Mandibular retromolar space in adults with different sagittal skeletal patterns: *Cone-beam computed tomography analysis*

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ABSTRACT

Objectives: To analyze the mandibular retromolar space among normal-divergent adult patients with different sagittal skeletal patterns by cone-beam computed tomography (CBCT).

Materials and Methods: CBCTs of a total of 120 normal-divergent adult patients were investigated. Patients were categorized into the following three groups according to their ANB angle: skeletal Class I (48 patients), skeletal Class II (36 patients), and skeletal Class III (36 patients). Four different planes parallel to the mandibular occlusal plane were used to measure the retromolar space. The retromolar space was measured by two reference lines and then compared between different sagittal skeletal patterns groups. The incidence of root contact with the inner lingual cortex was compared among the three groups.

Results: The retromolar space of the Class III patients was significantly larger than that of Class I patients and Class II patients. Compared with Class I and Class III patients, Class II patients had a smaller retromolar space and higher incidence of contact with the inner cortex of the mandible.

Conclusions: Class III patients had a larger retromolar space than Class I patients and Class II patients in four different planes. The mandibular retromolar space should be evaluated by CBCT in patients who need mandibular molar distalization. (*Angle Orthod.* 2022;92:606–612.)

KEY WORDS: Retromolar space; Sagittal skeletal pattern; CBCT; Molar distalization

INTRODUCTION

Molar distalization is a common nonextraction method of increasing arch length to gain space and adjust the molar relationship.[1,2] Many methods have been used for molar distalization, including Pendulum appliances, Jones jig appliances, and headgear.[3,4] However, these appliances depend on patient compliance and easily result in anchorage loss, which limits their clinical application.[5,6] In recent years, the use of microimplants in orthodontic practice enables better treatment outcomes in molar distalization.[6,7]

The success of molar distalization depends on having enough available posterior space. Anatomic limits for mandibular molar distalization may be divided into those at the crown level (the mandibular ramus) and the root level (lingual cortex of the mandible). A previous study showed that the anatomic limitation of mandibular molar distalization was more likely the lingual cortex of the mandible rather than the mandibular ramus.[8] Consequently, assessment of available posterior space at the root level has clinical significance. Lateral cephalometric and panoramic radiographs were used to analyze retromolar space,[8–10] but cone-beam computed tomography (CBCT) is more reliable for obtaining accurate linear and angular measurements.[8,9]

A recent study showed that vertical facial patterns had a notable effect on the retromolar space.[11]

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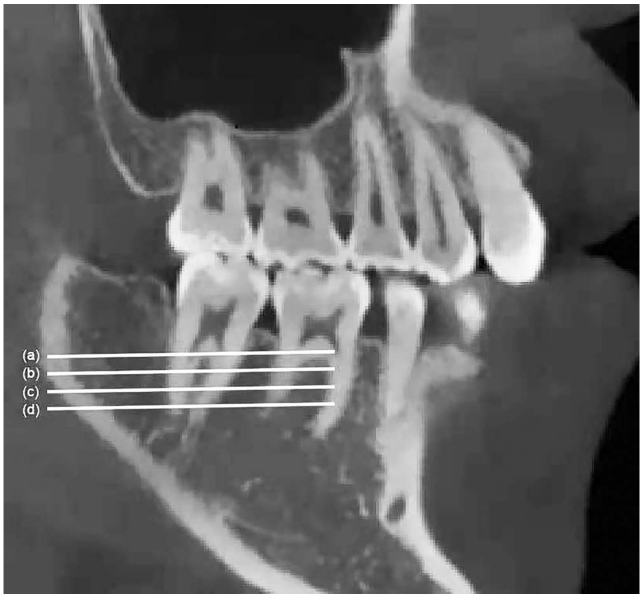

Figure 1. Four planes parallel to the mandibular occlusal plane. Four different planes, parallel to the mandibular occlusal plane, were used to measure the mandibular retromolar space. (a) The 0-plane passed through the furcation of the mandibular second molar root and the (b) 2-plane, (c) 4-plane, and (d) 6-plane were at 2, 4, and 6 mm, respectively, apical to the 0-plane.

