What determines dental protrusion or crowding while both malocclusions are caused by large tooth size?

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Objective: To examine the differences in lateral cephalometric characteristics between patients with dental protrusion and crowding in order to determine what factors affect dental protrusion or crowding while both malocclusion types are caused by large tooth size. **Methods:** Twenty nine individuals with dental protrusion and 22 individuals with dental crowding were enrolled in this study. All subjects had larger teeth than average and Class I molar relationships. Craniofacial characteristics and hyoid bone positions were determined from lateral cephalograms and compared between the two groups. **Results:** In the comparisons of craniofacial characteristics, the measurements indicating maxillary length and facial convexity showed greater values in the protrusion group than in the crowding group. Comparisons of hyoid bone positions showed that the hyoid bone was positioned more anteriorly and superiorly in the protrusion group than in the crowding group. **Conclusions:** The results of the present study indicate that some craniofacial characteristics and tongue position may affect the development of dental protrusion or crowding; when an individual has large teeth, dental protrusion or crowding might be determined according to maxillary growth and tongue position. **(Korean J Orthod 2009;39(5):330-336)**

Key words: Dental protrusion, Dental crowding, Cephalometric characteristics, Tooth size

INTRODUCTION

Bimaxillary dental protrusion is considered to be a subclass of Class I malocclusion, showing normal molar relationships, normal overbite and overjet and anterior inclinations of the maxillary and mandibular incisors.[1-3] Bimaxillary dental protrusion, with accompanying lip protrusion or lip sealing incompetency, results in unaesthetic facial profiles. Cox and van der Linden[4] reported that persons with poor facial esthetics generally have a relatively more convex face due to anterior positioning of the midface, including the teeth. Keating[5] reported the morphological features of bimaxillary protrusion in a cephalometric study. McCann and Burden[6] used dental casts of bimaxillary protrusions according to Keating's criteria and found a correlation between tooth size and bimaxillary dental protrusion.

Dental crowding is defined as a disharmony in the

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available basal arch length and the required arch length for proper alignment of the teeth.[7,8] Doris et al.[9] defined crowded arches as those with more than a 4 mm space deficiency, and reported that all of the teeth in the crowded group were uniformly larger than in the good alignment group.

A review of the literature regarding bimaxillary dental protrusion[6] and dental crowding[9,10] reveals that both types of malocclusions have larger teeth than normal; however, their tooth alignment and facial profiles show different patterns. These findings indicate that other factors might determine dental protrusion or dental crowding in an individual with large tooth size.

On the other hand, many etiologic factors have been suggested for the development of dental protrusion such as low lip force, mouth breathing, large tongue, and tongue thrusting habits.[11-14] However, few studies have directly compared dental protrusion with dental crowding. This study was performed to investigate the differences in the lateral cephalometric characteristics between dental protrusion and crowding and to determine the etiology of each type of malocclusion.

MATERIAL AND METHODS

Subjects

The sample in this study was selected from the orthodontic patient record of a university hospital. For the first step, patients with larger than average teeth were selected, on the basis of the four mandibular incisors, as both dental protrusion and dental crowding are found in patients with large teeth.[6,9,10] The sum of the four mandibular incisors was required to be larger than the average (males 22.8 mm, females 22.0 mm).[15] Any subject who presented Class II or Class III was excluded. The patients were also limited to those over 18 years of age.

The final step in the sample selection for the dental protrusion group was to investigate cephalometric measurements. The patients were restricted to those satisfying the criteria of Keating's study;[5] a maxillary incisor angle over 115°, mandibular incisor angle over 99°, and an interincisal angle under 125°. For the dental crowding group, they were required to have an arch length discrepancy over 4 mm in both the maxillary and mandibular arches.[9] Twenty nine subjects with dental protrusion and 22 subjects with dental crowding were selected from 4,500 patient records (Table 1).

Table 1. Distribution of age and gender in the samples

Sex	Protrusion		Crowding	
	Age (Mean ± SD)	N	Age (Mean ± SD)	N
Male	20.4 ± 1.6	6	24.8 ± 4.3	7
Female	23.9 ± 6.4	23	21.3 ± 2.2	15
Total	23.2 ± 5.9	29	22.4 ± 3.4	22

N, number; SD, standard deviation.

Measurement and comparison of tooth size

Patients with dental protrusion or dental crowding with large teeth were selected based on the dimensions of their mandibular incisors. However, this did not mean that all teeth were of equal sizes in the two groups. In order to confirm size, the mesiodistal diameters of 12 teeth, from the central incisor to the first molar of both sides in one arch and again in the other arch, were measured using a digital vernier caliper. Then, the sums of all of the measured values of the maxillary arch and the mandibular arch were compared between the two groups.

