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상악 제1대구치의 다양한 형태가 치아정렬 및 회전에 미치는 영향

Submorphotypes of the maxillary first molar and their effects on alignment and rotation

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서울대학교 대학원

치의과학과 구강해부학 전공

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<Abstract>

Submorphotypes of the maxillary first molar and their effects on alignment and rotation

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Introduction: The aim of this study was to explore the shape differences in maxillary first molars with orthographic measurements using 3-dimensional virtual models to assess whether there is variability in morphology that could affect the alignment results when treated by straight-wire appliance systems.

Methods: A total of 175 maxillary first molars with 4 cusps were selected for classification. With 3-dimensional laser scanning and reconstruction software, virtual casts were constructed. After performing several linear and angular measurements on the virtual occlusal plane, the teeth were clustered into 2 groups by the method of partitioning around medoids. To visualize the 2 groups, occlusal polygons were constructed using the average data of these groups.

Results: The resultant 2 clusters showed statistically

significant differences in the measurements describing the cusp locations and the buccal and lingual outlines. The rotation along the centers made the 2 cluster polygons look similar, but there was a difference in the direction of the midsagittal lines.

Conclusions: There was considerable variability in morphology according to 2 clusters in the population of this study. The occlusal polygons showed that the outlines of the 2 clusters were similar, but the midsagittal line directions and inner geometries were different. The difference between the morphologies of the 2 clusters could result in occlusal contact differences, which might be considered for better alignment of the maxillary posterior segment.

Keywords: 3-dimensional scanning, virtual model, Maxillary first molar
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Submorphotypes of the maxillary first molar and their effects on alignment and rotation

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I. Introduction

The straight-wire appliance (SWA), which is widely used in contemporary orthodontic treatment, was originally based on normative data of the dental arch form and individual tooth shape.[1] With regard to tooth shape, the average crown angulation, inclination, and relative crown prominence values from nonorthodontic normal subjects were calculated and used as the guidelines for determining the built-in prescription of SWA systems.[2] In this respect, research on the dimensions and the shapes of teeth should be considered as the fundamental basis for the orthodontic armamentarium.

Human dentition is not uniform but, rather, highly variable in its anatomic features.[3] Teeth are by nature imperfect structures, often individually disfigured and collectively forming malocclusions.[4] There have been several reports regarding tooth shapes and dimensions in the orthodontic literature, and orthodontists have traditionally focused on tooth dimensions, especially the mesiodistal dimensions, rather than shapes.[3,5,6] However, dimensional aberrations directly affect good alignment, whereas peculiar shapes frequently need restorative procedures in which the dimensions can be modified at the same time.

Variations in the size, shape, and arrangement of teeth have been an area of great interest not only to orthodontists, but also to physical anthropologists.[4] A number of studies have been carried out on interpopulational and interspecies differences to find evolutionary correlations between groups.[7–10] For this purpose, diverse methods of odontometry have been widely used,[11] and the use of 3-dimensional (3D) devices for odontometry has recently become popular.[12,13] In addition, the developmental origins of tooth morphology are being elucidated with molecular biology.[9,14–16]

The traditional measurements of tooth size, such as the mesiodistal and buccolingual diameters, are collective measures that do not provide sufficient information.[17] In contrast, the introduction of the occlusal polygon[7,18,19] with 3D technology[12] gives more comprehensive information about tooth morphology. For example, the authors of a previous study investigated the shape of the mandibular molars with respect to their bracket positions and found 2 distinct groups according to the cusp and groove configurations.[12]

The maxillary permanent first molar is the largest tooth in the maxillary dentition. Angle referred to this tooth as the “key to occlusion” because he thought that it was by far the most constant in taking its normal position.[20] This hypothesis was the basis of Angle's classification of malocclusions, which has withstood the test of time more than any of his other contributions and is still widely used as a universal description of malocclusions.[20] Clinically, this tooth frequently is mesially rotated; this exacerbates the arch length discrepancy and Class II molar relationships.[21,22]

According to the current version of the grading system for dental casts by the American Board of Orthodontics, the mesiodistal central grooves of the premolars and molars are used for the evaluation of proper alignment in the maxillary posterior region.[23] Because of the tooth's trapezoidal shape, SWA systems use general distal offset prescriptions of the tube or bracket.[24] Although the maxillary first molars have shown less variability in their shape than the mandibular first molars, especially in their cusp numbers, there are some occasions when the universal use of 1 prescription does not meet the objective of acquiring optimal alignment or occlusion from clinical experience.[19]

Until now, few studies have focused on the shape of the maxillary permanent first molar beyond its overall dimensions from an orthodontic perspective. In this study, we investigated the morphometric characteristics of maxillary permanent first molars using 3D technology and occlusal polygon methods. Our aim was to explore the shape differences in the maxillary first molars to assess whether there is considerable variability in morphology that affects the alignment results when treated with the SWA.

