Impaction of mandibular third molars after orthodontic treatment by the edgewise method: a retrospective study

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Abstract: This study aimed to determine the incidence of mandibular third molar (M3) impaction after orthodontic treatment by edgewise appliances, and identify possible determinant factors of M3 impaction. A retrospective cohort study was conducted with 1154 patients. Complete orthodontic records were analyzed pretreatment and posttreatment, considering the following variables: type of Angle malocclusion, treatment with or without extraction of first premolars, overbite, stage of dentition, M3 prior angulation and duration of orthodontic treatment. Impaction was determined after radiographic evidence of total closure of the root apex. The chi-square test and Poisson regression (p < 0.05) were used for statistical analysis with a hierarchical approach. Rate ratios (RR) and 95% confidence intervals (CI) were calculated. Mandibular M3 impaction incidence was 17%. Overbite equal to or greater than 4 mm (RR = 1.23, 95%CI: 1.11–1.26, p < 0.001), prior mesial angulation of M3 (RR = 0.59, 95%CI: 0.52–0.68, p < 0.001), non-extraction of first premolars (RR=1.06, 95%CI: 1.01–1.12, P=0.019) and orthodontic treatment time equal to or less than three years (RR = 0.94. 95%CI: 0.90–0.99, p < 0.014) were significantly associated with impacted M3. There was no correlation between the type of Angle malocclusion and the risk of impaction. In conclusion, the incidence of mandibular M3 impaction was considered low. The main pretreatment factors directly involved in impaction were mesioangulation of M3 and overbite equal to or greater than 4 mm. Orthodontic treatment with extraction of first premolars and treatment time greater than 3 years reduce the risk of impaction.

Keywords: Tooth, Impacted; Orthodontics; Third Molar.

Introduction

Impacted third molars (M3) are common in modern society, more likely in the mandible, with a prevalence rate of 24% that can extend up to roughly 68% throughout the world.[1,2] This condition can generate several complications, such as caries, external root resorption of adjacent teeth, localized periodontal problems, infections, and mandible fractures.[3,4,5] The etiology of M3 impaction has been associated with several factors, including a large variation in tooth morphology, prior tooth position and eruption pathway, root development, and deficient retromolar space.[1,6]

It has also been speculated that some occlusal and skeletal features may influence M3 impaction. A Class II dental and skeletal relationship with a shorter, narrower, and more acute gonial angle was found in association with an impacted M3.[6] In addition, vertical condylar growth may also lead to limited anterior remodeling of the mandibular ramus, leading to not enough space for a lower M3 to erupt.[7,8,9]

Several authors have defended the principle of premolar extraction to improve the position and angle of an impacted M3, thereby favoring its complete euption.[10,11,12,13] A critical appraisal of the literature finds that the main limitations of these studies are related to the unrepresentativeness of the sample, non-standardized use of the type of appliance and orthodontic mechanics, methodological differences regarding evaluations and different follow-up times.[10,12,13,14,15]

In this sense, orthodontists would improve treatment strategies if they could accurately predict the variables associated with M3 eruption.[14] However, recent systematic reviews reveal that orthodontists are unable to predict M3 eruption by examining a panoramic radiograph.[16,17] Furthermore, previous studies have used only the predictive value of available space and tooth position, while neglecting the possible influence of other variables.[1,14,15,16] Thus, a possible consequence is that prophylactic extraction of M3 may be occurring in a disorderly fashion and with no defined criteria.

For these reasons, the aims of the present study were to assess the incidence of M3 impaction in patients treated with the edgewise orthodontic method, and identify possible determinant factors.

Methodology

We followed the STROBE statement[18] for transparent reporting of this retrospective cohort study.

Study population

This retrospective cohort study consisted of a convenience sample of patients who underwent orthodontic treatment using a pure edgewise method, as part of the Postgraduate Orthodontic Program of Universidade Federal do Rio de Janeiro, Brazil.

