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Original Article

Third Molar Comparison in Class I and II Extraction and Non-extraction Orthodontic Treatment: A Retrospective Longitudinal Study

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Main Points

- Premolar extractions in Class I and II patients favored third molar angulation and eruption.
- The third molars showed a more upright position after treatment, regardless of the malocclusion type or extraction protocol.
- Third molar angulation can influence posterior eruption.

ABSTRACT

Objective: This study compared third molar angulation and eruption status in Class I and II malocclusions after orthodontic treatment with and without first premolar extractions.

Methods: The sample comprised 93 patients divided into four groups: Group 1, Class I malocclusion treated with first premolar extractions; Group 2, Class I malocclusion treated without extractions; Group 3, Class II malocclusion treated with first premolar extractions; and Group 4, Class II malocclusion treated without extractions. Panoramic radiographs were used to evaluate the third molar mesiodistal angulations at T1 (pretreatment), T2 (posttreatment), and T3 (long-term posttreatment). Third molar eruption status was assessed in dental casts. Intergroup angulations and eruption status comparisons were performed using one-way analysis of variance (ANOVA), followed by Tukey's test and Kruskal-Wallis test, respectively.

Results: Significantly greater mesial angulation and percentage of erupted right maxillary third molars were observed in the Class I extraction group. Significantly greater eruption status of the right mandibular third molars was observed in the Class I and Class II malocclusion extraction groups.

Conclusion: Class I and II malocclusion extraction treatment exhibited more favorable angulations and a greater number of erupted third molars than non-extraction treatment. The non-extraction groups exhibited a greater percentage of unerupted third molars.

Keywords: Molar, tooth, unerupted, tooth eruption, ectopic

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INTRODUCTION

Third molars are the teeth with the highest rate of impaction, therefore causing various complications frequently found in dental practice.[1,2] Many factors are involved in their impaction, such as morphology, growth, retromolar space, anatomy, and position.[3] Numerous factors have been researched to predict its future impaction.[4] It has been established that some of these factors can be modified to favor third molar eruption. Consequently, orthodontic treatment, mainly in extraction therapy, has been suggested to help to prevent their impaction by providing extra retromolar space.

Some researchers have proposed that forward movement of the posterior teeth might improve the position of the third molar by allowing them to develop further and consequently in a more upright position.[5] To prove or deny the influence of orthodontic treatment on third molar eruption, many authors have assessed the third molars before and after treatment. Some of them have compared extraction and no extraction groups to assess retromolar space gain.[6] The results of those studies have shown significant gains in retromolar space; however, this was not translated into later third molar eruption.[7]

Moreover, some authors have proposed that in addition to additional space, significant angulation changes should occur to avoid impaction.[8] Recent studies evaluating third molar angulation changes have shown significant differences in third molar position, especially after extraction therapy.[3,9] However, some researchers have not found that these changes were sufficient to avoid impaction, while others state that eruption does occur.[10,11] Despite the existing literature, it has been reported that the available evidence is still limited to confirm whether orthodontic treatment with premolar extractions can favor the angulation and subsequent eruption of the third molars; however, it highlights the possibility of a potential benefit.[12] Therefore, based on the need for more scientific evidence on the subject, the purpose of this study was to compare third molar angulation and eruption statuses in Class I and II malocclusions treated with and without first premolar extractions.

METHODS

This project was approved by the Ethics in Research Committee of University of São Paulo Bauru Dental School (approval no: 466/12, date: 12.18.2018).

Sample Characteristics

Sample size calculation was performed based on an alpha level of 5% and beta test power of 80% to detect a minimum intergroup difference of 6 degrees, with a standard deviation of 6 degrees.[13] The results showed that a minimum of 21 patients was necessary for each group. The sample comprised 93 patient records with Class I and II malocclusion treated with fixed appliances (standard or preadjusted edgewise mechanotherapy) with moderate anchorage (extraoral headgear in the maxillary teeth in extraction treatments and Class II non-extraction treatment), with and without first premolar extractions, and with unerupted third molars. The records were retrospectively selected from the files of the Orthodontic Department at University of São Paulo Bauru Dental School. The inclusion criteria for sample selection were patients with unerupted third molars visible panoramic radiographs at the initial stage, without dental anomalies of number and form, and the presence of all permanent teeth, excluding the first premolars in the extraction cases. All participants' records should have the initial, final, and last follow-up panoramic radiographs and dental casts with the presence of the third molar in a 1-to 5-year interval after debonding. Patients with erupted third molars at the initial stage, Class III malocclusion, previous orthodontic treatment, or asymmetric extractions were not included in the study.