Ⅱ. Material and Methods

The study method used in this investigation has been previously reported.[12] Two hundred Korean children (109 boys, 91 girls) at a minimum age of 10 years were selected from the data of the Korean Dental Growth Study. Informed consents were provided according to the Declaration of Helsinki, and the institutional review board for the protection of human subjects reviewed and approved the research protocol (S-D2010015).

The children were allowed to stay in the study if at least 1 maxillary molar was fully erupted, and also if the score of the simplified version of the tooth wear index was 0.[25] Exclusion criteria of the investigation included any alterations on the teeth including caries, restorations, or surface defects that could affect measurements. Even if both maxillary first molars met the inclusion criteria, only 1 molar was randomly chosen, to rule out interdependence. Finally, a total of 175 maxillary first molars from 175 children (94 boys, 81 girls) were chosen for morphometric examinations.

The virtual 3D models were generated from the selected casts using a 3D scanner (optoTOP-HE; Breuckmann, Meersburg, Germany) according to the routine protocol previously reported.[12,26,27] Then the prepared 3D models were analyzed, and measurements were made using specialized software (Rapidform

2004; INUS Technology, Seoul, Korea). The reference points were created through the consensus of 2 observers (H.-K.K. and Y.-S.P.); for reproducibility of the measurements, the process was repeated 2 times by the same 2 observers over a 3-week period. To test the reliability, 10 of the 3D scans were randomly selected and measured again on separate days 6 months after the initial measurements.

On the occlusal surfaces of the maxillary first molars, the following landmarks were identified to create reference points: 4 cusp tips (mesiobuccal, distobuccal, mesiolingual, and distolingual), 3 occlusal pits (central, mesial, and distal), and 2 contact points (mesial and distal). Based on these structures, the occlusal plane and the midsagittal line were defined for reproducible orientation and orthographic measurements (Fig 1). The landmarks were identified with the customized program described in a previous study.[28] After the occlusal plane was defined using the least squares method based on the locations of the 4 cusp tips, the normal vectors from all reference points mentioned above were drawn to add additional reference points for orthographic measurements.[12] The midsagittal line was defined from the 3 additional reference points originally constructed from the mesial, central, and distal occlusal pits by the least squares method. The center of the midsagittal line was defined as C point by bisecting the line (Table I). In addition, 6 more occlusal reference points were created: the outermost points of the 2 grooves (buccal and lingual) and the 4 outermost points of each cusp (mesiobuccal, distobuccal, mesiolingual, and distolingual vertex) (Fig 1, C and D).

Additional parameters were constructed on the virtual casts to define the linear and angular characteristics of the maxillary first molar. First, the angles formed by the midsagittal line and the lines from the center to the respective 4 cusp tips were measured to determine the cusp tip locations. Next, the angles formed by the midsagittal line and the lines from the center to the respective 2 grooves and 4 vertices were also measured. For linear measurements, distances from the 4 cusp tips to the midsagittal line, distances from the 4 vertices from the midsagittal line, and also the mesiodistal diameter, which was defined as the distance between the mesial and distal contact points, were measured. The definitions of each measurement and descriptions are provided in Table I and Figure 1, respectively.

Once the measurements described above were completed, principal component analysis was used to reduce the dimensionality.[29] The cluster analysis was conducted using only 10 angular measurements to rule out the effect of size differences. Partitioning around medoids was used with the principal components. We tried to find 2 distinct clusters using the silhouette provided by partitioning around medoids, and then the molar samples were assigned to the classification table accordingly.[30,31] Although the previously measured linear variables were not used in the classification of the morphotypes, this information was then added to describe the shapes of the maxillary first molars in more detail.

For the statistical analysis, the homoscedasticity and the normality of the measurement data were verified first. The Student t test was performed to examine any variables that could significantly influence the characteristic forms of the maxillary first molars. The reported P values were based on 2-sided levels of significance.

To visually examine the shape differences between the clusters, a polygon was constructed for each cluster according to the locations of the 4 cusp tips and the 4 vertex points. The resultant comparative diagrams were used to depict the morphologic differences between the clusters according to the unsupervised classification.