Sample size was calculated using OpenEpi® software, (https://www.openepi.com/SampleSize/SSCC.htm), and was performed with the following parameters: 95% confidence interval (CI), power of 80%, percentage of 75% positive individuals among the unexposed group, and rate ratio (RR) of 1.5 (pilot study with 10% of the sample). The minimum required sample was set at 968 records. Another 186 records were added to the sample to compensate for possible losses. A total of 1,154 pretreatment and posttreatment (immediately after removal of the orthodontic appliance) records were analyzed. The selection criteria excluded records of unconcluded orthodontic treatment, patients with severe craniofacial deformities, clefts and radiographic signs of pathologies, such as cysts, tumors, congenitally missing M3 teeth, and radiographs of poor quality. No patient was undergoing retreatment. Treatment was provided by resident dentists supervised by experienced clinicians working in the orthodontic clinic of the same university.

The final sample comprised 1,037 orthodontic records of patients with a mean age of 15.3 (SD, 0.92) years. Mean duration of the active phase of treatment was 3.24 years. Follow-up panoramic radiographs were analyzed to assess the M3 condition, and M3 was considered impacted only when no buccal or lingual cusps were present at the level of the occlusal plane, and the radiographic confirmed total closure of the root apex.[11] The radiographic distortion was not so significant that it caused diagnostic errors in dental impaction.

Data collection

The independent variables were acquired from all the records by analyzing the clinical charts, and included demographic characteristics (age at onset of treatment and gender), pretreatment diagnosis and other relevant information, such as treatment with or without extraction of the four first premolars, malocclusion according to the Angle classification (Class I, Class II and Class III), overbite, stage of dentition (mixed or permanent) and duration of the orthodontic treatment. The angle of the M3 prior to orthodontic treatment was based on the Winter classification,[19] which refers to the angle formed between the longitudinal axes of the second molar and

the M3. Thus, the vertical (10° to -10°), mesioangular (11° a 79°), horizontal (80° to 100°), and distoangular (-11° a -79°) previous M3 positions were determined, among other types (≥ 111° or ≤ -80°).

Training and calibration exercises

The training and calibration exercises of the examiners were performed by two orthodontists with at least eight years of clinical experience, with a random selection of 10% of all the radiographs. Their evaluation was performed considering impaction and tooth position. M3 impaction was evaluated using panoramic radiographs pre- and post-orthodontic treatment, using a negatoscope with standard light intensity. The minimum kappa coefficients for intraexaminer and interexaminer agreement on a tooth-by-tooth basis were 0.93 and 0.88, respectively.

Statistical analysis

The results were entered into a database and analyzed using the Statistical Package for Social Sciences (version 20.0, SPSS, Chicago, USA). Absolute and relative frequencies were studied first. A hierarchical approach was employed to select the variables,[20] which were grouped within a hierarchy of categories from distal to proximal determinants. The chi-square test was used to exclude variables with a *P*-value < 0.20. For each level, Poisson regression analysis with robust variance was used to correlate M3 impaction (dependent variable) with the characteristics of each patient, treatment and dentition (in that order). Explanatory variables were selected for the final model when p-value was < 0.05 after adjustment of the variables on the same or previous level of the determinants. Proportion ratios (PRs) and 95%CI were calculated.

Results

The incidence of M3 impaction after orthodontic treatment was 17% (n=176). The female gender accounted for 56% of the patients, and was not associated with M3 impaction (p > 0.05).

The frequency between impacted M3 and independent variables is shown in Table 1. M3 impaction was significantly associated with the extraction of

the first premolars (p < 0.001), duration of treatment equal to or less than three years (p = 0.001), overbite equal to or greater than 4 mm (p < 0.001), Class I (p = 0.032) and Class II Division 1 (p = 0.004), prior mesioangular M3 (p < 0.001), prior distoangular M3 (p < 0.001), prior vertical M3 (p < 0.001) and prior horizontal M3 (p < 0.001).

The univariate analysis revealed that the dependent variable (M3 impaction) was associated with the non-extraction of the four first premolars (PR = 1.16, 95%CI: 1.09–1.23), treatment time greater than three years (PR = 0.89, 95%CI: 0.85–0.95), overbite equal to or greater than 4 mm (PR = 1.37, 95%CI: 1.21–1.56), Class I (PR = 0.94, 95%CI: 0.89–0.99) and Class II Division 1 (PR = 1.09, 95%CI: 1.03–1.15), and prior mesioangular M3 (PR = 0.89, 95%CI: 0.81–0.99) (Table 2).