The sample was divided into four groups according to the malocclusion type and the orthodontic treatment performed, with or without first premolar extractions: Group 1 consisted of 23 records of patients with Class I malocclusion treated with first premolar extractions, comprising 12 females and 11 males. The mean treatment and follow-up time was 2.72 years (±1.15) and 4.55 years (±1.58), respectively. The group exhibited a mean age of 13.18 years (±1.00) at the initial stage, 15.90 years (±1.50) at the end of treatment, and 20.45 years (±1.85) at the last follow-up examination.

Group 2 comprised 23 records of patients with Class I malocclusion treated without extractions, consisting of 14 females and 9 males. The mean treatment time was 2.29 years (±0.85) with a follow-up time of 4.37 years (±1.85). The initial mean age was 13.36 years (±1.35), 15.65 years (±1.58) at the final stage, and 20.03 years (±2.37) at the last follow-up examination stage.

Twenty-four Class II malocclusion patients treated with first premolar extractions comprised group 3 with 11 females and 13 males. The group had a mean treatment time of 2.61 years (±0.90) and a mean follow-up time of 3.93 years (±1.66). The initial, final, and last follow-up mean ages were 12.84 years (±1.29), 15.46 years (±1.59), and 19.39 years (±1.00), respectively. Class II malocclusion patients treated without extractions comprised group 4, with 23 records (11 females and 12 males). The mean treatment time was 2.28 years (±0.48) and the follow-up time was 4.15 years (±1.52). The mean age was 12.47 years (±1.23) at the initial stage, 14.75 years (±1.17) at the final stage, and 18.90 years (±1.85) at the last follow-up examination.

To assess third molar angulation changes, angular measurements were performed on panoramic radiographs at the initial (T1) and final stages (T2) of treatment and at the last follow-up stage (T3) after a mean posttreatment period of 4.24 years (±1.64). To assess the third molar eruption status, dental casts were used at T3. They were designated as the right maxillary third molar (18), left maxillary third molar (28), left

mandibular third molar (38), and right mandibular third molar (48), according to the International Numbering System.[14]

Panoramic Radiographs

Panoramic radiographs were digitized using a Microtek ScanMaker i800'den sonrası parantez ici olacak. (Microtek International, Carson, USA) scanner and saved in TIFF format. Subsequently, the radiographs were digitally traced using Dolphin Imaging Software Version 11.5 (Dolphin® Imaging and Management Solutions, Patterson Dental Supply, Inc., Chatsworth, California, USA).

Third Molar Angulation

Third molar mesiodistal angulation was assessed using angular measurements traced on panoramic radiographs. The nasal septum, anterior nasal spine, hard palate, and maxillary and mandibular third molars were used as anatomical reference structures. The reference lines were as follows: (A) the midline reference plane (MRP), a vertical line traced outlining the nasal septum and anterior nasal spine; (B) a horizontal reference plane (HRP), constructed as a line perpendicular to the MRP extending through the palatal shadow[13,15,16] (Figure 1). Thus, the long axes of the maxillary and mandibular third molars were traced as lines bisecting the middle of the crown and root furcation. To determine the third molar angulations, the outer angles formed between the third molar axes and HRP were measured (Figures 1 and 2). Increases in the angular measurements denoted mesial angulations of the maxillary molars and distal angulations of the mandibular molars, indicating a more upright position of the third molars.