Ⅲ. Results

The intraexaminer reliability coefficients ranged from 0.963 to 0.982. In terms of root mean squares, the random errors of estimation were lower than 0.06 mm for linear measurements and 0.57° for angular measurements. No variable showed a statistically significant difference between the test and retest measurements.

All maxillary first molars had 4 cusps. Because there were no statistically significant differences between the sexes in the comparison of angular measurements during the preliminary investigations (Table II), cluster analysis was performed on the pooled sample.

Using scree plots provided by the principal component analysis, 4 principal components were determined to account for about 87.2% of the sample variability of the data (Tables III and IV). We assumed that there were 2 clusters, since several measurements showed bimodal distributions in the exploratory data analysis. In addition, an average partitioning around medoids silhouette width was calculated to validate the number of clusters; a high average width represents good clustering. As a result, a cluster number of 2 showed the largest silhouette width in the trials of 2 to 20 clusters (Fig 2). Therefore, 2 clusters appeared to be an appropriate number for grouping the pooled

175 maxillary first molars according to morphologic characteristics. Based on the results of clustering, 107 molars belonged to cluster 1, and the remaining 68 molars belonged to cluster 2.

The means and standard deviations of the measured variables according to the clusters and the *P* values of the Student *t* test for comparison between the groups are summarized in Table V. All measurements except the distobuccal vertex distance and the mesiodistal diameter showed statistically significant differences between the classified clusters. In terms of a general outline, the teeth of cluster 2 had a more skewed form than did those of cluster 1 (Fig 3); this was inferred from the smaller mesiobuccal groove angle and distobuccal groove angle, and the larger lingual groove angle.

Ⅳ. Discussion

In an odontometric study, there are the 3 major sources of imprecision: (1) identifying and marking the reference points, particularly in the case of worn cusps; (2) variability in orientations: ie, the occlusal viewpoints; and (3) identification of landmarks during the use of computer software.[7] To prevent these sources of imprecision, respectively, we used the following strategies: (1) the data consisted of dental casts of 10-year-old children and the teeth of the simplified version of the tooth wear index of 0 to minimize the effects of tooth wear; (2) all 4 cusp tips were used for making virtual occlusal planes by the least squares method, and all measurements were performed from the orthographic view to improve reproducibility; and (3) identification of landmarks was done as objectively as possible with the specialized program described in the previous study.[26]

In general, the occlusal surfaces of maxillary first molars have a roughly trapezoidal or rhomboidal outline, with the buccal and lingual surfaces converging in the distal direction. In other words, the intercuspal distance between the mesial cusps is larger than the intercuspal distance between the distal cusps. This tendency can be more clearly seen in the maxillary second molar and is called the reduction tendency of the distal cusp by anthropologists. At the same time, the buccal cusps are located somewhat mesial to the lingual cusps.[16] The reduction tendency is explained by genetics and embryology in that the distal cusps form later, grow more slowly, and are less significantly under genetic control.[8] In addition, this reduction tendency is more obvious in Asians than in Europeans.[11]

From the orthodontic point of view, the degree of the reduction tendency of the maxillary molar is perhaps expressed as a shorter distance between the bracket base and the slot on the mesial than the distal half of the molar, or the distal offset prescription of the SWA system. Because the reduction tendency was originally based on the cusp tip position, its application to the bracket prescription is not perfectly pertinent. The buccolingual dimensions of the tooth are known to be established far later during development than the cusp position, which mainly depends on the formation of enamel knots.[9,32,33] Therefore, the buccolingual outline is reported to be independent of the cusp position. In this respect, the measurements on the outermost points of the 4 cusps were inserted as raw data for cluster analysis in this study, since these points are where the bracket or tube base is bonded. However, the angle between the midsagittal line and the buccal cusp line is not so different from the angle between the midsagittal line and the buccal vertex line.

We believed that there might be more than 2 distinct submorphotypes. Histograms for several variables showed a clear bimodal distribution. On the biplots for the first 2 principal components, however, the principal component space did not clearly show a dimorphism. Therefore, the clustering was an assumption of this investigation and should not be a main conclusion. Also, the resultant 2 clusters should not imply that there is some genetic basis for the 2 submorphotypes.

