Prevalence of second molar external root resorption caused by mandibular third molars: a CBCT study

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The aims of this study were to use cone beam computed tomographic (CBCT) scans to assess the prevalence of second molar external root resorption (ERR) caused by impacted mandibular third molars and to associate the location and severity of ERR with the third molar position using 2 classification systems—1 proposed by Pell and Gregory and the other proposed by Winter. In this cross-sectional study, 2 calibrated observers evaluated a total of 107 CBCT scans (71 female and 36 male patients). After the presence or absence of ERR was determined, ERR was classified according to its location (cervical, middle, apical third, or root apex) and severity (mild, moderate, or severe resorption). The data were assessed with the Pearson chi-square test, the chi-square test for linear trend, and Poisson regression analysis. The significance level was set at $P < 0.05$. The prevalence of second molar ERR in the sample as a whole was 47.7% (n = 51). The prevalence was significantly higher (69.4%) for male patients ($P = 0.002$; Pearson chi-square test). The probability that ERR would affect the second molar was 1.71 times greater when the third molar exhibited the Pell and Gregory class IC position (95% CI, 1.27-2.31) and 1.64 times greater when the third molar exhibited the Winter mesioangular position (95% CI, 1.38-1.95). There was a statistically significant association between ERR location and severity; the cervical third was the most affected by mild ERR and the middle third was the most affected by severe ERR. The prevalence of mandibular second molar ERR caused by impacted third molars is high, especially in male patients. Mandibular third molars in the Pell and Gregory class IC position or Winter mesioangular position demonstrated greater potential to result in ERR of the adjacent second molar.

Received: September 17, 2021
Accepted: December 14, 2021

Keywords: cone beam computed tomography, external root resorption, impacted tooth, second molar, third molar

GENERAL DENTISTRY SELF-INSTRUCTION CE CREDIT
Exercise No. GD506, p. 64
Subject code: Basic Science (010)

Third molars are the last teeth to erupt in the oral cavity due to their late root development, and a lack of space or the presence of a physical barrier can disrupt their eruption trajectory.[1,2] As a result, they present a higher rate of dental impaction than other teeth.[1,3] Several pathologic conditions can result from dental impaction, including pericoronitis, carious lesions, odontogenic cysts or tumors, periodontal disease, and external root resorption (ERR) of adjacent teeth.[1,4-10] External root resorption occurs when cementoblasts are removed from the outer layer of the teeth, exposing the root surface, which activates nearby osteoclasts that promote root resorption.[8,11] Root resorption may also be induced by chronic apical periodontitis, excessive force of orthodontic appliances, dental trauma, cysts, or tumors.[8,9,12,13]

The reported prevalence of ERR caused by impacted third molars varies from 20.17% to 81%.[14,15] The prevalence of ERR has been previously investigated in an attempt to characterize associated etiologic factors, including tooth position.[1,2,4,10,16,17] In a previous study, researchers assessed panoramic radiographs and cone beam computed tomographic (CBCT) scans and found that the ERR detection rate is 4.3 times higher using CBCT images than it is using panoramic radiographs.[4] CBCT scans are more likely to predict ERR than panoramic radiographs because the 3-dimensional CBCT image does not present overlapped images, providing accurate information on root resorption.[15,18] According to the recommendations of the European Academy of DentoMaxilloFacial Radiology, CBCT imaging is indicated when there is a specific clinical question that cannot be answered by 2-dimensional (2D) radiography.[5] Because root resorption is generally not identifiable on 2D images, CBCT is indicated when a second molar has to be evaluated for the presence of ERR.[6,15,18]

The aims of the present study were to use CBCT scans to evaluate the prevalence of second molar ERR caused by impacted mandibular third molars and to associate the location and severity of ERR with the third molar position using 2 classification systems—1 proposed by Pell and Gregory and the other proposed by Winter.[19,20]

Methods

This study protocol was approved by the Institutional Review Board of Integrated Faculties of Patos, Patos, Brazil (No. 2.117.792), in accordance with the Helsinki Declaration. All patients signed a statement of informed consent.

Study setting and eligibility criteria

This cross-sectional study was performed using CBCT images obtained from the databases of the Department of Dental

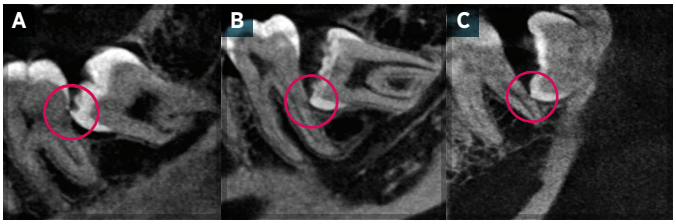

Fig 1. Classification of external root resorption location (red circles). A. Cervical third. B. Middle third. C. Apical third.