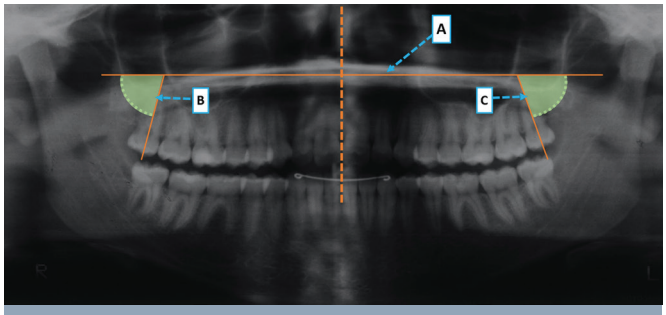

Figure 1. Third molar angulation measurements. **A)** Horizontal reference plane (HRP), **B)** HRP and right maxillary third molar long axis angle, **C)** HRP and left maxillary third molar long axis angle

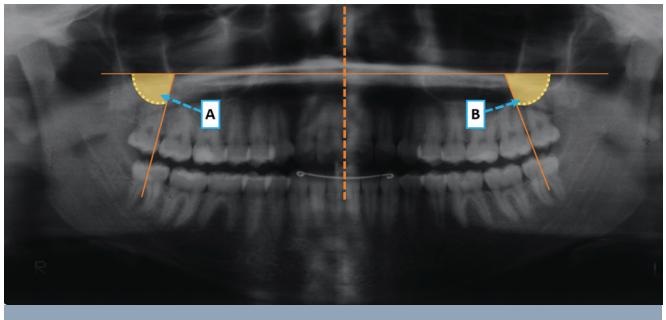

Figure 2. A) Horizontal reference plane (HRP) and right mandibular third molar long axis angle and **B)** HRP and left mandibular third molar long axis angle

Third Molar Eruption

Third molar eruption was assessed in the last follow-up dental casts with the presence of third molars.

The eruption stage was classified according to the third molar clinical crown position.[17] It was classified as unerupted when the clinical crown could not be seen in the dental casts; partially erupted when the crown was partially visible; or erupted when the clinical crown could be fully seen. Thus, the eruption stages were scored on an ascending scale from one to three, assigning a score of one when unerupted, two when partially erupted, and three when erupted.

Error Study

Thirty panoramic radiographs were randomly selected and re-measured at an interval of 30 days from the first measurement by the same examiner (D.P.R.). Random errors were assessed using the formula [$Se^2 = S\ (d^2 / 2n)^2$], proposed by Dahlberg.[18] To calculate the systematic errors, dependent t-tests were performed at $p<0.05$.[19] Thirty dental casts were also randomly selected and re-evaluated after a 30-day interval to assess the reproducibility of the eruption status evaluation. The intra-examiner agreement was then calculated using Kappa statistics.[20]

Statistical Analysis

The normal distribution of the variables was assessed using Kolmogorov-Smirnov normality tests. Intergroup comparability regarding sex distribution was evaluated using the chi-square test. One-way analysis of variance (ANOVA), followed by Tukey's test, was used for intergroup comparability regarding initial, final, and follow-up ages, treatment, and follow-up times.

Intergroup comparisons of third molar angulations at T1, T2, and T3 were performed using ANOVA, followed by Tukey tests, when necessary.

Descriptive statistics were performed to assess the third molar eruption status score frequency at T3. Intergroup comparisons for third molar eruption status were performed using Kruskal-Wallis tests. All statistical tests were performed using Statistica software (Statistica for Windows, version 7.0, StatSoft Inc., Tulsa, Okla, USA) at $p<0.05$.

RESULTS

The random errors ranged from 1.92º (right mandibular third molar angulation) to 2.52° (left maxillary third molar angulation) and were within acceptable limits.[21] None of the variables showed significant systematic errors. Intraexaminer reproducibility of the eruption status assessment showed perfect and substantial agreement between the first and second evaluations.

The groups were comparable in terms of sex distribution, initial, final, and follow-up ages, treatment and follow-up times, and third molar angulations at T1 (Tables 1 and 2). Intergroup comparisons in each stage showed significantly

greater angulation of the right maxillary third molar in the Class I extraction group at T2 and T3 than in the Class II non-extraction group, and at T3 in the other groups. The left maxillary third molar in the Class I extraction group at T2 showed significantly greater angulation than the other groups (Table 2).