Table 3 displays the covariates that remained significantly associated with M3 impaction (p < 0.05) after applying the final hierarchical Poisson regression model. The following pretreatment dentition characteristics were associated with M3 impaction: overbite equal to or greater than 4 mm increases the risk by 23% (RR = 1.23, 95%CI: 1.11–1.26), and absence of mesioangular M3 reduces the risk by 41% (RR = 0.59, 95%CI: 0.52–0.68). Orthodontic treatment without extraction of the first premolars increases the risk of M3 impaction by 6% (RR = 1.06, 95%CI: 1.01–1.12), whereas a treatment time greater than three years reduces the risk of impaction by 6% (RR = 0.94. 95%CI: 0.90–0.99).

Discussion

This study showed that the pretreatment variables associated with impaction of M3 were prior mesioangular positioning of M3 (11° to 79°) in relation to the second molar, and an overbite equal to or greater than 4 mm. Treatment variables associated with reduced risk of impaction were extraction of first premolars, and treatment time greater than three years. No association was found between the type of Angle malocclusion and the risk of impaction. Our results might support a previous finding that extraction treatment of the first premolar can reduce the risk of mandibular M3 impaction, and that mesioangular impaction is the most often

Table 1. Analysis of relationship between impaction of third molar and independent variables.

Variables	Impaction of third molar		Total	p-value	Cohen
	Yes	No			
	n (%)	n (%)			
Gender					
Female	90 (15.9)	485 (84.3)	575 (100)	0.207*	0.039
Male	86 (18.6)	376 (81.4)	462 (100)		
Extraction of 4 premolar					
No	97 (24.4)	300 (75.6)	397 (100)	< 0.001*	0.157
Yes	79 (12.3)	561 (87.7)	640 (100)		
Treatment time					
≤ 3 years	19 (9.2)	188 (90.8)	207 (100)	0.001ᶜ	0.104
> 3 years	157 (18.9)	673 (81.1)	830 (100)		
Dentition (T1)					
Mixed	106 (17.5)	499 (82.5)	605 (100)	0.578*	0.017
Permanent	70(16.2)	362 (83.8)	432 (100)		
Overbite (T1)					
≥4mm	53 (37.1)	90 (62.9)	143 (100)	<0.001*	0.214
<4mm	123 (13.8)	771 (86.2)	894 (100)		
Class I (T1)					
Yes	51 (13.6)	323 (86.4)	374 (100)	0.032ᶜ	0.067
No	125 (18.9)	538 (81.1)	663 (100)		
Class II, Division 1 (T1)					
Yes	103 (20.4)	401 (83.5)	504 (100)	0.004ᶜ	0.090
No	73 (13.7)	460 (87.4)	533 (100)		
Class II, Division 2 (T1)					
Yes	15 (13.1)	106 (87.6)	121 (100)	0.154*	0.044
No	161 (14.7)	755 (82.4)	916 (100)		
Class III (T1)					
Yes	7 (18.9)	30 (81.1)	37 (100)	0.748*	0.010
No	169 (16.9)	831 (83.1)	1000 (100)		
M3 mesioangular (T1)					
Yes	142 (99.3)	1 (0.7)	143 (100)	< 0.001*	0.899
No	28 (3.2)	866 (96.8)	894 (100)		
M3 distoangular (T1)					
Yes	6 (100)	0 (0)	6 (100)	< 0.001**	0.196
No	168 (16.2)	862 (83.8)	1030 (100)		
M3 molar horizontal (T1)					
Yes	24 (100)	0 (0)	24 (100)	< 0.001**	0.363
No	149 (14.7)	863 (85.3)	1012 (100)		
M3 molar vertical (T1)					
Yes	4 (100)	0 (0)	4 (100)	0.001**	0.138
No	172 (16.6)	860 (83.4)	1032 (100)		

*Pearson Qui-Square test; **Fisher's exact test. M3: third molar.

