in all categories. Relative cusp ratio

Table 3. Comparison of mandibular first and second premolars in female

		N	Mean	S.D	t-test			
					t	p-value	Confidence interval (95%)	
							Min.	Max.
Crown diameter (mm)	ID (P1)	33	4.23	0.54	-4.17	0.000**	-0.819	-0.288
	ID (P2)	33	4.78	0.53				
	MD (P1)	33	6.43	0.44	-1.18	0.240	-6.620	2.042
	MD (P2)	33	6.57	0.51				
	BL (P1)	33	6.99	0.53	-3.71	0.000**	-0.704	-0.211
	BL (P2)	33	7.45	0.46				
Area (mm ²)	BC area (P1)	33	22.0	2.79	-0.61	0.543	-1.760	0.935
	BC area (P2)	33	22.4	2.68				
	LC area (P1)	33	12.7	2.51	-6.37	0.000**	-5.226	-2.732
	LC area (P2)	33	16.7	2.55				
	Crown area (P1)	33	34.7	4.74	-3.82	0.000**	-6.684	-2.100
	Crown area (P2)	33	39.1	4.57				
Area ratio	BC ratio (P1)	33	0.63	0.03	7.16	0.000**	0.044	0.078
	BC ratio (P2)	33	0.57	0.03				
	LC ratio (P1)	33	0.36	0.03	-7.16	0.000**	-0.078	-0.044
	LC ratio (P2)	33	0.42	0.03				

ID: Intercuspal distance, MD: mesiodistal diameter, BL: buccolingual diameter, BC area: buccal cusp area, LC area: lingual cusp area, BC ratio: buccal cusp ratio to total crown area, LC ratio: lingual cusp ratio to total crown area, F: female, M: male, S.D standard deviation. * $p < 0.05$, ** $p < 0.01$

also showed that the tooth locates more distal, lingual cusp area ratio (LC ratio) increases while buccal cusp area ratio (BC ratio) decreases. In male, all cusp area in second premolars were significantly larger than first premolars, although both of cusp area ratio had no statistically prominent difference (Table 2). Likewise, female had significantly larger values in second premolars than in first premolars except BC area ($p = 0.543$) (Table 3).

3) Morphological traits of mandibular first premolars

To investigate the morphological characteristics of mandibular first premolars, the number of lingual cusp and the presence of mesiolingual developmental groove were categorized. Total 66 subjects were divided into 3 categories according to the number of lingual cusp. As shown in Table 4, 1 cusp type (97.0%) was the most common, followed by 0 cusp type (3.0%) were in order. The mean value of presence ratio of mesiolingual developmental groove was 59.1%, and was more frequently marked in female (66.7%) than male (51.5%).

4) Morphological traits of mandibular second premolars

To investigate the morphological characteristics of mandibular second premolars, the number of lingual cusp and the pattern of occlusal groove were categorized (Table 4). Most common type of lingual cusp was 1 cusp type (54.6%

Table 4. Comparison of morphological traits between mandibular first premolar and second premolars

Items	First premolar		Second premolar	
	Lingual cusp number			
	Male (%)	Female (%)	Male (%)	Female (%)
0	3.0	3.0	0.0	0.0
1	97.0	97.0	57.6	51.6
2	0	0	42.4	48.4
Mesiolingual developmental groove				
	Male (%)	Female (%)		
Presence	51.5	66.7		—
Non-presence	48.5	33.3		
Occlusal groove pattern				
			Male (%)	Female (%)
H pattern			45.4	42.4
Y pattern	—		45.4	48.4
U pattern			9.1	9.1
Others			0.0	0.0

%), followed by 2 cusp type (45.4%) and 0 cusp type (0.0%) in order. Pattern of occlusal groove in mandibular second premolars are divided into 4 categories: H pattern, Y pattern, U pattern, and the other [1]. By analyzing the pattern on occlusal surface, Y pattern was more frequently presented than other 3 patterns. Most common type was Y pattern (46.9%), followed in order by H pattern (43.9%),

U pattern (9.2%) and other (0%), respectively.