Descriptive statistics for the third molar eruption status score showed a frequency of erupted maxillary third molars of 60.87% in the Class I extraction group, 54.35% unerupted in the Class I non-extraction group, and 45.83% and 63.04% unerupted in the Class II extraction and non-extraction groups, respectively. For the mandibular third molars, the erupted frequency was 45.65% in the Class I extraction group and 47.83% in the Class I non-extraction group. In the Class II extraction group, 58.33% erupted, and 56.52% unerupted in the Class II non-extraction group (Table 3).

Intergroup comparisons of third molar eruption status showed a significantly greater percentage of erupted maxillary third molars in the Class I extraction group than in the Class II non-extraction group. A significantly greater percentage of erupted right mandibular third molars was also found in the Class I and II extraction groups than in the Class I and II non-extraction groups (Table 4).

Table 1. Intergroup comparison of sex distribution, initial and final ages, treatment and follow up times (chi-square and one-way ANOVA tests)

Variables	Group 1, Class I Ex n=23	Group 2, Class I Non-Ex n=23	Group 3, Class II Ex n=24	Group 4, Class II Non-Ex n=23	p value
Sex	n (%)	n (%)	n (%)	n (%)	
Female	12 (52.17)	14 (60.87)	11 (45.83)	11 (47.17)	0.742†
Male	11 (47.83)	9 (39.13)	13 (54.17)	12 (52.83)	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Initial age	13.18 (1.00)	13.36 (1.35)	12.84 (1.29)	12.47 (1.23)	0.079††
Final age	15.90 (1.50)	15.65 (1.58)	15.46 (1.59)	14.75 (1.17)	0.057††
Follow-up age	20.45 (1.85)	20.03 (2.37)	19.39 (1.00)	18.90 (1.85)	0.051††
Treatment time	2.72 (1.15)	2.29 (0.85)	2.61 (0.90)	2.28 (0.48)	0.215††
Follow-up time	4.55 (1.58)	4.37 (1.85)	3.93 (1.66)	4.15 (1.52)	0.604††

Statistically significant at p<0.05
†Chi-square test
††One-Way ANOVA
SD, standard deviation

Table 2. Intergroup comparisons for the third molars angulations at T1, T2 and T3 (one-way ANOVA and Tukey tests)

Angulation comparisons						
Variables	Stage	Class I, Ex n=23	Class I, Non-Ex n=23	Class II, Ex n=24	Class II, Non-Ex n=23	p value
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
18	T1	55.64 (15.70)	53.72 (16.53)	51.12 (12.50)	51.75 (11.13)	0.689
	T2	64.97 (15.64)^{A}	56.94 (13.34)^{AB}	56.72 (13.15)^{AB}	51.79 (15.04)^{B}	0.022*
	T3	70.36 (13.24)^{A}	58.96 (10.59)^{B}	59.84 (14.59)^{B}	58.78 (19.37)^{B}	0.023*
28	T1	47.61 (11.48)	48.35 (15.70)	44.60 (12.20)	50.91 (13.94)	0.453
	T2	62.04 (17.48)^{A}	52.91 (13.96)^{B}	54.97 (14.50)^{B}	49.90 (13.76)^{B}	0.048*
	T3	65.13 (17.38)	56.75 (13.89)	59.77 (15.45)	56.09 (16.87)	0.210
38	T1	36.04 (9.20)	37.36 (8.22)	37.44 (9.85)	38.11 (11.93)	0.912
	T2	39.53 (9.21)	41.68 (14.00)	35.78 (13.50)	39.93 (10.24)	0.387
	T3	41.60 (22.43)	49.71 (23.10)	50.97 (22.18)	44.64 (20.28)	0.433
48	T1	38.36 (9.03)	38.67 (8.08)	36.20 (12.10)	36.04 (10.39)	0.722
	T2	41.93 (11.47)	39.85 (12.84)	40.97 (12.61)	37.05 (9.64)	0.525
	T3	44.30 (18.39)	45.97 (25.54)	56.04 (18.10)	39.62 (23.06)	0.068