However, the relationship between sagittal skeletal pattern and the retromolar space remains unclear, and little research was conducted using CBCT images.

The purpose of this study was to assess the association between retromolar space for mandibular molar distalization among different sagittal skeletal patterns using CBCT images. The null hypothesis was that the mandibular retromolar space would not be different among patients with different sagittal skeletal patterns.

MATERIALS AND METHODS

This research included 120 CBCT scans of 120 patients (aged 18-30 years) and was approved by the Research Ethics Committee of Shandong University Dental School (Protocol No. 20210919). Sample selection was based on the following inclusion criteria[8,11,12]: (1) $27.3° \leq$ SN-MP $\leq 37.7°$, $62\% \leq$ facial height index (FHI) $\leq 68\%$; (2) crowding of less than 5 mm in the lower arch; (3) healthy periodontal state without noticeable alveolar bone loss; (4) no history of orthodontic or orthognathic treatment; (5) no noticeable facial asymmetry; (6) no missing teeth, except the third molars; and (7) no history of cleft lip and palate. According to the ANB, samples were divided into the following three groups: Class I group ($0.7° \leq$ ANB $\leq 4.7°$), Class II group (ANB $> 4.7°$), and Class III group (ANB $< 0.7°$).

Figure 2. Reference lines. Two reference lines were used in this study. (a) The cuspal line connected the buccal cusps of the mandibular first and second molars and (b) the sagittal line was parallel to the midsagittal reference plane. α indicates the angle between the cuspal and sagittal lines.

All CBCT images were taken using NewTom (5G; Verona, Italy). The scanning parameters were set at 110 kV and 5 mA with a scanning time of 10 seconds and a voxel size of 0.30 mm. Then the data were exported in Digital Imaging and Communications in Medicine format.

Two reference planes were defined to reorient the three-dimensional images. The mandibular occlusal plane connected both mesiobuccal cusps of the mandibular first molars and the midpoint of the mandibular incisor tip. The midsagittal reference plane was passing through the crista galli, opisthion, and ANS. Four different planes parallel to the mandibular occlusal plane were used to measure the mandibular retromolar space (Figure 1). The 0-plane was passing through the furcation of the mandibular second molar root, and the 2-plane, 4-plane, and 6-plane were at 2, 4, and 6 mm apical to the 0-plane. In each plane, the retromolar space was measured by two reference lines: the sagittal line and the cuspal line (Figure 2). The sagittal line was parallel to the midsagittal reference plane, and the cuspal line was connecting the buccal cusps of the mandibular first and second molars. The distances between the most lingual point of the distal root of the second molar and cortex of the mandibular body were measured by two reference lines at each plane (Figure 3). All measurements were taken on Mimics software (version 21.0; Materialise, Leuven, Belgium).

To minimize measurement errors, 30 samples were remeasured by the same researcher 2 weeks apart.

Figure 3. Measurement of retromolar space. The distances between the most lingual point of the distal root of the second molar and inner and outer cortex of the mandibular body were measured by two reference lines at each plane. (a) The shortest distance to the inner lingual cortex of the mandibular body along the cuspal line. (b) The shortest distance to the inner lingual cortex of the mandibular body along the sagittal line. (c) The shortest distance to the outer lingual cortex of the mandibular body along the cuspal line. (d) The shortest distance to the outer lingual cortex of the mandibular body along the sagittal line.

Interobserver agreement was calculated using the intraclass correlation coefficient. The intraclass correlation in the present study showed good agreement between measurements (the intraclass correlation coefficient ranged from 0.77 to 0.98). The method errors were evaluated by Dahlberg's formula: $\sqrt{d^2/2n}$ (d for deviations between the two measurements; n for the number of paired objects). The method errors ranged from 0.01 to 0.78 mm.

STATISTICAL ANALYSIS

All statistical analyses were performed by SPSS version 26 (IBM SPSS Statistics for Windows, Armonk, NY). All data distributions were checked for normality by the Shapiro-Wilk test and homogeneity of variances by Levene's test.