According to the results of the cluster analysis as a quantization method, it might be safe to state that considerable variability was found between the group extremes in the samples of this study. Compared with the outline of the polygon made from cluster 1, the outline of the polygon made from cluster 2 showed a counterclockwise rotation when the midsagittal line was put as a fiducial line (Fig 3). As an additional investigation, the rotation was tried with the midpoint of the midsagittal line as the center up to the degree when the lines connecting the mesial cusp tips of the 2 polygons became parallel. The amount of rotation needed was about 11°, and the 2 polygons looked similar except at the midsagittal line. This means that the difference between the 2 clusters lies in the direction of the midsagittal line when the overall outline is considered as a fiducial reference. In other words, the outlines of the 2 clusters are similar, but their inner geometries are different and might result in occlusal contact differences.

The midsagittal line can be roughly considered as an equivalent of the central groove. Interestingly, the buccal surface alignment of the maxillary first molars in cluster 2 was mesially rotated even if its midsagittal line was well superimposed on the extensions of the central grooves from the premolars (Fig 4). Conversely, if the buccal surfaces of the maxillary posterior teeth were aligned with the SWA systems, the midsagittal lines or the central grooves of the maxillary first molars in cluster 2 might result in misalignment because of their distal rotation in reference to the extension of the central grooves of the premolars. Since the current American Board of Orthodontics grading system recommends using the central groove as a guide for the evaluation of proper alignment, the individual treatment outcome under this scoring could be influenced by this morphogenic variation.[23] Therefore, judicious clinicians should make a keen observation for this kind of aberration and be able to counteract them to finish with excellent treatment results.

Often, maxillary first molars must be derotated to obtain idealized Class I molar relationships in the correction of Class II malocclusions. It is unclear why the maxillary first molars frequently show mesial rotation in Class II patients. However, they are believed to provide an arch length gain with the derotation, which can subsequently be used to resolve deficiencies that are mesial to it.[34] For the proper rotational position of the maxillary first molars, Ricketts[35] described a line through the mesiopalatal and distobuccal cusps of the molar. If this line passes the distal half of the canine on the contralateral side, the molar is positioned correctly. According to the rule for clinical evaluation by Cetlin,[36] the buccal surfaces of the molars should be parallel when viewed from the anterior. Because the focus of our study was limited to the morphology of the first molars, the evaluation of the proper rotation compared with other dentitions was not possible.

The optimal rotational state of individual maxillary first molars should be in harmony with their antagonists, and the degree of rotation appears to be related to the intercuspation of the opposing dentition. According to Dahlquist et al,[37] the palatal cusps of mesially rotated maxillary first molars were reported to often occlude correctly in the fossae of opposing molars. Limitations of this investigation might include the fact that the occlusal polygons did not consider cuspal heights. Further studies are needed to elucidate the relationship between the dentitional morphogenic variations and their mutual influences on possible alignment, rotation, and extrusion to maintain a stable occlusion in the real 3D situation.[38] It would be better to consider another issue in the sample selection—the dental fluctuating asymmetry, which was beyond the scope of this study.[39] In addition, the value of tooth-altering procedures should be reevaluated based on the results of further studies.[40]

V. Conclusions

Contemporary maxillary first molars were classified using unsupervised cluster analysis, assuming the existence submorphotypes. The results showed considerable variability in molar morphology, which was demonstrated by statistically significant differences between clusters in the measurements describing the cusp configurations and outlines. The 2 clusters showed essential differences in the direction of the midsagittal line when the cluster 2 polygon was rotated in a counterclockwise direction until the 2 cluster polygons showed similar alignments. This means that the entire outlines of the 2 clusters are similar, but the inner geometry is different and might result in occlusal contact differences. In addition, the differences between the 2 cluster morphologies were related to the rotation of the tooth, which can be affected or treated by SWA systems.

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Table Ⅰ. Variable abbreviations and definition on the virtual occlusal plane

Variable	*Definition*
Midsagittal line (MSL)	Virtual line constructed from 3 points (mesial pit, central pit, distal pit) by the least squares method
M	Mesial endpoint of MSL; foot of the mesial pit on the MSL
D	Distal end point of MSL; foot of the distal pit on the MSL
C	Center of MSL; the midpoint between points M and D
Mesiobuccal cusp angle (MBCA)	Angle formed by point M, point C, and the mesiobuccal cusp (MBC) tip
Distobuccal cusp angle (DBCA)	Angle formed by point M, point C, and the distobuccal cusp (DBC) tip
Mesiolingual cusp angle (MLCA)	Angle formed by point M, point C, and the mesiolingual cusp (MLC) tip
Distolingual cusp angle (DLCA)	Angle formed by point M, point C, and the distolingual cusp (DLC) tip
Buccal groove angle (BGA)	Angle formed by point M, point C, and the outermost point from the occlusal view on the mesiobuccal groove (BG)
Lingual groove angle (LGA)	Angle formed by point M, point C, and the outermost point from the occlusal view on the lingual groove (LG)
Mesiobuccal vertex angle (MBVA)	Angle formed by point M, point C, and the most prominent point of the mesiobuccal cusp of the teeth from the occlusal view (mesiobuccal vertex [MBV])
Distobuccal vertex angle (DBVA)	Angle formed by point M, point C, and the most prominent point of the mesiobuccal cusp of the teeth from the occlusal view (MBV)
Mesiolingual vertex angle (MLVA)	Angle formed by point M, point C, and the most prominent point of the lingual side of the teeth from the occlusal view (mesiolingual vertex [MLV])