*Statistically significant at p<0.05
Different letters in a row indicate the presence of a statistically significant difference among the groups, indicated by the Tukey test.
$^{A, B}$: They indicate statistically significant differences between the groups.
SD, standard deviation

DISCUSSION

Third molar angulation was measured on panoramic radiographs, a method preferred over lateral cephalograms, due to reduced bias from superimposed images.[11,13] Previous studies have supported the reliability and accuracy of angular measurements in panoramic radiographs, which present less angular distortion even with changes in head position.[15,22] Many studies have used the occlusal plane, mandibular plane, and second molar long axis as anatomical references to measure third molar angulation, which are susceptible to growth and treatment changes.[9,12] In the present study, the hard palate and anterior nasal spine were used as references.[13,23] for angulation measurements due to their stability and minimal susceptibility to growth or treatment changes. Initial third molar angulation measurements may face criticism due to incomplete crown formation at younger ages. However, measurements based on the dental crown can still be conducted, despite incomplete root development.[21]

Class I patients treated with first premolar extractions exhibited a more upright position in their right maxillary third molars at T2 and T3 compared to Class II non-extraction cases. At T3, they also exhibited greater upright positioning compared to the non-extraction Class I group. The left maxillary third molar at T2 was more upright than the other groups (Table 2). Artun et al.[24] found a similar trend in their assessment of posttreatment angulation of maxillary third molars in extraction groups, aligning with our findings. Artun et al.[24] found a similar trend in their assessment of posttreatment angulation of maxillary third molars in extraction groups, aligning with our findings.

This was expected given the more mesial positioning of maxillary posterior teeth in Class II patients compared to in Class I patients.[10] Therefore, in most Class II non-extraction cases, restricting anterior movement of the posterior teeth is imperative to correct the sagittal discrepancy.[25] In Class I cases, distalization of the maxillary posterior teeth is not

Table 3. Descriptive statistics of the eruption status of the maxillary and mandibular third molars at T3

Eruption status						
Third molars	Score	Class I, Ex n=23	Class I, Non-Ex n=23	Class II, Ex n=24	Class II, Non-Ex n=23	Total
		N (%)	N (%)	N (%)	N (%)	
Maxillary	1	10 (21.74)	25 (54.35)	22 (45.83)	29 (63.04)	86
	2	8 (17.39)	8 (17.39)	11 (22.92)	9 (19.57)	36
	3	28 (60.87)	13 (28.26)	15 (31.25)	8 (17.39)	64
Mandibular	1	13 (28.26)	22 (47.83)	12 (25)	26 (56.52)	73
	2	12 (26.09)	9 (19.57)	8 (16.67)	7 (15.22)	36
	3	21 (45.65)	15 (32.60)	28 (58.33)	13 (28.26)	77
Total number of teeth		92	92	96	92	372
Total number of patients (n=93)		23	23	24	23	93

Eruption score: (1) unerupted, (2) partially erupted, (3) erupted

Table 4. Intergroup eruption status comparisons (Kruskal-Wallis tests)

Eruption status						
Tooth number	Score	Class I, Ex (n=23)	Class I, Non-Ex (n=23)	Class II, Ex (n=24)	Class II, Non-Ex (n=23)	p value
		n (%)	n (%)	n (%)	n (%)	
18	1 2 3	5 (21.74) 5 (21.74) 13 (56.52)^{A}	13 (56.52) 4 (17.39) 6 (26.09)^{AB}	11 (45.83) 6 (25) 7 (29.17)^{AB}	15 (65.22) 4 (17.39) 4 (17.39)^{B}	0.010*
28	1 2 3	5 (21.74) 3 (13.04) 15 (65.22)^{A}	12 (52.17) 4 (17.39) 7 (30.43)^{AB}	11 (45.84) 5 (20.83) 8 (33.33)^{AB}	14 (60.87) 5 (21.74) 4 (17.39)^{B}	0.009*
38	1 2 3	7 (30.44) 8 (34.78) 8 (34.78)	11 (47.83) 4 (17.39) 8 (34.78)	6 (25) 5 (20.83) 13 (54.17)	13 (56.52) 3 (13.04) 7 (30.43)	0.164
48	1 2 3	6 (26.09) 4 (17.39) 13 (56.52)^{A}	11 (47.82) 5 (21.74) 7 (30.43)^{B}	6 (25) 3 (12.5) 15 (62.5)^{A}	13 (56.52) 4 (17.39) 6 (26.09)^{B}	0.021*