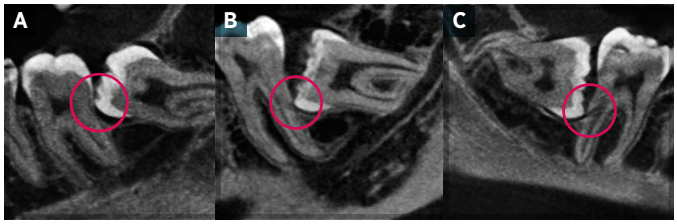

Fig 2. Classification of external root resorption severity (red circles). A. Mild. B. Moderate. C. Severe.

Radiology, Integrated Faculties of Patos, Patos, Brazil, and a private oral and maxillofacial radiology practice in Patos, Brazil, from January 2016 to December 2017. The inclusion criterion was that the image should present a second molar adjacent to the mandibular third molar. CBCT scans with evidence of a pathologic cystic or tumoral process, third molars with less than two-thirds of the root formed, extensive caries in the second molars, or second molars restored with high-density materials were excluded from the sample. A total of 141 CBCT scans were assessed, and 107 scans met the inclusion criterion.

Image acquisition and processing

The CBCT scans were acquired using 2 different CBCT scanners. An Orthophos XG 3D scanner (Dentsply Sirona), operated at 85 kV/5 mA, 0.1-mm voxel size, and 5 × 5-cm field of view, was used to obtain 33 scans. The remaining 74 CBCT scans were obtained with an Orthopantomograph OP300 scanner (Instrumentarium Dental), operated at 90 kV/5 mA, 0.1-mm voxel size, and 5 × 5-cm field of view.

All scans were exported in the Digital Imaging and Communications in Medicine (DICOM) format and analyzed separately by 2 previously trained and calibrated observers (J.T.L.-S. and J.A.S.) with experience assessing CBCT scans (interobserver agreement, $\kappa = 0.82$). All CBCT scans were assessed using ImageJ software (version 1.52a, National Institutes of Health). For the analysis of the intraobserver agreement, 20 randomly selected CBCT scans were reassessed after a 2-week interval ($\kappa = 0.80$).

Analysis of external root resorption

External root resorption of the second molar was diagnosed when hypodensity was visible on the root surface. The region affected by resorption was classified according to its location: cervical, middle, apical third, or root apex (Fig 1).[21] The severity of ERR was classified according to the following definitions: in mild ERR, the resorption was visible in up to half of the dentin, based on its distance to the root canal; in moderate ERR, the resorption was visible in more than half of the dentin but the root canal was still intact; and in severe ERR, the resorption reached the root canal (Fig 2).[22]

For the assessment of the position of the third molar, both the Pell and Gregory and the Winter classifications were used.[19,20] Pell and Gregory classified the mandibular third molars according to their relationship with the anterior border of the ramus and the occlusal plane.[19] The anterior border of the ramus is classified as class I when the space between the anterior border of the ramus and the distal surface of the second molar is greater than the mesiodistal diameter of the third molar crown, class II when this space is smaller than the mesiodistal diameter of the third molar crown, and class III when the ramus is next to the second molar and therefore the third molar is located fully within the ramus. The relationship of the third molar to the occlusal plane is classified as being in position A when the highest portion of the third molar is located at or above the occlusal plane, B when the highest portion of the third molar is between the occlusal plane and the cervical margin of the second molar, and C when the highest portion of the third molar is at or below the cervical margin of the second molar.

Winter classified third molars according to their inclination in relation to the long axis of the second molar.[20] The third molar is classified as vertical when the long axis of the third molar is parallel to the long axis of the second molar; mesioangular when the long axis of the molar is tilted toward the long axis of the second molar in a mesial direction; distoangular when the long axis of the third molar is tilted toward the long axis of the second molar in a distal direction; horizontal when the long axis of the third molar is perpendicular to the long axis of the second molar; linguoversion when the long axis of the third molar is angled lingually in relation to the long axis of the second molar; buccoversion when the long axis of the third molar is angled buccally in relation to the long axis of the second molar; and inverted when the tooth is entirely inverted (ie, with the crown directed downward and the roots upward).