Distolingual vertex angle (DLVA)	Angle formed by point M, point C, and the most prominent point of the lingual side of the teeth from the occlusal view (MLV)
Mesiobuccal vertex distance (MBVD)	Distance from MSL to MBV
Distobuccal vertex distance (DBVD)	Distance from MSL to distobuccal vertex (DBV)
Mesiolingual vertex distance (MLVD)	Distance from MSL to MBV
Distolingual vertex distance (DLVD)	Distance from MSL to distolingual vertex (DLV)
Mesiodistal diameter (MDD)	Distance between mesial contact point and distal contact point

Table Ⅱ. Means and standard deviations of measurements according to sex as the result of comparisons between clusters with the Student *t* test

	Female (n = 81)	*Male (n = 94)*
MBCA (°)	45.44 ± 7.65	45.58 ± 7.96
DBCA (°)	118.20 ± 6.89	120.22 ± 5.46
MLCA (°)	76.10 ± 11.30	75.45 ± 10.68
DLCA (°)	145.34 ± 8.37	146.17 ± 7.64
MBVA (°)	72.13 ± 6.46	71.22 ± 8.26
DBVA (°)	105.67 ± 6.45	106.37 ± 7.37
MLVA (°)	89.39 ± 8.42	89.59 ± 8.28
DLVA (°)	124.95 ± 7.29	124.14 ± 8.76
BGA (°)	86.90 ± 6.17	87.24 ± 6.74
LGA (°)	110.36 ± 8.16	110.04 ± 10.24
MBVD (mm)	5.49 ± 0.45	5.50 ± 0.56
DBVD (mm)	5.38 ± 0.34	5.50 ± 0.40
MLVD (mm)†	5.64 ± 0.39	5.92 ± 0.40
DLVD (mm)	4.84 ± 0.51	4.95 ± 0.63
MDD (mm)*	9.35 ± 0.68	10.27 ± 0.72

**P* <0.01; † *P* <0.001 at the comparisons between clusters.

Table Ⅲ. Principal component (PC) table with coordinate loadings of 10 angular measurements (°)

	PC1	*PC2*	*PC3*	*PC4*
MBCA	0.562	−0.252	0.052	−0.420
DBCA	−0.421	0.507	0.278	−0.057
MLCA	−0.085	−0.131	−0.425	−0.086
DLCA	0.073	−0.509	0.630	0.182
MBVA	−0.077	0.058	0.167	−0.442
DBVA	0.120	−0.194	−0.355	0.129
MLVA	0.419	0.434	0.043	−0.448
DLVA	0.390	0.288	0.186	0.409
BGA	0.366	0.293	0.038	0.413
LGA	−0.112	−0.064	0.388	−0.171

Table Ⅳ. Principal component (PC) analysis: 4 principal components accounted for 87.4% of variations

	PC1	*PC2*	*PC3*	*PC4*
Eigenvalue	296.728	109.178	73.958	56.898
Proportion of variance	0.466	0.171	0.136	0.099
Cumulative proportion	0.466	0.637	0.773	0.872

Table V. Means and standard deviations of measurements according to clusters by partitioning around medoid cluster analysis and the result of comparison between clusters with the Student *t* test

	Cluster 1 (n = 108)	*Cluster 2 (n = 67)*
MBCA (°)†	49.76 ± 5.59	38.68 ± 5.72
DBCA (°)†	121.28 ± 5.69	116.09 ± 6.36
MLCA (°)†	69.82 ± 8.29	85.32 ± 7.35
DLCA (°)†	142.75 ± 6.55	150.68 ± 8.33
MBVA (°)†	75.54 ± 5.40	65.33 ± 5.93
DBVA (°)†	108.32 ± 7.39	102.34 ± 6.71
MLVA (°)†	85.18 ± 6.75	96.45 ± 5.41
DLVA (°)*	120.86 ± 6.11	130.41 ± 5.61
BGA (°)†	90.06 ± 5.20	82.28 ± 5.37
LGA (°)†	106.52 ± 6.88	116.10 ± 9.72
MBVD (mm)†	5.75 ± 0.38	5.09 ± 0.43
DBVD (mm)	5.43 ± 0.37	5.33 ± 0.36
MLVD (mm)*	5.68 ± 0.38	5.96 ± 0.42
DLVD (mm)*	5.03 ± 0.52	4.69 ± 0.62
MDD (mm)	9.72 ± 0.58	9.67 ± 0.61

*P <0.01; † P <0.001 at the comparisons between clusters.