A total of 30 samples were remeasured by the same researcher 2 weeks apart, and a paired *t*-test was used to evaluate reproducibility of the measurements. Because there was no statistical difference between the measurements of the right and left sides by independent *t*-test and Mann-Whitney *U*-test, the averaged values were used. According to the existence of third molars, all patients were divided into two groups: the third-molar group (third molars existed) and the no-third-molar group (third molars were congenitally missing or extracted). Because the independent *t*-test and Mann-Whitney *U*-test demonstrated no statistical difference between the two groups, the follow-up statistical analyses were carried out for all samples.

One-way analysis of variance (ANOVA) and the least significant difference test were performed for subsequent data analysis to investigate the effect of depth and skeletal sagittal pattern on retromolar space. The number of patients whose root was in contact with the inner lingual cortex of the mandible among the three groups was compared by chi-square test. The number of roots that were in contact with the inner lingual cortex of the mandible among different planes was compared by chi-square test. The angle of the cuspal line and the sagittal line among the three groups was compared by One-Way ANOVA. Significance was set at $P < .05$.

RESULTS

There were no statistical differences between the measurements performed 2 weeks apart shown by the paired *t*-test. A total of 120 patients were enrolled in this study, and patient characteristics of both groups are shown in Table 1.

No statistical differences were observed between the two sides of the retromolar space. Likewise, the differences were not statistically significant between the third-molar group and the no-third-molar group. When comparing retromolar space among different

Table 1. Patient Characteristics[a]

	Number	Age[b]	ANB[b]	SN-MP[b]	FHI[b]	Sex[c]	
						Male	Female
Class I	48	22.56 ± 3.31	2.64 ± 0.96	32.83 ± 2.30	65.80 ± 1.44	17	31
Class II	36	22.19 ± 3.92	6.04 ± 1.13	33.32 ± 2.74	65.13 ± 1.79	12	24
Class III	36	21.50 ± 3.30	−2.34 ± 2.23	32.21 ± 2.92	65.63 ± 1.65	16	20
P	–	.341	.000**	.266	.225	.578	

[a] Values are presented as mean ± standard deviation.
[b] Kruskal-Wallis test.
[c] Chi-square test.
** $P < .01$.

Table 2. Comparison of the Distance of the Second Molar Roots to the Inner Cortex Among Different Planes in the Three Groups[a]

	0-plane	2-plane	4-plane	6-plane	F[b]	P[c]
Through cuspal line						
Class I	5.18 ± 2.15	4.31 ± 2.15[d]	3.55 ± 1.84[d]	3.05 ± 1.77[d,e]	10.441	.000**
Class II	4.69 ± 2.45	3.83 ± 2.37	3.09 ± 2.20[d]	2.61 ± 1.97[d,e]	5.810	.001**
Class III	6.19 ± 2.15	5.39 ± 1.91	4.55 ± 1.77[d]	3.87 ± 1.66[d,e]	10.326	.000**
Through sagittal line						
Class I	2.90 ± 1.30	2.57 ± 1.35	2.36 ± 1.37[d]	2.06 ± 1.25[d]	3.436	.018*
Class II	2.72 ± 1.30	2.42 ± 1.39	2.15 ± 1.54	1.80 ± 1.40[d]	2.792	.043*
Class III	3.03 ± 1.19	2.84 ± 1.06	2.68 ± 1.05	2.49 ± 1.13	1.556	.203

[a] Values are presented as mean ± standard deviation.
[b] "F " is the value for an ANOVA test.
[c] One-way ANOVA.
[d] Significant difference with the 0-plane group.
[e] Significant difference with the 2-plane group.
* $P < .05$; ** $P < .01$.

planes, statistical differences were observed with the retromolar space at the 6-plane significantly smaller than the other planes (Tables 2 and 3). Statistically significant differences were found among the three sagittal skeletal patterns for retromolar space, especially along the cuspal line (Tables 4 and 5).