Tracing and measurement of lateral cephalometric radiographs

Lateral cephalograms were traced and 16 skeletal landmarks, 4 dental landmarks, and 8 cervical and hyoid bone landmarks were designated as shown in Fig 1. The measurements reflecting the craniofacial characteristics, the incisor positions, and the positions of the hyoid bones were defined on each tracing. The measurements of hyoid bone positions were determined as shown in Fig 2.

Statistical analysis

SPSS software (SPSS for windows version 12.0,

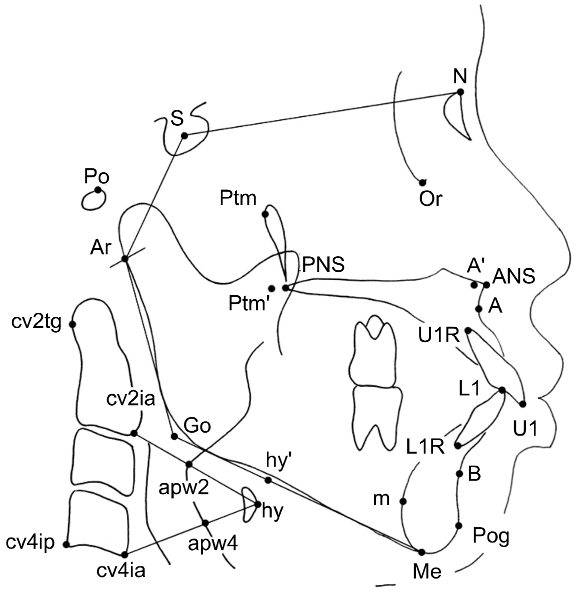

Fig 1. Cephalometric landmarks and tracing used in this study. S, Sella; Po, porion; Ar, articulare; N, nasion; Or, orbitale; Ptm, the eleven o'clock position of the pterygomaxillary fissure; Ptm', the perpendicular point from Ptm along palatal plane (ANS-PNS plane); ANS, anterior nasal spine; PNS, posterior nasal spine; A, point A; A', the perpendicular point from A along palatal plane; B, point B; Pog, pogonion; Me, menton; m, the most posterior point on the mandibular symphysis; Go, gonion; cv2tg, the most posterior point on the odontoid process of the second cervical vertebra; cv4ip, the most posteroinferior point on the corpus of the fourth cervical vertebra; cv2ia, the most anteroinferior point on the corpus of the second cervical vertebra; cv4ia, the most anteroinferior point on the corpus of the fourth cervical vertebra; hy, the most anterosuperior point on the body of the hyoid bone; hy', the perpendicular point from hy along the mandibular plane; apw2, the anterior pharyngeal wall along the line intersecting cv2ia and hy; apw4, the anterior pharyngeal wall along the line intersecting cv4ia and hy; U1, the tip of the upper central incisor; U1R, the root apex of the upper central incisor; L1, the tip of the lower central incisor; L1R, the root apex of the lower central incisor.

Chicago, Il, USA) was used for the calculation of means and standard deviations of all the measurements, and independent *t*-tests were used to determine significant differences between the two groups. A *p*-value < 0.05 was considered significant.

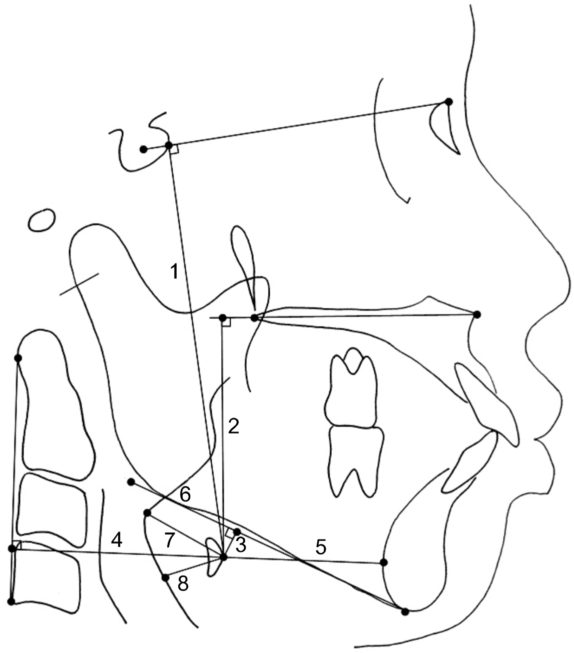

Fig 2. Measurements for hyoid bone position used in this study. 1, The perpendicular distance from hy to S-N plane (hy-SN); 2, the perpendicular distance from hy to palatal plane (hy-PP); 3, the perpendicular distance from hy to mandibular plane (hy-MP); 4, the perpendicular distance from hy to cervical vertebrae tangent (hy-CVT); 5, the distance from hy to m (hy-m); 6, the distance from hy' to Go (hy'-Go); 7, the distance from hy to apw2 (hy-apw2); 8, the distance from hy to apw4 (hy-apw4).