Fig. 1. A, Landmarks of 4 cusp tips, 3 occlusal pits, and MSL; B, angular measurements related to the 4 cusp tips; C, angular measurement related to 2 occlusal grooves and 4 vertices; D, linear measurements. (See Table I for explanation of abbreviations.)

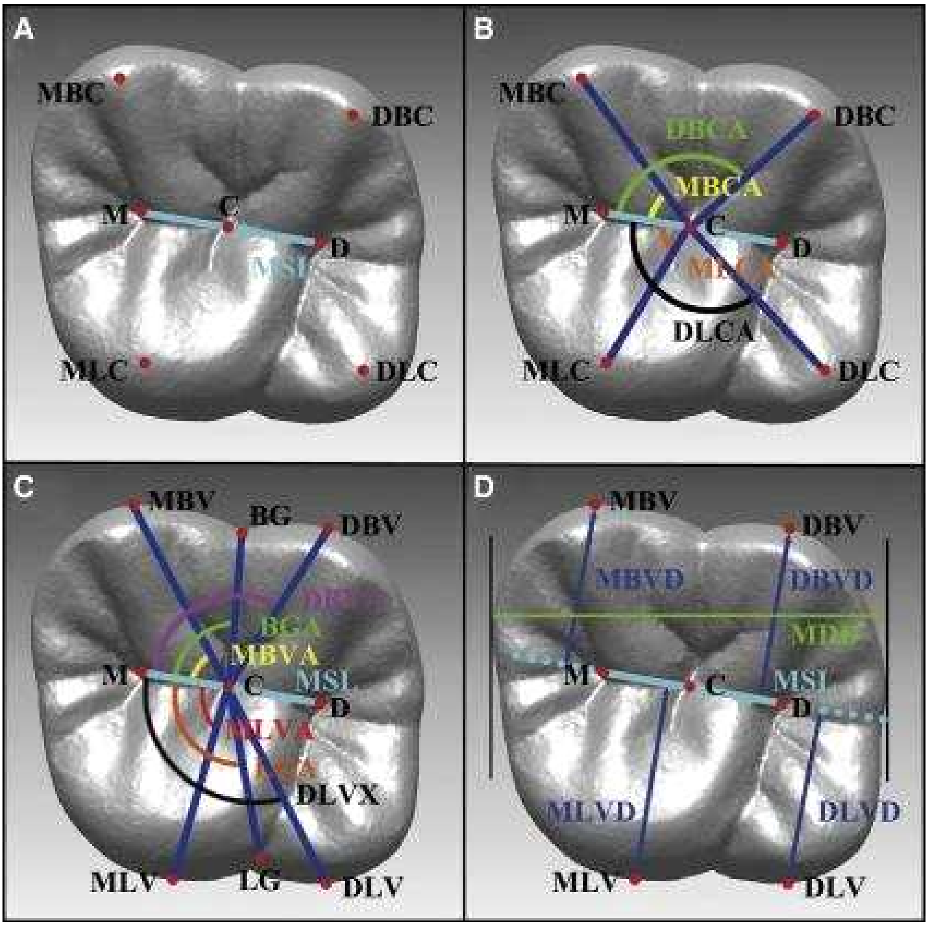


Fig. 2. Average silhouette widths according to the number of clusters from 2 to 20