Statistical analysis

Data were analyzed with the statistical program SPSS for Windows (version 22.0, IBM), through analytical statistics and absolute and percentage distribution using inferential statistics.

Based on inferential statistics, the Pearson chi-square test was performed to assess the variables sex, location, Pell and Gregory classification, and Winter classification.[19,20] To assess the severity variables, the chi-square test for linear trend was used, and significance was set at $P < 0.05$. Variables that presented a value of $P < 0.20$ in the bivariate analysis in the Poisson regression were included in the adjusted regression analysis, and those with a value of $P < 0.05$ remained in the model in the adjusted analysis. Variables with value of $P < 0.05$ were considered significantly associated with ERR and remained in the adjusted model.

The variables for statistical adjustment were selected using a directed acyclic graph (DAG) using DAGitty software (version 3.0) (Chart).[23] The DAG is a useful resource to assist in understanding the effect of exposure variables on the prevalence of

Chart. Directed acyclic graph used for the analysis of the variables.

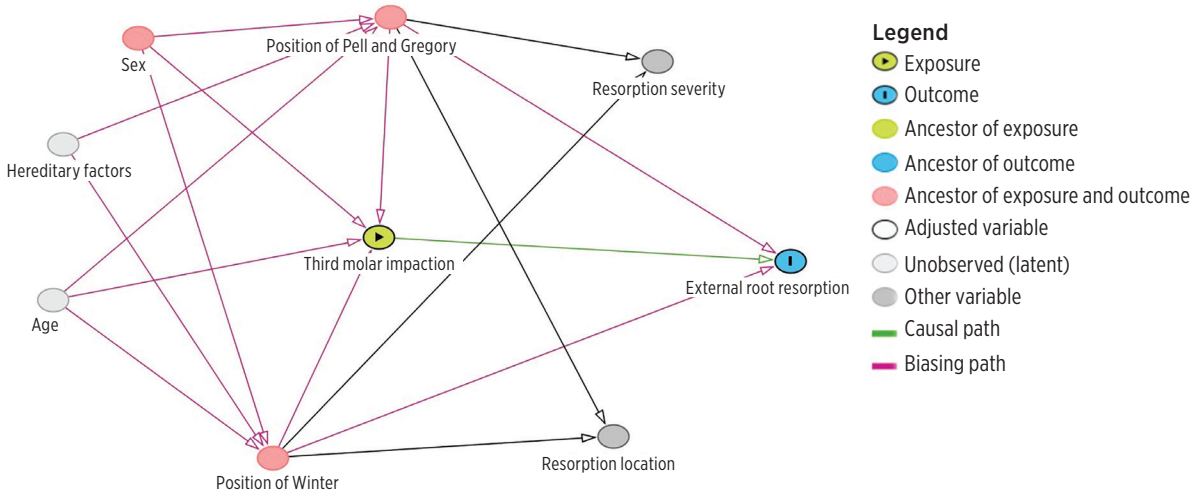

Table 1. Association between external root resorption (ERR) of the second molar and the Pell and Gregory classification of third molar position (N = 107).

	Pell and Gregory classification, n (%)[a]						
ERR	IA	IIA	IB	IIB	IC	Total	*P*[b]
Present	1 (4.8)	11 (57.9)	3 (30.0)	34 (61.8)	2 (100.0)	51 (47.7)	< 0.001
Absent	20 (95.2)	8 (42.1)	7 (70.0)	21 (38.2)	0 (0.0)	56 (52.3)	
Total	21 (100.0)	19 (100.0)	10 (100.0)	55 (100.0)	2 (100.0)	107 (100.0)	

[a]None of the third molars in the study demonstrated a class IIC, IIIA, IIIB, or IIIC position.[19]

[b]Statistically significant difference (Pearson chi-square test).

ERR. The variables included in the DAG were selected based on previous studies that reported an association between ERR and the following variables: sex; age (latent variable not collected in this study); third molar impaction; position of the third molar position according to the Pell and Gregory classification; position of the third molar according to the Winter classification; and hereditary factors (latent variable not collected in this study).[4,6,8-10,14,24] The DAG result indicated that the following variables should be incorporated in the analysis for statistical control: Pell and Gregory classification and Winter classification.

Results

Of the 107 CBCT images, 71 (66.3%) were of female patients and 36 (33.7%) were of male patients. The prevalence of ERR was 47.7%, corresponding to 51 scans of the total sample, and was significantly higher for male patients (69.4%) ($P = 0.002$).