RESULTS

Tooth size comparison

A comparison of the sum of the mesiodistal diameters from the central incisor to the first molar showed no significant differences between the two groups in either the maxillary or the mandibular dentitions (Table 2).

Comparison of craniofacial measurements

Comparisons of the craniofacial measurements revealed significant differences between the two groups in five of seventeen measurements: S-N, A'-Ptm', SNA,

Table 2. Comparison of the sum of tooth size between protrusion and crowding groups (Unit: mm)

	Protrusion (n = 29)	Crowding (n = 22)	Significance
	Mean ± SD	Mean ± SD	
Maxilla	101.8 ± 4.9	100.1 ± 4.3	NS
Mandible	92.5 ± 4.2	91.6 ± 3.7	NS

N, number; SD, standard deviation; NS, not significant.

Table 3. Comparison of craniofacial measurements between protrusion and crowding groups

Variables	Protrusion (n = 29)	Crowding (n = 22)	Significance
	Mean ± SD	Mean ± SD	
S-N (mm)	71.0 ± 3.5	68.7 ± 2.4	*
S-Ar (mm)	37.9 ± 3.9	37.0 ± 3.0	NS
Go-Me (mm)	77.8 ± 4.1	76.6 ± 4.1	NS
A′-Ptm′ (mm)	50.9 ± 4.1	48.2 ± 2.8	*
PFH/AFH (%)	64.1 ± 4.0	65.0 ± 4.2	NS
Saddle angle (°)	124.8 ± 5.2	125.6 ± 4.7	NS
Articular angle (°)	151.1 ± 5.8	150.2 ± 5.6	NS
Gonial angle (°)	121.4 ± 4.9	121.1 ± 5.7	NS
Sum (°)	397.1 ± 4.8	397.0 ± 5.3	NS
SNA (°)	82.1 ± 4.0	80.2 ± 2.1	*
SNB (°)	77.5 ± 3.5	77.2 ± 2.8	NS
ANB (°)	4.6 ± 1.8	3.0 ± 1.8	*
Facial angle (°)	86.0 ± 3.1	87.5 ± 2.3	NS
Facial convexity (°)	9.2 ± 4.0	4.7 ± 4.4	*
FMA (°)	28.7 ± 4.4	27.5 ± 4.9	NS
PP-MP (°)	27.4 ± 5.0	26.2 ± 5.5	NS
OP-MP (°)	20.8 ± 10.7	18.8 ± 3.6	NS

N, number; SD, standard deviation; NS, not significant; $^{*}p < 0.05$.

ANB and facial convexity. All these measurements showed greater values in the protrusion group than in the crowding group, indicating that the patients with dental protrusion have a larger cranial base, longer maxillary length, and greater facial convexity compared to the patients with dental crowding (Table 3).

Table 4. Comparison of measurements of the incisor position in protrusion and crowding groups

Variables	Protrusion (n = 29)	Crowding (n = 22)	Significance
	Mean ± SD	Mean ± SD	
U1-SN (°)	114.4 ± 5.8	107.4 ± 7.1	*
U1-APog (mm)	14.2 ± 1.9	9.5 ± 2.7	*
L1-APog (mm)	9.5 ± 2.3	4.8 ± 2.3	*
U1-FP (mm)	17.1 ± 2.2	11.0 ± 3.4	*
L1-FP (mm)	12.5 ± 2.6	6.3 ± 2.9	*

N, number; SD, standard deviation; $^{*}p < 0.05$.

Table 5. Comparison of hyoid bone position between protrusion and crowding groups

Variables	Protrusion (n = 29)	Crowding (n = 22)	Significance
	Mean ± SD	Mean ± SD	
hy-SN (mm)	107.2 ± 8.4	109.1 ± 8.9	NS
hy-PP (mm)	60.4 ± 6.2	64.5 ± 6.8	*
hy-MP (mm)	6.9 ± 5.4	14.2 ± 11.0	*
hy-CVT (mm)	53.3 ± 3.9	49.3 ± 10.4	NS
hy-m (mm)	34.9 ± 4.9	38.0 ± 9.0	NS
hy′-Go (mm)	35.8 ± 6.1	30.5 ± 5.8	*
hy-apw2 (mm)	21.1 ± 6.0	22.4 ± 7.2	NS
hy-apw4 (mm)	17.3 ± 2.5	15.9 ± 3.8	NS

N, number; SD, standard deviation; NS, not significant; $^{*}p < 0.05$.