Eruption score: (1) unerupted, (2) partially erupted, (3) erupted.
*Statistically significant at p<0.05
Different letters in a row indicate the presence of a statistically significant difference among the groups.
$^{A, B}$: They indicate statistically significant differences between the groups.

necessary; therefore, extraction in Class I cases may allow some mesialization of the posterior providing more space and improving third molar angulation.[26] This is particularly evident at T3, where the extractions in Class I malocclusions provided more space compared to non-extraction Class I cases and Class II non-extraction cases. The difference observed in Class II extraction cases may be attributed to the need for maxillary molars to maintain their position or undergo some degree of distalization.[9,27] The left maxillary third molar at T2 showed similar results to the right maxillary molar at T3; thus explaining the similarity in explanations. However, at T3, no more intergroup significant differences were found. These results show that all maxillary third molars tend to be come more upright over time, although the degree of uprighting may vary in different malocclusions.

Among the groups, the Class I extraction group had the highest frequency of erupted maxillary third molars (60.87%). Regarding mandibular third molars, eruption frequencies were 45.65% and 58.33% in the Class I and II extraction groups, respectively. A significantly greater percentage of erupted maxillary third molars was observed in the Class I extraction group compared to the Class II non-extraction group. Similarly, a greater percentage was found for the right mandibular third molars in the Class I and II extraction groups compared to the Class II non-extraction group. These results confirm that extraction treatment facilitates the eruption of third molars by providing additional space in the retromolar area after space closure, particularly in the maxilla for Class I and in the mandible for Class II treatments.

Mandibular third molar angulation comparisons showed no significant differences, as reported in previous studies.[28] Many studies have also shown that, mandibular third molars exhibit similar angulations after orthodontic treatment, regardless of extraction and non-extraction therapy.[11] Tarazona,[26] stated that independent of extraction or non-extraction therapy, third molar angulations will improve over time. These results also contradict previous studies, which showed smaller upright positions, indicated by mesial angulations of the mandibular molars, which are unfavorable for eruption.[2,29]

Therefore, this study cannot conclusively state that non-extraction treatment increases mandibular third molar impaction. The Class I extraction group had the highest frequency of erupted maxillary third molars (60.87%). Concerning the mandibular third molars, eruption frequencies were 45.65% and 58.33% in the Class I and II extraction groups, respectively (Table 3). A significantly greater percentage of erupted maxillary third molars was observed in the Class I extraction group than in the Class II non-extraction group (Table 4). A greater percentage was also found for the right mandibular third molars in the Class I and II extraction groups than in the Class II non-extraction group. These results confirm that the extraction treatment favors the eruption of the third molars due to a greater space gain in the retromolar space after space closure, especially in the maxilla, in Class I, and in the mandible, in Class II treatments.[30]

The significantly more upright position of the maxillary and right mandibular third molars in Class I and II extraction groups, respectively, as demonstrated in our results, likely influenced their eruption. This suggests a cause-effect relationship between third molar angulation and posterior eruption. Some authors have even proposed that the angulation of the third molar, rather than retromolar space, is the primary factor for impaction.[8] Similar findings were reported by Kim et al.[1], where over 50% of the maxillary and mandibular third molars had erupted in the extraction group. In contrast, Gungormus[17] showed that only 15% of the mandibular third molars had erupted in the extraction group, with none unerupted in the non-extraction group.