5) Comparison of mandibular premolars with other races

Comparing the number of lingual cusp of mandibular premolars between Koreans and Caucasian, the proportion of no lingual cusp in mandibular first premolars was significantly less in Korean (0%) than in Caucasian (5.4%), while the proportion of 2 lingual cusp in mandibular

Table 5. Comparison of morphological traits between Koreans and Caucasian [2]

Items	Mandibular first premolars		Mandibular second premolars	
	Koreans (%)	Caucasian (%)	Koreans (%)	Caucasian (%)
Lingual cusp number				
0	0	5.4	0.0	0.0
1	97.0	88.5	54.6	73.7
2	3.0	6.1	45.4	26.3
Occlusal groove pattern				
			Koreans (%)	Caucasian (%)
H pattern			43.9	51.2
Y pattern	—		46.9	32.5
U pattern			9.2	16.3
Others			0.0	0.0

second premolars was higher in Korean (45.4%) than in Caucasian (26.3%) (Table 5). In terms of occlusal groove pattern in mandibular second premolars, most Koreans had Y pattern (46.9%) while most Caucasian had H pattern (51.2%).

2. Gender difference

Gender differences of mandibular premolars were listed in Table 6. All measurements were larger in male than female. Especially MD, BL, BC area and total crown area were statistically significantly different between genders. However, other measurements had no significant distinctions between male and female in mandibular premolars.

Discussion

In the present study, various anatomical features of the mandibular premolars in Koreans were analyzed by measuring with digital graphic software. Regarding methodological point of view, more precise measurement could be achievable from enlarged image as compared with using a conventional caliper. Moreover, these methods can minimize measurement errors, therefore can reduce time and effort of experiment. Also previous studies demon-

Table 6. Gender difference of mandibular premolars

		Sex	N	Mean	S.D	t-test			
						t	p-value	Confidence interval (95%)	
								Min.	Max.
Crown diameter (mm)	ID	F	66	4.50	0.60	-0.516	0.607	-0.234	0.137
		M	66	4.55	0.46				
	MD	F	66	6.50	0.48	-2.547	0.012*	-1.285	0.013
		M	66	6.71	0.46				
	BL	F	66	7.22	0.54	-2.026	0.045*	-0.394	-0.004
		M	66	7.42	0.58				
Area (mm ²)	BC area	F	66	22.23	2.72	-2.844	0.005**	-2.920	-0.524
		M	66	23.95	4.09				
	LC area	F	66	14.73	3.21	-1.824	0.070	-1.970	0.079
		M	66	15.68	2.71				
	Crown area	F	66	36.96	5.12	-2.759	0.007**	-4.580	-0.754
		M	66	39.63	5.95				
Area ratio	BC ratio	F	66	0.60	0.04	0.102	0.919	-0.014	0.015
		M	66	0.60	0.04				
	LC ratio	F	66	0.39	0.04	-0.102	0.919	-0.015	0.014
		M	66	0.39	0.04				

ID: Intercuspal distance, MD: mesiodistal diameter, BL: buccolingual diameter, BC area: buccal cusp area, LC area: lingual cusp area, BC ratio: buccal cusp ratio to total crown area, LC ratio: lingual cusp ratio to total crown area, F: female, M: male, S.D standard deviation.

*p < 0.05, **p < 0.01

strated a reliable results about morphological traits of the mandibular molar in Korean [9], the digital analysis software seems to be an advantage compared to the measurement using a conventional caliper.

With respect to tooth size, most of mean values of mandibular premolars were significantly larger in the second premolar than in the first premolar with the exception of mesiodistal diameter. Regarding gender difference, male had greater values than female including intercuspal distance, mesiodistal diameter, buccolingual diameter, individual cusp area, and total crown area of first and second premolars. These results were consistent with the previous studies, which showed that mandibular first premolar is smaller than second premolar, because first premolar functions along with the canine, while second premolar supports function of mandibular first molar for efficient occlusion [1,3-5,11-14]. The measurements of the tooth size in Korean were significantly smaller compared to other races [9,17,18].

Also, the number of lingual cusp was investigated to compare differences between mandibular first premolars and second premolars. Having one lingual cusp appeared dominant in both mandibular first and second premolar. One lingual cusp was for the most part found in the first premolar, while two lingual cusp was frequent as much as one lingual cusp in the second premolar in Koreans. This result may be explained by the transition in dental arch. A mandibular first premolar resembles a mandibular canine, and first premolar is a transition from the canine to the second premolar, usually having one lingual cusp or no lingual cusp like canine. Likewise, the second premolar is a transition from the premolar to the first molar, usually having one or two lingual cusps for effective mastication with opposite dental arch [15,16]. Regarding racial differences, the proportion of no lingual cusp in first premolar was relatively less in Korean (3.0%) than in Caucasian (5.4%). Also, the proportion of two lingual cusps in the second premolar was much higher in Korean (45.4%) than in Caucasian (26.3%).