Table 2. Univariate analysis for association between impaction of third molar, characteristics of dentition and characteristics of treatment.

Covariates	Robust RR* (95%CI)	p-value**
Gender		
Female	1	
Male	0.96 (0.91–1.02)	0.210
Extraction of 4 premolar		
Yes	1	
No	1.16 (1.09–1.24)	< 0.001
Treatment time		
≤ 3 years	1	
> 3 years	0.89 (0.85–0.95)	< 0.001
Overbite		
< 4 mm	1	
≥ 4 mm	1.37 (1.21 –1.56)	< 0.001
Class I		
Yes	1	
No	0.94 (0.89–0.99)	0.038
Class II, Division 1		
Yes	1	
No	1.09 (1.03–1.15)	0.003
Class II, Division 2		
Yes	1	
No	0.93 (0.87–1.00)	0.062
M3 mesioangular (T1)		
Yes	1	
No	0.89 (0.81–0.99)	0.030

*RR: Rate Ratio; **Calculated by Wald chi-square.

Table 3. Final poisson regression model for covariates associated with impacted third molar.

Covariates	Robust RR** (95% CI)	p-value***
Characteristics of patient		
Gender		
Female	1	
Male	0.96 (0.91–1.02)	0.178
Characteristics of treatment – level 1ª		
Extraction of 4 premolars		
Yes	1	
No	1.16 (1.09–1.23)	< 0.001
Treatment time		
≤ 3 years	1	
> 3 years	0.89 (0.85–0.94)	< 0.001
Characteristics of dentition – level 2*		
Overbite		
< 4 mm	1	
≥ 4 mm	1.23 (1.11–1.26)	< 0.001
M3 mesioangular (T1)		
Present	1	
Absent	0.59 (0.52–0.68)	< 0.001
Extraction of 4 premolar		
Yes	1	
No	1.06 (1.01–1.12)	0.019
Treatment time		
≤ 3 years	1	
> 3 years	0.94 (0.90–0.99)	0.014

*Model adjusted for the variables significant in the final model of previous levels; **RR: Rate Ratio; ***Calculated by Wald Chi-square test.

seen orientation.[1,21] However, one major weakness of any similar study is not having a large enough and standardized sample, a lack which may create sampling bias.

We provided an orthodontic pretreatment prediction factor for M3 impaction (the mesioangulation of M3), thus questioning previous recommendations that only posttreatment angulation may be a clinically useful predictor.[6,21,22] Some evidence suggests that successful eruption of lower M3 requires that the angle between the second molar and M3 be greater than 40° at 10 years old. Afterwards, this angle would adjust physiologically to eventually become a right angle, by the time the lower M3 is completely erupted.[6,23]

Our results contradict this, since patients who had an angle of 11° to 79° presented a higher risk of impaction after the root apex closure, which represents the end of the eruption pathway. The initial mesioangulation leaves the pathway of M3 eruption angled toward the surface of the adjacent tooth, which can block its movement and lead to impaction. Prior angulation of M3 is a specially important observation that should be included in the planning of an orthodontic treatment as supplementary information for making a clinical decision, especially regarding borderline cases contemplating tooth extraction or nonextraction.

Another risk factor found in this study for mandibular M3 impaction was pretreatment overbite

equal to or greater than 4 mm. We believe that the mandibular growth pattern may help understand this association. A small gonial angle is related to an anterior rotation of the mandible during the growth period,[6,7] leading to an increase in overbite. The association among such factors as small gonial angle, anterior mandibular growth pattern, and risk of M3 impaction is known, since this pattern of mandibular rotation leads to a limited remodeling of the mandibular ramus.[21,23] Thus, increased overbite may be a clinical characteristic associated with lower risk of M3 impaction.