The findings of the current study differ from previous studies, where only 24% of mandibular third molars in the extraction group erupted.[8] This might be due to sample differences, as previous studies included non-growing patients. It is noted that in growing patients, the third molar is still developing and pre-eruptive movements can occur, facilitating its eruption.[13]

Clinical Implications

Assessing the position of unerupted third molars is crucial for accurate diagnosis, considering factors like angulation and root development to avoid overdiagnosis or underdiagnosis of potential impaction. Additionally, treatment planning should account for the impact of extraction or non-extraction therapy on third molar eruption. While extraction therapy may assist third molar eruption in some cases, other factors must be considered to ensure success. Moreover, incomplete root development precludes accurate prediction of impaction.

Evaluation of the unerupted third molar position is crucial for accurate diagnosis, considering factors like angulation and root development to avoid overdiagnosis or underdiagnosis of its potential impaction.[8] Furthermore, the effect of an extraction or non-extraction therapy on third molar eruption should be considered during treatment planning. While extraction therapy may assist third molar eruption in some cases, other factors must be considered to ensure success.[7] In addition, incomplete root development precludes accurate prediction of.[8]

Although this study did not find worsening of third molar angulation with non-extraction therapy, the frequency of non-erupted third molars in these treatments should be considered. Therefore, it is important to recognize that a "non-extraction treatment" may necessitate third molar extraction in some cases. The authors advocate an evaluation of the third molar angulation before and after orthodontic treatment and monitoring eruption until root development is complete, thereby mitigating unnecessary extractions or future complications.

CONCLUSION

Based on the results of this study, it can be concluded that:

- Premolar extractions in Class I malocclusion treatment positively influenced maxillary third molar angulation and eruption, with 60.87% of maxillary third molars erupted.

- Class II extraction treatment positively effected mandibular third molar posterior eruption, with 58.33% of mandibular third molars erupted.
- Less than 32.60% of the third molars erupted in the Class I non-extraction group.
- Third molars showed a more upright position after treatment, regardless of the malocclusion type or extraction protocol.
- These results suggest that third molar angulation can influence posterior eruption.

Ethics

Ethics Committee Approval: This project was approved by the Ethics in Research Committee of University of São Paulo Bauru Dental School (approval no: 466/12, date: 12.18.2018).

Informed Consent: A retrospective longitudinal study.

Author Contributions: Concept - D.P.-R.; Supervision - M.R.F.; Materials - K.M.S.F.; Analysis and/or Interpretation - A.A.-D.C.; Writing - J.Q.F., S.A.B.-P.; Critical Review - G.J.