The analysis of second molar ERR prevalence based on the position of the adjacent third molars revealed that ERR was significantly more frequent ($P < 0.001$) when the third molar was in a class IC (100.0%) or IIB (61.8%) position according to the Pell and Gregory classification (Table 1). Analysis based on the Winter classification revealed that ERR was significantly more frequent ($P < 0.001$) when the adjacent third molar was in the horizontal position (72.0%) (Table 2).

A statistically significant association ($P = 0.01$) was observed between the severity and location of ERR (Table 3). The highest prevalence of mild ERR was found in the cervical third, and the highest prevalence of severe ERR was observed in the middle third.

In the Poisson regression analysis, statistically significant associations were observed in the univariate analysis for the following variables: sex of the patient, Pell and Gregory classification, and Winter classification (Table 4). After adjustment for the analyzed variables, the factors associated with a propensity for ERR in the second molars were the sex of the patient (prevalence ratio [PR], 1.27; 95% CI, 1.07-1.50); Pell and Gregory classes IIA (PR, 1.38; 95% CI, 1.09-1.73), IIB (PR, 1.26; 95% CI, 1.01-1.58), and IC (PR, 1.71; 95% CI, 1.27-2.31);

Table 2. Association between external root resorption (ERR) of the second molar and the Winter classification of third molar position (N = 107).

	Winter classification, n (%)[a]					
ERR	Vertical	Mesioangular	Distoangular	Horizontal	Total	*P*[b]
Present	0 (0.0)	33 (62.3)	0 (0.0)	18 (72.0)	51 (47.7)	< 0.001
Absent	20 (100.0)	20 (37.7)	9 (100.0)	7 (28.0)	56 (52.3)	
Total	20 (100.0)	53 (100.0)	9 (100.0)	25 (100.0)	107 (100.0)	

[a]None of the third molars in the study exhibited a linguoversion, buccoversion, or inverted position.[20]

[b]Statistically significant difference (Pearson chi-square test).

Table 3. Association between the severity and location of external root resorption of the second molar (n = 51).

	Location, n (%)					
Severity	Cervical	Middle	Apical third	Root apex	Total	*P*[a]
Mild	14 (70.0)	6 (30.0)	0 (0.0)	0 (0.0)	20 (100.0)	0.01
Moderate	7 (63.6)	2 (18.2)	2 (18.2)	0 (0.0)	11 (100.0)	
Severe	6 (30.0)	12 (60.0)	2 (10.0)	0 (0.0)	20 (100.0)	

[a]Statistically significant difference (chi-square test for linear trend).

Table 4. Regression analysis of clinical and radiographic parameters associated with ERR of the second molar.

	ERR, n (%)		Unadjusted PR (95% CI)	*P*	Adjusted PR (95% CI)	*P*
Variable	Present	Absent				
Sex						
Female (n = 71)	26 (36.6)	45 (63.4)	1 (Reference)	0.002[a]	1 (Reference)	< 0.001[a]
Male (n = 26)	25 (69.4)	11 (30.6)	1.38 (1.15-1.67)		1.27 (1.07-1.50)	
Pell and Gregory classification[b]						
IA (n = 21)	1 (4.8)	20 (95.2)	1 (Reference)	< 0.001[a]	1 (Reference)	
IIA (n = 19)	11 (57.9)	8 (42.1)	1.70 (1.33-2.16)		1.38 (1.09-1.73)	< 0.001[a]
IB (n = 10)	3 (30.0)	7 (70.0)	1.28 (0.95-1.73)		0.95 (0.72-1.25)	0.97
IIB (n = 55)	34 (61.8)	21 (38.2)	1.76 (1.51-2.07)		1.26 (1.01-1.58)	< 0.001[a]
IC (n = 2)	2 (100.0)	0 (0.0)	2.59 (2.36-2.83)		1.71 (1.27-2.31)	< 0.001[a]
Winter classification[c]						
Vertical (n = 20)	0 (0.0)	20 (100.0)	1 (Reference)	< 0.001[a]	1 (Reference)	< 0.001[a]
Mesioangular (n = 53)	33 (62.3)	20 (37.7)	1.86 (1.63-2.12)		1.64 (1.38-1.95)	
Horizontal (n = 25)	18 (72.0)	7 (28.0)	2.05 (1.72-2.45)		1.56 (1.23-1.99)	

Abbreviations: ERR, external root resorption; PR, prevalence ratio.