According to the present study, the presence of the mesiolingual developmental groove was 59.1% in the mandibular first premolar. Therefore, the presence of this groove can be regarded as one of the characteristics on mandibular first premolar [3,7].

Mandibular second premolars can be categorized by 3 types of occlusal groove as follows: H pattern, Y

pattern and U pattern. The pattern of occlusal groove has close correlation with the number of lingual cusp in second premolars. Mainly, mandibular second premolars which have two lingual cusp usually show Y pattern. On the other hand, second premolars having one or no lingual cusp usually show H pattern or U pattern. In this study, Y pattern (46.9%) showed most frequent, followed in order by H pattern (43.9%) and U pattern (9.2%). Compared to other races, Caucasian have H pattern (51.2%) predominantly, followed in order by Y pattern (32.5%) and U pattern (16.3%). These results suggest that Korean have more Y pattern premolars because Korean have two lingual cusp in second premolars more frequently, and that may implicate the systematic transition to compensate functional efficiency of occlusion derived from smaller teeth and dental arch, compared with other races [19-21].

From the perspective of gender differences, all measured values in male were larger than in female. Among them, measurements including mesiodistal diameter ($p=0.012$), buccolingual diameter ($p=0.045$), buccal cusp area ($p=0.005$) and total crown area ($p=0.007$) in male were significantly larger than those of female. According to data, buccal cusp area and total crown area show a significant parameter to compare male and female.

For further studies, genetic screening would be needed to focus the factors which influence the tooth morphology during development. In recent reports, there are preliminary gene screening studies regarding dentofacial malformation [22]. Moreover, Osborne et al. used the twin study method and found that genetically controlled variations in dental arch width occurred in all the anterior teeth except the canines with a significance [23]. This study could have a use for compare characteristics of mandibular premolars with Koreans in clinical dentistry for better treatment, and forensic science for providing more correct evidence in personal identification. Moreover, it would be expected to expand systematic database of dental anatomy between Korean and other races.

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한국인 아래턱작은어금니 교합면 분석연구

유홍일, 박하연, 김선현

전남대학교 치의학전문대학원 구강해부학교실

간추림 : 본 연구의 목적은 한국인 아래턱 첫째 및 둘째작은어금니와 관련된 크기와 형태에 있어서 차이를 살펴보고 남녀간 차이점을 알아보기 위함이다. 조사 대상은 전남대학교 치의학전문대학원에 재학 중인 총 66명(남자 33명, 여자 33명)의 치아모형을 제작하였다. 아래턱 첫째 및 둘째작은어금니의 교두사이거리, 볼쪽-혀쪽너비, 안쪽-면쪽너비, 총교두면적, 교두개별면적, 교두면적비율, 혀쪽교두 존재유무, 중심고랑의 형태, 그리고 안쪽혀쪽발달고랑의 존재유무를 조사하였다. 남녀 간의 성별차이 및 치아 간의 차이와 상관관계에 대해 알아보기 위해 paired *t*-tests, independent *t*-tests를 사용하였다.

조사 결과 아래턱둘째작은어금니가 첫째작은어금니에 비해 대부분의 측정값이 더 큰 것으로 나타났으며 안쪽-면쪽너비($p=0.223$)을 제외한 나머지 값들에서 통계적 유의성을 보였다. 남녀 간의 비교에서 모든 평균치 측정값은 남자가 여자보다 크게 나타났고 교두사이거리($p=0.607$)와 혀쪽교두면적($p=0.070$)을 제외하고는 통계적으로 유의하였다. 또한 아래턱 첫째작은어금니의 특징인 안쪽혀쪽고랑은 전체의 59.1%(남자 51.5%, 여자 66.7%)에서 존재하였으며, 둘째작은어금니에서 교합면 고랑 형태의 비율은 Y형이 가장 많았고 그 다음으로 H형과 U형 순으로 조사되었다. 이상의 결과는 한국인 아래턱작은어금니의 비교치아형태학 자료를 제공한다.

찾아보기 낱말 : 아래턱작은어금니, 한국인, 교합면