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REFERENCES

1. Kim TW, Artun J, Behbehani F, Artese F. Prevalence of third molar impaction in orthodontic patients treated nonextraction and with extraction of 4 premolars. *Am J Orthod Dentofacial Orthop*. 2003;123(2):138-145. [CrossRef]
2. Saysel MY, Meral GD, Kocadereli I, Tasar F. The effects of first premolar extractions on third molar angulations. *Angle Orthod*. 2005;75(5):719-722. [CrossRef]
3. Miclotte A, Grommen B, Cadenas de Llano-Perula M, Verdonck A, Jacobs R, Willems G. The effect of first and second premolar extractions on third molars: A retrospective longitudinal study. *J Dent*. 2017;61:55-66. [CrossRef]
4. Björk A, Jensen E, Palling M. Mandibular growth and third molar impaction. *Acta Odont Scandinav*. 1957:231-272. [CrossRef]
5. Tait RV. Mesial migration and lower third molar tilt. *Br J Orthod*. 1982;9(1):41-47. [CrossRef]
6. Richardson ME. The effect of mandibular first premolar extraction on third molar space. *Angle Orthod*. 1989;59(4):291-294. [CrossRef]
7. Behbehani F, Artun J, Thalib L. Prediction of mandibular third-molar impaction in adolescent orthodontic patients. *Am J Orthod Dentofacial Orthop*. 2006;130(1):47-55. [CrossRef]
8. Turköz C, Ulusoy C. Effect of premolar extraction on mandibular third molar impaction in young adults. *Angle Orthod*. 2013;83(4):572-577. [CrossRef]
9. Gohilot A, Pradhan T, Keluskar KM. Effects of first premolar extraction on maxillary and mandibular third molar angulation after orthodontic therapy. *J Oral Biol Craniofac Res*. 2012;2(2):97-104. [CrossRef]
10. Staggers JA, Germane N, Fortson WM. A comparison of the effects of first premolar extractions on third molar angulation. *Angle Orthod*. 1992;62(2):135-138. [CrossRef]
11. Artun J, Thalib L, Little RM. Third molar angulation during and after treatment of adolescent orthodontic patients. *Eur J Orthod*. 2005;27(6):590-596. [CrossRef]
12. Durgesh BH, Gowda KH, AlShahrani OA, et al. Influence of premolar extraction or non-extraction orthodontic therapy on the angular changes of mandibular third molars. *Saudi J Biol Sci*. 2016;23(6):736-740. [CrossRef]
13. Jain S, Valiathan A. Influence of first premolar extraction on mandibular third molar angulation. *Angle Orthod*. 2009;79(6):1143-1148. [CrossRef]
14. ICS SC -. ISO 3950:1984 Dentistry-Designation system for teeth and areas of the oral cavity. Standards Catalogue - ICS; 1984: p. 2. [CrossRef]
15. Elsey MJ, Rock WP. Influence of orthodontic treatment on development of third molars. *Br J Oral Maxillofac Surg*. 2000;38(4):350-353. [CrossRef]
16. You TM, Ban BH, Jeong JS, Huh J, Doh RM, Park W. Effect of premolar extraction and presence of the lower third molar on lower second molar angulation in orthodontic treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2014;118(3):278-283. [CrossRef]
17. Güngörmüs M. Pathologic status and changes in mandibular third molar position during orthodontic treatment. *J Contemp Dent Pract*. 2002;3(2):11-22. [CrossRef]
18. Dahlberg G. Statistical methods for medical and biological students. *Br Med J*. 1940;2(4158):358-359. [CrossRef]
19. Houston WJ. The analysis of errors in orthodontic measurements. *Am J Orthod*. 1983;83(5):382-390. [CrossRef]
20. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159-174. [CrossRef]
21. Janson G, Putrick LM, Henriques JF, de Freitas MR, Henriques RP. Maxillary third molar position in Class II malocclusions: the effect of treatment with and without maxillary premolar extractions. *Eur J Orthod*. 2006;28(6):573-579. [CrossRef]
22. Nikneshan S, Sharafi M, Emadi N. Evaluation of the accuracy of linear and angular measurements on panoramic radiographs taken at different positions. *Imaging Sci Dent*. 2013;43(3):191-196. [CrossRef]
23. Nanda RS. Reappraising "Wits". *Am J Orthod Dentofacial Orthop*. 2004;125(2):18A. [CrossRef]
24. Artun J, Behbehani F, Thalib L. Prediction of maxillary third molar impaction in adolescent orthodontic patients. *Angle Orthod*. 2005;75(6):904-911. [CrossRef]
25. Miclotte A, Grommen B, Lauwereins S, et al. The effect of headgear on upper third molars: a retrospective longitudinal study. *Eur J Orthod*. 2017;39(4):426-432. [CrossRef]
26. Tarazona B, Paredes V, Llamas JM, Cibrian R, Gandia JL. Influence of first and second premolar extraction or non-extraction treatments on mandibular third molar angulation and position. A comparative study. *Med Oral Patol Oral Cir Bucal*. 2010;15(5):e760-766. [CrossRef]
27. Janson G, Brambilla Ada C, Henriques JF, de Freitas MR, Neves LS. Class II treatment success rate in 2- and 4-premolar extraction protocols. *Am J Orthod Dentofacial Orthop*. 2004;125(4):472-479. [CrossRef]
28. Dierkes DD. An investigation of the mandibular third molars in orthodontic cases. *Angle Orthod*. 1975;45(3):207-212. [CrossRef]
29. Staggers JA. A comparison of results of second molar and first premolar extraction treatment. *Am J Orthod Dentofacial Orthop*. 1990;98(5):430-436. [CrossRef]
30. Mihai AM, Lulache IR, Grigore R, Sanabil AS, Boiangiu S, Ionescu E. Positional changes of the third molar in orthodontically treated patients. *J Med Life*. 2013;6(2):171-175. [CrossRef]