Significant differences in the percentage of roots that contacted the inner cortex of the mandibular body among the groups were found by the chi-square test. It was significantly easier to touch the inner cortex of the roots for Class II patients (36.11%) compared with Class I (31.25%) and Class III patients (8.33%) (Table 6). The percentage significantly increased when the measurement plane was closer to the apex level, especially in Class II patients (Table 7). In addition, there was no significant difference in the angle between the two reference lines (Table 8).

DISCUSSION

The retromolar space analysis originated from Merrifield's viewpoint of total space analysis.[13] Merrifield advocated that it was important to relieve crowding of the anterior and middle arch through the posterior space.[13] The mandibular ramus was considered to be the posterior anatomic limit of the mandibular arch.[14] However, a previous study showed that the anatomic limit for mandibular molar distalization was the cortical layer of the alveolar bone rather than the mandibular ramus.[8]

Once the mandibular molar roots touched the alveolar bone, it would easily slow down tooth movement and cause undesirable root resorption.[15] If the roots moved beyond the alveolar bone, it would easily result in the loss of periodontal tissue.[16] In addition, CBCT, compared with lateral cephalometric and panoramic radiographs, could precisely estimate the distance between the roots and alveolar bone.[16,17] Hence, evaluation of the retromolar space by CBCT is recommended for patients who require molar distalization.

CBCT research on the mandibular retromolar space is lacking, and skeleton pattern-related studies are especially rare. Sagittal skeletal patterns are related to the morphology of the mandible, especially mandibular length.[18] A study revealed that the mandibular third molars of Class III patients were less likely to have become impacted than in Class I and II patients because of the larger retromolar space.[18] Therefore, it

Table 3. Comparison of the Distance of the Second Molar Roots to the Outer Cortex Among Different Planes in the Three Groups[a]

	0-plane	2-plane	4-plane	6-plane	F[b]	P[c]
Through cuspal line						
Class I	9.56 ± 2.18	8.68 ± 2.28	7.87 ± 2.18[d]	7.37 ± 2.29[d,e]	8.893	.000**
Class II	8.97 ± 2.49	8.10 ± 2.50	7.01 ± 2.38[d]	6.41 ± 2.29[d,e]	7.963	.000**
Class III	10.54 ± 2.24	10.04 ± 1.91	9.31 ± 1.90[d]	8.73 ± 2.25[d,e]	5.289	.002**
Through sagittal line						
Class I	5.96 ± 1.51	5.87 ± 1.59	5.59 ± 1.67	5.06 ± 1.64[d,e]	3.075	.029*
Class II	5.80 ± 1.53	5.61 ± 1.64	5.16 ± 1.86	4.55 ± 1.68[d,e]	3.942	.010*
Class III	6.47 ± 1.58	6.34 ± 1.32	6.32 ± 1.44	5.86 ± 1.56	1.160	.327

[a] Values are presented as mean ± standard deviation.
[b] "F " is the value for ANOVA test.
[c] One-way ANOVA.
[d] Significant difference with the 0-plane group.
[e] Significant difference with the 2-plane group.
* $P < .05$; ** $P < .01$.

Table 4. Comparison of the Distance of the Second Molar Roots to the Inner Cortex Among Different Sagittal Skeleton Pattern Groups[a]

	Distance Measured Through the Sagittal Line					Distance Measured Through the Cuspal Line				
	Class I	Class II	Class III	F^b	P^c	Class I	Class II	Class III	F^b	P^c
0-plane	2.90 ± 1.30	2.72 ± 1.30	3.03 ± 1.19	0.552	.577	5.18 ± 2.15	4.69 ± 2.45	6.19 ± 2.15[d,e]	4.209	.017*
2-plane	2.57 ± 1.35	2.42 ± 1.39	2.84 ± 1.06	0.998	.372	4.31 ± 2.15	3.83 ± 2.37	5.39 ± 1.91[d,e]	5.045	.008**
4-plane	2.36 ± 1.37	2.15 ± 1.54	2.68 ± 1.05	1.421	.246	3.55 ± 1.84	3.09 ± 2.20	4.55 ± 1.77[d,e]	5.352	.006**
6-plane	2.06 ± 1.25	1.80 ± 1.40	2.49 ± 1.13	2.770	.067	3.05 ± 1.77	2.61 ± 1.97	3.87 ± 1.66[d,e]	4.514	.013*

