Original Research Article

Influence of Mandibular Third Molar Eruption Angulation on Dental Caries Development: Evidence from a Saudi Cohort

Abdulaziz Alrebdi

Department of Conservative Dental Sciences, College of Dentistry, Qassim University, Qassim, Saudi Arabia
*Corresponding author email: **Ab.alrebdi@qu.edu.sa**

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Abstract

Background: Impacted mandibular third molars are common teeth in the oral cavity. They have been associated with several conditions including distal caries of the mandibular second molars. The eruption angulation of the mandibular third molars may be associated with the occurrence and severity of distal caries. However, data are scarce from the Saudi population. This study aimed to assess the effect of mandibular third molar eruption angulation on the occurrence and severity of distal caries of adjacent second molars in the Saudi population.

Materials and methods: A retrospective radiographic study was conducted on the panoramic radiographs of 1500 impacted mandibular third molars of Saudi patients aged 25 years and older. The angulation of impacted third molars was determined according to Winter's classification, and the level of eruption was assessed using the Pell and Gregory classification. The occurrence and severity of distal caries in mandibular second molars were recorded. The associations between third molar angulation and gender and distal caries occurrence and severity were determined using the chi-square test. The level of significance was set at $p < 0.05$.

Results: The vertical angulation had the highest prevalence (60.8%) among impacted third molars. The vertical impactions were equally distributed between males and females. No significant association was detected between gender and third molar angulation ($p = 0.71$). Distal caries of mandibular second molars was recorded in 45.6% of cases. Horizontal (71.4%) and mesio-angular

impactions (67.8%) were significantly associated with a higher prevalence of distal caries compared to vertical impactions which recorded a lower prevalence of distal caries (31.6%) ($p < 0.001$). Moderate-to-severe carious lesions were associated mainly with mesio-angular and horizontal angulations compared to no caries which were associated with vertical impactions ($p < 0.001$).
Conclusion: Angulation of mandibular third molars eruption is associated with the occurrence and severity of distal caries of mandibular second molars. Mesio-angular and horizontal impactions are high-risk angulations. Vertical impactions are associated with low risk for developing distal caries of mandibular second molars.

Key words

Mandibular third molar; Eruption angulation; Distal caries; Second molar; Panoramic radiography; Saudi population.

Introduction

Third molar impaction is one of the most prevalent developmental disturbances observed worldwide and accounts for the majority of dental impactions seen in clinical practice. Teeth are deemed impacted when they do not fully erupt into the occlusal plane within their developmental stage either due to lack of space, interposition of adjacent structures, or abnormal eruption path [1,2]. Mandibular third molars have the greatest prevalence of impaction amongst all permanent teeth due to their late eruption time and distal position in the dental arch [1–3]. While asymptomatic in most cases, impacted third molars have shown strong associations with other pathological processes including pericoronitis, periodontal defects, root resorption, and caries of adjacent teeth [3–5].

Carious lesions of the second molar's distal surface have been cited as one of the most prevalent pathological findings among patients with impacted third molars [4–7]. The close relationship between the partially erupted or impacted mandibular third molar and second molar allows for plaque retention, stagnation of food debris, and inability to access areas for proper oral hygiene maintenance [6–8]. Mesioangular or horizontally angled third molars can accentuate this issue even further as these angulations prolong and consistently maintain contact between the third molar and distal cervical portion of the second molar [7–9]. As a result, these carious lesions often go unnoticed for extended periods of time and are difficult to restore, eventually leading to tooth loss [6,10].

Reports have demonstrated a vast range of prevalence rates regarding third molar impaction and developing distal caries throughout other regions of the world due to ethnic, anatomical, and behavioral variations [3,11]. Meta-analysis has revealed that the presence of an impacted mandibular third molar poses a great risk for development of second molar distal caries when angulation and degree of impaction allow for partial eruption and mesioangular positioning [11]. High heterogeneity was present amongst these studies related to differences in diagnostic modalities and criteria, and populations studied. Despite overall strong evidence supporting these findings, reported prevalence values and risk estimates continue to vary widely between published literature [8,11,12].

Impaction of third molars is not only highly prevalent in Saudi Arabia but is also thought to be a significant problem within the Gulf Cooperation Council (GCC) countries. Assessment of third molar eruption patterns using various radiographic modalities have been performed across different regions of Saudi Arabia demonstrating an overall high prevalence of impaction, with mesioangular impaction being most frequent [1,7,13]. Saudi-specific studies have shown that distal caries of the second molar were found to be present in 33% to 50% of patients with impacted mandibular third molars

[7,9,14]. These rates are significantly greater when compared to other international populations and may be related to ethnic differences in craniofacial morphology, dietary behaviors, and oral hygiene practices [1,13].