Comparison of the position of incisors

The measurements of U1-SN, U1-APo, L1-APo, U1-FP and L1-FP showed that all of these measures were greater in the protrusion group, and hence confirmed that the upper and lower incisors in the protrusion patients were more anteriorly positioned than in the crowding patients (Table 4).

Comparison of the position of the hyoid bone

In the comparisons of the hyoid bone measurements, significant differences were observed for hy-PP, hy-MP and hy'-Go. The measurements for hy-PP and hy-MP showed smaller values in the protrusion group indicating that the position of the hyoid bone was placed more superior in the protrusion group than in the crowding group. For hy'-Go, it showed a greater value in the protrusion group indicating that the hyoid bone was located more anteriorly in the protrusion group than in the crowding group (Table 5).

DISCUSSION

A review of the literature indicates that dental protrusion is caused by large tooth size.[9,10] The results of tooth size measurement in the present study showed that the tooth size for the protrusion group was greater than that of normal occlusion individuals.[15] However, there was no significant difference in tooth size between the protrusion group and the crowding group in this study; dental crowding is also caused by large tooth size. These findings indicate that tooth size is not the sole factor that determines dental protrusion. When an individual has larger teeth than normal, he or she might develop into dental protrusion or dental crowding according to some other factors. The purpose of the present study was to investigate the differences in the lateral cephalometric characteristics between dental protrusion and crowding in order to determine what factors affect dental protrusion or crowding while both types of malocclusions are caused by large tooth size.

In order to draw meaningful conclusions, the matter of sample selection is of utmost importance. The sample for this study was selected from the orthodontic patient records of a university hospital. For the first step, the patients with larger than average teeth were selected because both dental protrusion and dental crowding are found in patients with large teeth.[6,9,10] The sizes of the four mandibular incisors were used as the inclusion criteria for the selection of patients since they are known to be relatively stable, whereas the maxillary incisors show variability in sizes.[16,17] The sum of the mesiodistal diameters was required to be larger than average.[15] In addition, subjects with Class I molar relationships were included; any subject who presented Class II or Class III was excluded because accurate comparisons of lateral cephalometric measurements were not possible for these subjects. The patients were also limited to those over 18 years of age in order to compare differences after growth was complete. Finally, the subjects were restricted to those satisfying the cephalometric criteria of Keating's study for the dental protrusion group.[5] As for the dental crowding group, they were required to have an arch length discrepancy over 4 mm in both the maxillary and mandibular arches.[9] Twenty nine subjects with dental protrusion and 22 subjects with dental crowding were selected as the sample for the study. Substantial efforts were required to select these numbers of the sample; 4,500 consecutive patient records were used for the sample selection of the present study.

In the comparisons of craniofacial measurements, there were significant differences between the protrusion and crowding groups for S-N, A'-Ptm', SNA, ANB and facial convexity. These measurements were greater in the protrusion group, indicating that the patients with dental protrusion had a larger cranial base, longer maxillary length and greater facial convexity compared to the crowding individuals. Keating[5] reported similar number of values for A'-Ptm' (50.7 mm), SNA (82.3^{o}), and ANB (9.7^{o}) in his study regarding bimaxillary protrusion. The results of that study indicated that dental protrusion would develop in cases of maxillary protrusion. Considering that only Class I subjects were used in this study, a skeletal Class II tendency is a contributing factor to dental protrusion, even in an individual with a Class I molar relationship. On the other hand, Rose and Roblee[18] maintained, in a recent review, that alveolar bone discrepancies should be considered as a leading cause of dental crowding. They further insisted that treatment should focus on the development of alveolar bone to relieve crowding. Their study suggests that dental crowding is developed in case of bone deficiency.

It is also interesting to note that the measurements for S-N showed greater values in the protrusion group. Considering that the measurements for facial convexity also presented greater values in the protrusion group, it is suggested that the size of the craniofacial skeleton is greater in the protrusion group than in the crowding group. These results indicate that the size of the craniofacial skeleton might be a determining factor for dental protrusion or dental crowding.