[a] Values are presented as mean ± standard deviation.
[b] "*F* " is the value for ANOVA test.
[c] One-way ANOVA.
[d] Significant difference with the Class I group.
[e] Significant difference with the Class II group.
* $P < .05$; ** $P < .01$.

is reasonable to assume that the sagittal skeletal patterns might affect retromolar space. A recent study showed that vertical facial patterns had a remarkable influence on the retromolar space.[11] Growth also had a significant effect on the posterior space of the dental arch in adolescents.[19] To exclude the potential effect of vertical facial patterns and growth on the retromolar space, all samples enrolled in the current study were normal-divergent adult patients.

The retromolar space gradually decreased from the 0-plane to the 6-plane along the sagittal and cuspal lines in this study. The result was consistent with previous studies in normal-divergent patients.[8,11] It indicated that the retromolar space was smaller at the apex level than at the furcation level. Therefore, the anatomic limit of mandibular molar distalization was more likely located at the apex level in normal-divergent patients because of the mandibular anatomical structure. The anatomical structure between the buccal and lingual cortical bone in the mandibular molar area was V-shaped.[8,12]

Significant differences in the retromolar space were observed among the three groups based on sagittal skeleton patterns. The retromolar space in Class III patients was significantly larger than in Class I and II patients, especially along with the cuspal line. However, a previous study reported that Class III patients had a smaller retromolar space than Class I patients at the apex level, which indicated that sagittal skeleton pattern might not affect the retromolar space.[12] A recent study found that the influence of vertical facial patterns was statistically significant for Class I patients, and the retromolar space in hypodivergent patients was more than twice as great as in hyperdivergent patients.[11] Therefore, it was assumed that the effect of vertical facial patterns might cause different results.

There might be two reasons explaining the effect of sagittal skeletal pattern on retromolar space. On one hand, Class III patients had a larger mandible, which indicated that mandibular length might be related to the retromolar space.[18] On the other hand, the mandibular molars of Class III patients were more lingually inclined, which suggested that the roots of the mandibular second molars were far from the inner cortex of the mandible.[20] In orthodontic practices, orthodontists could not change mandibular length through tooth movement but could increase the retromolar space by adjusting the inclination of the mandibular molars. In addition, the buccal and lingual inclinations of molars are key to establishing an ideal occlusion. Orthodontists should recognize that excessive adjustment of molar inclination could affect the occlusion.

The current study showed that the existence of the third molar had no significant influence on the retromolar space. These results were in agreement with previous studies.[8,11] Although the existence of the third molar might result in adaptive remodeling of

Table 5. Comparison of the Distance of the Second Molar Roots to the Outer Cortex Among Different Sagittal Skeleton Pattern Groups[a]

	Distance Measured Through the Sagittal Line					Distance Measured Through the Cuspal Line				
	Class I	Class II	Class III	F^b	P^c	Class I	Class II	Class III	F^b	P^c
0-plane	5.96 ± 1.51	5.80 ± 1.53	6.47 ± 1.58	1.876	.158	9.56 ± 2.18	8.97 ± 2.49	10.54 ± 2.24[e]	4.331	.015*
2-plane	5.87 ± 1.59	5.61 ± 1.64	6.34 ± 1.32	2.102	.127	8.68 ± 2.28	8.10 ± 2.50	10.04 ± 1.91[d,e]	7.135	.001**
4-plane	5.59 ± 1.67	5.16 ± 1.86	6.32 ± 1.44[d,e]	4.497	.013*	7.87 ± 2.18	7.01 ± 2.38	9.31 ± 1.90[d,e]	10.361	.000**
6-plane	5.06 ± 1.64	4.55 ± 1.68	5.86 ± 1.56[d,e]	5.954	.003**	7.37 ± 2.29	6.41 ± 2.29	8.73 ± 2.25[d,e]	9.419	.000**

[a] Values are presented as mean ± standard deviation.
[b] "*F* " is the value for ANOVA test.
[c] One-way ANOVA.
[d] Significant difference with the Class I group.
[e] Significant difference with the Class II group.
* $P < .05$; ** $P < .01$.