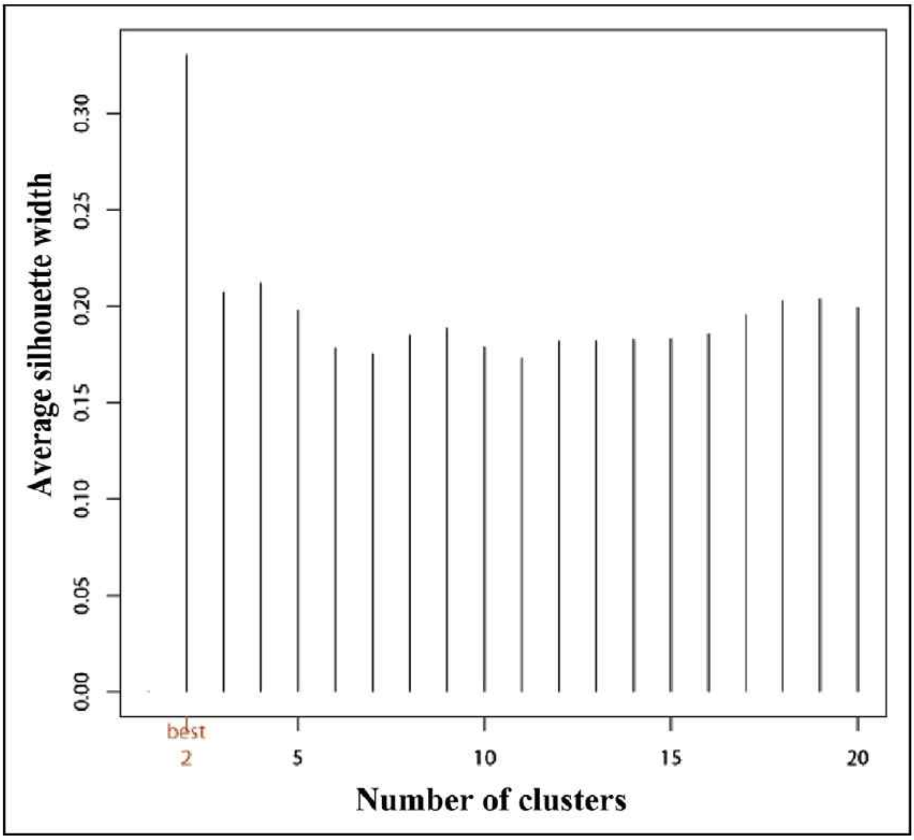


Fig. 3. Diagram of the polygon made from 5 cusp tips and 3 occlusal grooves of mandibular first molar: **A**, cluster 1; **B**, cluster 2; **C**, superimposition of 2 clusters; **D**, counterclockwise rotation of about 11° of cluster 2 polygon.

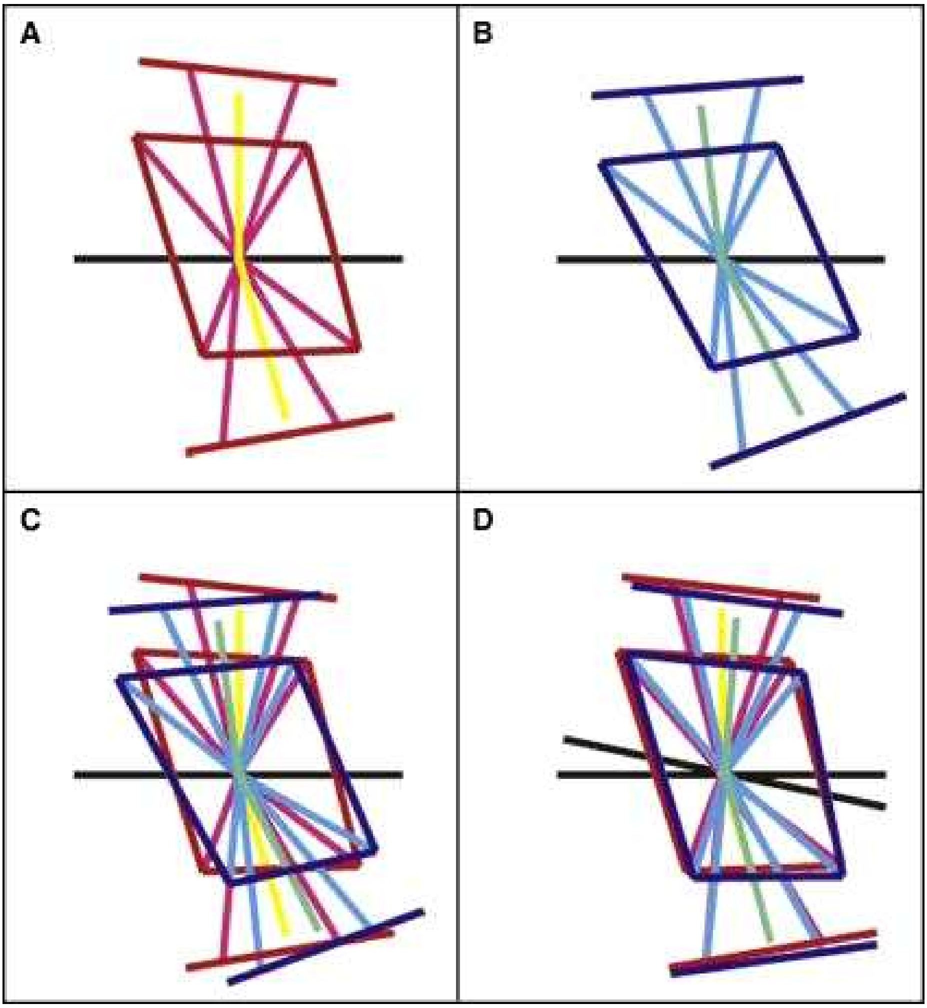
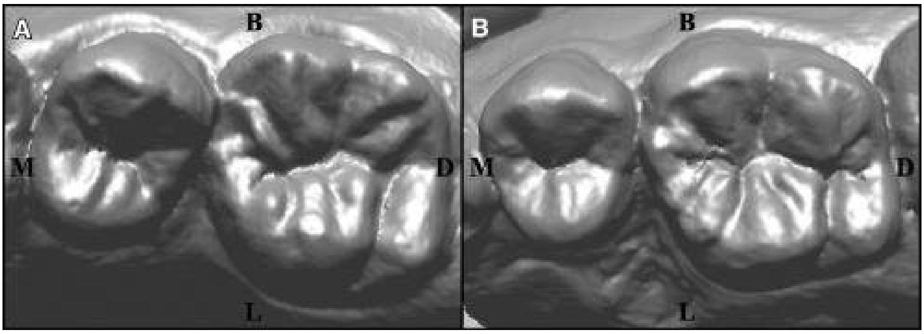