As soft tissue components have been reported to be related to the development of dental protrusion in addition to skeletal features,[11-14] investigation of tongue position was needed. Considering that tongue position is influenced by the position of the hyoid bone,[19,20] the measurements indicating the hyoid bone position were defined in this study. It has been reported that hyoid position might be influenced by many factors: the supra- and infra-hyoid muscles,[19-21] head posture[21,22] and craniocervical posture.[23,24] With this in mind, particular attention was paid to defining the measurements reflecting hyoid bone position in this study. The measurements of hy-SN and hy-PP were established to reflect the hyoid position on the basis of the cranium and nasomaxillary complex, whereas the hy-MP and hy'-Go were defined on the basis of the mandible. The measurements of hy-apw2 and hy-apw4 were established based on the anterior pharyngeal wall. In addition, hy-CVT was defined on the basis of the cervical column according to Carlsoo and Leijon[25] who reported that determination of hyoid position using the cervical column as a reference was more valid than using the cranium or mandible.

Comparisons of the hyoid bone measurements between the two groups showed that the hyoid bone was positioned more superiorly and anteriorly in the protrusion group than in the crowding group. These results indicate that a difference in the hyoid position might have an effect on the determination of whether dental protrusion or crowding develops. Considering that hyoid position influences the position of the tongue,[19,20] this suggests that tongue position or pressure affects whether dental protrusion or crowding develops in an individual with large tooth size.

Overall, the findings of this study are that the protrusion group showed a larger cranial base, longer maxillary length, greater facial convexity and a tendency for an antero-superior position of the hyoid bone compared to the crowding group. These results indicate that dental protrusion or crowding might be determined according to maxillary growth and tongue position when an individual has larger teeth than normal. However, the exact cause-effect relationship could not be elucidated in the present study. The above characteristics might be the results of dental protrusion or crowding, but not necessarily the causes. Additional studies to investigate these relationships should be conducted.

On the other hand, Angle's classification alone was used as an inclusion criteria while Class I subjects were used as the sample for both groups in the present study. Considering that Class I subjects might show Class II or III in terms of skeletal characteristics, it would be interesting to investigate the hyoid bone position of the dental protrusion or crowding individuals with skeletal Class I as well as dental Class I characteristics.

CONCLUSION

Comparisons of the cephalometric characteristics showed that the protrusion group showed a larger cranial base, longer maxillary length, greater facial convexity and a tendency of an antero-superior position of the hyoid bone compared to the crowding group. These results indicate that some cephalometric characteristics could be determining factors for whether dental protrusion or crowding develops; when an individual has large teeth, dental protrusion or crowding might be determined according to maxillary growth and tongue position.

- 국문초록 -

치아전돌자와 치아밀집자의
측모두부방사선학적 비교

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치아크기가 전반적으로 클 때 어떤 환자에서는 전돌이 나타나는 반면, 어떤 환자에서는 치아밀집 현상이 나타난다. 본 연구는 치아전돌자와 치아밀집자 간의 측모두부방사선규격사진상의 특징을 비교함으로써 치아전돌 또는 치아밀집 발생 원인을 규명하기 위하여 시행되었다. 치아크기가 정상

에 비하여 크면서 제1급 구치관계를 가지는 치아전돌자 29명, 치아밀집자 22명을 선정한 후 중절치부터 제1대구치까지 치아크기를 비교하는 한편, 측모두부방사선규격사진에서 투사도를 작성하고 골격형태, 설골 및 절치 위치를 나타내는 여러 가지 계측치를 설정하고 치아전돌자와 치아밀집자 양 군 간의 비교분석을 시행하였다. 연구 결과 본 연구에서 선정된 치아전돌자와 치아밀집자의 치아크기는 양 군 간에 유의한 차이를 보이지 않았으며, 골격형태를 나타내는 계측항목 중 S-N, A'-Ptm', SNA, ANB, 그리고 facial convexity에서 치아전돌자가 통계적으로 유의한 큰 값을 보였다. 또한 설골의 수직위치를 나타내는 hy-PP와 hy-MP는 치아전돌자에서 통계적으로 더 작게, 설골의 전후방 위치를 나타내는 hy'-Go는 치아전돌자에서 통계적으로 더 크게 나타났다. 이상의 결과는 치아전돌자가 치아밀집자에 비해 골격적으로는 상악전돌 경향을 보이고 설골의 위치는 전방 또는 전상방에 위치하고 있어 이러한 차이가 치아전돌 또는 치아밀집 결정과 관련이 있음을 시사하였다.

주요 단어: 치아전돌, 치아밀집, 측모두부방사선규격사진 분석, 치아크기

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