We found no association between Angle classification malocclusion and M3 impaction in the final regression model. This was surprising, because several studies reported an association between a Class II skeletal and dental relationship and M3 impaction. The total length of the mandible in patients with impacted M3, may be smaller than in patients without impacted molars, thus diminishing the retromolar space.[6,24] Other associated Class II skeletal characteristics are an acute gonial angle and a narrow mandible.[6] Likewise, it is expected that the space-to-width ratio in Class III patients will attain the values needed for eruption of the lower M3, thus acting as a protective factor against impaction,[9] even though this was not confirmed by our results. This disagreement may be attributed to how we evaluated the sagittal relationship, in which we observed the dental relationship, versus how other studies evaluate dental and skeletal relationships.

An important finding herein was the influence of orthodontic treatment performed with extraction of the first premolars, considering that the risk of M3 impaction in patients undergoing first premolar removal was reduced (6%). Recent studies have reported a similar yet stronger association.[10,11,12,13,14,25] The hypothesis is that orthodontic treatment with premolars extraction favors mesial movement and uprighting of molars, with a concomitant increase in retromolar space, thereby allowing successful eruption of M3.[12,14,25] Opting not to extract premolars is tantamount to requiring more frequent surgical removal of M3. Thus, orthodontic treatment without extraction of premolars is not always a treatment without extraction.[26] Nevertheless, planning for

cases of premolar extraction when there is a risk of M3 impaction should be done carefully. The amount of posterior space created for M3 eruption will depend on the amount of distal movement of the canine. Canine retraction with maximum anchorage will not create the space needed in the posterior portion in the arch, thus risking extraction of four mandibular teeth.

When the treatment time was greater than three years, the risk of M3 impaction was lower than it would have been with a shorter treatment time. The factors that influence longer orthodontic treatment time can be broken down into four components: sociodemographic characteristics, malocclusion characteristics, patient cooperation and treatment method.[27] Regarding the treatment method, previous studies have demonstrated that the extraction of the first premolars was significantly associated with a longer treatment time. This association of premolar extraction and treatment time is strongly associated with a lower frequency of M3 extraction after orthodontic treatment.[28] However, in our study even after applying the hierarchical statistical approach, the duration of treatment continued to reduce the risk of M3 impaction.

The decision about what factors to include in the statistical model should be based on a conceptual framework that describes the hierarchical relationships between the risk factors. We have used conceptual hierarchical frameworks to study the determinants of M3 impaction. These frameworks have provided guidance for using multivariate techniques and interpreting their results according to the knowledge of demographic and biological factors. Multivariate analysis, often used to predict risk, is based entirely on statistical associations, rather than any conceptual basis for determining the interrelationships between factors, and all explanatory variables are treated as belonging to the same hierarchical level. When assessing whether a variable has a direct effect on or is affected by other factors, a hierarchical analytical approach is preferable.[20] This may be considered an advantage of this study.

A possible weakness of this study is the age and phase of dentition of the sample (some patients started treatment in the mixed dentition). The root apex of M3 closes at a mean age of approximately 20 years.[29]

The mean posttreatment age of our sample was slightly younger than this, and may have contributed to the low incidence of impaction found. However, the identification of the determining factors was not influenced, since the statistical hierarchical approach includes only the cases where the impaction was confirmed by the root apex closure. This provided a more homogeneous sample at the time of the dependent variable analysis (M3 impaction). Other potentially related factors not covered by the analysis may be related to M3 impaction. These include amount of pretreatment crowding,[30] pattern of mandibular and condylar growth, available retromolar space and residual mandibular growth in Class III patients.[9]

The clinical implications of our findings might guide clinical actions and improve the understanding M3 impaction behavior. In sum, mesioangulation of M3 and a pronounced overbite before orthodontic treatment are predictive dental and occlusal characteristics of future disturbances regarding M3 eruption, and indicate orthodontic treatment with premolar extraction in borderline cases. Thus, the possibility of monitoring and improving M3 eruption conditions during orthodontic treatment could prevent late-onset complications regarding tooth positioning.

Conclusion

A low incidence of mandibular M3 impaction was found in orthodontic patients treated with the edgewise method. Pretreatment factors directly involved in impaction were mesioangulation of M3, and overbite equal to or greater than 4 mm. Orthodontic treatment with extraction of first premolars and treatment time greater than 3 years reduce the risk of impaction.

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