Table 6. Comparison of the Number of Patients Whose Roots Contacted With the Inner Cortex of the Mandible Among the Three Groups

	Number	Percentage
Class I	15	31.25
Class II	13	36.11
Class III	3	8.33
χ^2	8.474	
P[a]	.014*	

[a] Chi-square test.
* $P < .05$.

Table 8. Comparison of the Angle Between the Sagittal Line and the Cuspal Line Among the Three Groups[a]

Parameter	Value
Class I, angle (°)	18.49 ± 2.38
Class II, angle (°)	18.37 ± 2.20
Class III, angle (°)	19.11 ± 2.21
F[b]	1.119
P[c]	.330

[a] Values are presented as mean ± standard deviation.
[b] "F " is the value for ANOVA test.
[c] One-way ANOVA.

surrounding alveolar bone and bone cortex, it was insufficient to cause remarkable changes in the retromolar space. In addition, the third molar was always extracted before molar distalization. However, orthodontists should pay attention to the timing of extraction. Immediate extraction of the third molar before molar distalization could produce local acceleration that helps the teeth move quickly.[21] If the third molar was extracted too early, however, the dense bone cortex at the distal of the second molar could make molar distalization more difficult.

It was observed that some mandibular second molar roots were in contact with the inner lingual cortex before treatment. Other researchers also observed this phenomenon.[8,11] In addition, the percentage of Class II patients whose roots were in contact with the inner lingual cortex was the highest among the three groups. The roots were more easily in contact with the cortex in the 6-plane rather than the 0-plane, which was related to the anatomical mandibular structure. For these patients whose roots touched the inner lingual cortex before treatment, molar distalization was not recommended and other alternative treatments, such as extraction and expansion, should be considered. Therefore, it is necessary to assess whether the root contacts the lingual cortex using CBCT before molar distalization.

The sagittal line was an anatomically stable reference line, but it was significantly different from the direction of distalization. Hence, an additional reference line, "the cuspal line," was used because mandibular molars are more likely to move along the cuspal line. There were no statistically significant differences in the angle of the cuspal line and the sagittal line among the three groups. This was similar to previous results.[11] Therefore, the cuspal line could serve as a stable reference line.

During molar distalization, orthodontists often pay more attention to the limitation of the hard tissue and ignore the soft tissue. The accumulation of the soft tissue in the retromolar area would block molar distalization and cause pericoronitis. A part of the distal gingival flap of the mandibular second molars should be removed when thick soft tissue obstructs molar movement. Related research on the association between molar distalization and soft tissue is lacking. Further research is warranted.

There are several limitations of the current study. The effect of sex on the retromolar space was not assessed because of the higher percentage of females. In addition, the eruption status of the mandibular third molars might affect the retromolar space; the study only grouped the third molars according to their existence, not impaction status.

CONCLUSIONS

- Class III patients had a larger mandibular retromolar space than Class I and Class II patients. Class II patients had the smallest retromolar space.
- A higher incidence of root contact with the inner cortex was found in Class II patients (36.11%).
- CBCT is recommended before molar distalization, especially in patients who need a large amount of space for distalization.

Table 7. Comparison of the Number and Percentage of Roots Contacting the Inner Cortex of the Mandible Among the Three Groups

	0-plane	2-plane	4-plane	6-plane	χ^2	P[a]
Class I (number/%)	7/7.29	12/12.50	14/14.58	17/17.71	4.875	.181
Class II (number/%)	6/8.33	11/15.28	17/23.61	18/25.00	8.739	.033*
Class III (number/%)	1/1.39	1/1.39	1/1.39	3/4.17	2.043	.564

[a] Chi-square test.
* $P < .05$.

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Declaration of Competing Interest

The authors declare no competing or financial interests.

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