[a]Statistically significant association (Poisson regression analysis).

[b]None of the third molars in the study exhibited a class IIC, IIIA, IIIB, or IIIC position.[19]

[c]None of the third molars with a distoangular position (n = 9) caused ERR in the second molar. None of the third molars in the study exhibited a linguoversion, buccoversion, or inverted position.[20]

and Winter mesioangular (PR, 1.64; 95% CI, 1.38-1.95) and horizontal positions (PR, 1.56; 95% CI, 1.23-1.99). None of the third molars in the Winter distoangular position was associated with ERR of the second molar.

Discussion

The diagnosis of ERR is considered a challenge for dental professionals assessing 2D images.[10] External root resorption can be diagnosed as a well-delimited root surface tissue loss, and multiplanar reconstructions provide greater precision during the visualization of the process.[14,24] Unlike 2D images, CBCT scans allow a careful evaluation without overlapping anatomical structures. Therefore, the prevalence of ERR identified on 2D images is low (0.9% to 12.5%) compared with that observed on CBCT images.[11,25]

The prevalence of ERR observed in the present study (47.7%) is in agreement with the rates reported in previous studies, which ranged from 20.17% to 81%.[14,15] Although similar studies in the literature have not shown statistically significant differences in the presence of ERR based on the sex of the individual, the present study found a significantly higher probability of ERR in males.[14,16,26] Possibly this result can be explained by the fact that men present greater bone density than women, resulting in a greater number of impacted teeth and consequently a higher prevalence of ERR.[27] This finding may be related to sex hormones because female hormones are associated with the regulation of bone metabolism through the activation of osteoclasts.[6,27] Therefore, women may present reduced bone mineral density compared with men.

In the present study, the probability of second molar ERR was 1.71 times higher when the adjacent third molar was in the class IC position described by Pell and Gregory. A previous study found that the Pell and Gregory B impaction classification has higher ERR probability compared with classes A and C, diverging from the results found in the present study.[14] Other studies have reported a higher presence of ERR associated with classes A and B.[24,26] Thus, there is a divergence in the results regarding the association between the Pell and Gregory position of third molars and the presence of ERR in the adjacent second molar, and longitudinal studies are necessary to characterize this association.

The tilt of the third molar toward the root of the second molar (mesioangular and horizontal positions) may directly influence ERR development, since no second molar ERR associated with vertically or distally positioned third molars was observed in the present study. In addition, the Winter mesioangular classification was 1.64 times more likely to be associated with ERR of the second molar. Previous studies have shown that third molars in the mesioangular and horizontal positions are more prone to cause ERR of the second molar.[4,9,14,26] A possible explanation for this result is that the mesioangular position, although presenting a smaller area of contact, exerts greater pressure on the root of the second molar.

In the present study, mild ERR was more frequent in the cervical third, while severe resorption occurred mainly in the middle and apical thirds. Similar studies have found that mild ERR frequently affects the cervical third.[14,24,26] This result may be explained by the absence of protection (periodontal ligament or alveolar bone) in the cervical region, which results in its greater vulnerability to ERR than the other thirds.[6] The presence of severe ERR in the middle and apical thirds may be explained by the root conicity; the reduced amount of dental tissue in the apical third favors the progression of ERR.[10]

Second molar ERR is a common condition that in most cases is asymptomatic; however, when it reaches the root canal, ERR presents painful symptoms and may lead to tooth loss.[5,7,12,28] Early detection and treatment may reduce ERR and improve the prognosis of tooth survival.[28] CBCT images may play an important role in ERR treatment decisions.[4,7]

The literature reports various results regarding the success of ERR treatment.[29,30] Previous studies have shown that ERR can be stopped with the use of a calcium hydroxide intracanal dressing, resulting in root healing.[29] The use of mineral trioxide aggregate to close the resorption has also been suggested as a way to preserve the tooth in the oral cavity for a period.[30] However, in severe cases of ERR, tooth extraction should be considered.[7] A systematic review found that there are no reports of randomized clinical trials on the effectiveness of different ERR treatments.[12] Therefore, clinical trials are needed to clarify the most effective approaches to treatment.

Conclusion

The prevalence of mandibular second molar ERR caused by impacted third molars is high, especially in male patients. Mandibular third molars in the Pell and Gregory class IC position or Winter mesioangular position demonstrated greater potential to result in ERR of the adjacent second molar.

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Conflicts of interest

None reported.

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