Fig. 4. Typical examples of **A,** cluster 1 and **B,** cluster 2.
M, mesial; *B*, buccal; *D*, distal; *L*, lingual.



<국문요약>

상악 제1대구치의 다양한 형태가 치아정렬 및 회전에 미치는 영향

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연구목적: 이 연구의 목적은 교정치료에 많이 이용되는 straight wire appliance (SWA)에 의한 교정치료 시 치아정렬 및 회전에 영향을 미칠 수 있는 상악 제1대구치의 형태의 특징과 종류를 3차원 가상 모델에서 직교 측정을 이용해 형상의 차이를 알아보는 것이다.

연구대상 및 방법: 총 175명(남자: 81개, 여자: 94명)의 10세 한국 어린이들의 4 교두형인 상악 제1대구치를 3차원 스캐너와 재건 소프트웨어를 이용하여 가상모델을 제작하였다. 상악 제1대구치 가상모델에서 4개의 cusp, 3개의 pit, 2개의 contact point를 추출하고, occlusal plane, midsagittal line(MSL), central point를 설정하였다. 이 landmark를 바탕으로 치아 형태의 특징을 나타내는 cusp angle, groove angle, vertex angle 등의 값을 계산 한 후, principal component analysis (PCA), partitioning around medoids (PAM) 등의 통계적 기법을 활용하여 치아 형태의 종류를 분석하였다. 그리고 그룹을 시각화하기 위해, 그룹의 평균 데이터를 사용하여 교합면 다각형을 재현하였다.

결과: 치아의 형태에 영향을 미칠 수 있는 변수들 중 결정적인

영향을 미칠 변수를 분석하기 위해 PCA를 시행하였고, 이를 바탕으로 cluster method 의 일종인 PAM을 사용하여, 크게 2개의 cluster로 나눌 수 있음을 알 수 있었다. 형태와 성별의 상관관계는 낮은 것으로 나타났다. 2개의 cluster의 다각형은 유사하게 보였으나 2개 cluster의 교두 위치 그리고 협・설측 윤곽선의 기술 측정에서 통계적으로 유의한 차이를 가지고 있었다. 2개 cluster의 중심을 기준으로 midsagittal 라인의 방향에 따른 차이가 있었다.

결론: 2개 cluster의 교합면 다각형 즉, 상악 제1대구치의 형태가 비슷하게 보이지만, 4각형을 이루는 cusp의 위치와 groove, 그리고 midsagittal line의 방향등 차이가 있었다. 따라서 교정치료 시 평균적인 값(normative data)을 기준으로 하고 있는 straight wire appliance(SWA) 사용 시 치아의 variation을 보상하기 위해 추가적인 변형으로 사용해야 한다.

주요어: 삼차원스캐너, 가상모델, 상악 제1대구치
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