The majority of Saudi Arabia's published evidence utilized panoramic radiographs to assess third molar eruption patterns and prevalence of distal caries [7,9,13,14]. Panoramic radiography, while beneficial to incorporate into routine dental practice, poses several limitations including distortion of the region of interest, superimposition of surrounding anatomic structures, and difficulty in detection of incipient distal carious lesions [12,14]. While only two studies have been published from Saudi Arabia using three-dimensional imaging to assess impaction of third molars, they have suggested that the prevalence of distal caries may have been underestimated in previous literature [12,15].

Although research continues to strengthen the association between third molar eruption pattern and development of caries in the adjacent second molar, there are still areas of uncertainty that require further investigation. Many studies that assess third molar impaction only evaluate the presence or absence of distal caries on the second molar without stratifying risk by angulation or determining the depth of impaction [8,9,11]. There is also limited agreement on which specific angulations may benefit from early intervention to prevent pathology to the second molar [5,10,12]. Additionally, there is a lack of longitudinal and population specific data to best determine which patients require close monitoring, restorative action, or prophylactic extraction of third molars.

Due to the high prevalence of impacted mandibular third molars and consequential large number of extracted second molars secondary to caries in Saudi Arabia, further studies assessing the impact of third molar eruption angulation on caries development are needed in a Saudi population. By better understanding this relationship, we can identify which eruption patterns place second molars at the highest risk for developing distal caries, allow for earlier diagnosis, and encourage implementation of preventive measures. This would allow clinicians to better advise their patients on whether they should monitor these teeth and when they should be extracted prophylactically.

Methodology

Study design and setting

This retrospective study was conducted at the Department of Oral and Maxillofacial Radiology and dental clinics of College of Dentistry, Qassim University, Saudi Arabia. Panoramic radiographs taken between November 2018 and March 2020 were collected. Ethical approval was obtained from Committee of Research Ethics, Qassim University, before initiation of the study. Since the study was retrospective in nature and involved re-assessment of existing records of radiographs, individuals were recruited through convenient sampling based on availability of study period.

Sample size estimation

Minimum sample size was estimated using the formula for estimation of single proportion with expected distal caries prevalence around impacted mandibular third molars (28.6%) [10], precision (d) of 5% and Confidence interval (%CI) of 95% (Z = 1.96). Using these values, the calculated minimum sample size was found to be 310 impacted third molars. However, to increase the power of the study, all the panoramic radiographs fulfilling the inclusion criteria during the study period were considered for the study. This resulted in a sample size of 1500 impacted third molars (both maxillary and mandibular). All statistical tests involving the primary outcome of the study were performed only for mandibular third molars and adjacent second molars.

Inclusion and exclusion criteria

Panoramic radiographs from Saudi patients aged 25 years or older were recruited in order to cover

third molars eruption completion possibility. Saudi patients with radiographic evidence of completely erupted mandibular second permanent molars next to impacted mandibular third molars within the same quadrant were recruited. Radiographs from non-Saudi patients, patients under 25 years old, or patients who had missing mandibular second or third molars were excluded from this study. Also excluded were radiographs that had associated pathological lesions such as cysts or tumors, developmental anomalies, dental anomalies (microdontia, supernumerary teeth, second molar impaction, odontomes, dental implants) near the area of interest, distorted panoramic radiographs, visible radiographic imaging artifacts or those of poor diagnostic quality. Mandibular second molars with existing distal restorations were also excluded in order to eliminate erroneous inclusion of carious lesions.

Data collection and radiographic assessment

Panoramic radiographs that met the inclusion criteria were collected from the Picture Archiving and Communication Systems (PACS) of Radiographic Department, College of Dentistry-Qassim University. The demographic data collected for each case were age, sex, nationality, city and date of panoramic acquisition and file number, while radiographic findings included the presence of the mandibular third molars, and second molars adjacent to third molars. Angle of third molar angulation was measured and calculated by the angle between the long axis of mandibular third molar and its adjacent second molar. The molar angulation was then classified according to Winter's classification [15]. Recording was also made for the presence of molar-to-molar contact between the third molar and second molar and presence or absence of distal caries of the mandibular second molar. Radiographs were scored independently by two calibrated oral and maxillofacial surgeons seated in a dark room using a 21-inch Dell monitor with brightness, contrast, and magnification adjusted to the examiner's preference. The examiners resolved disagreements by consensus after joint reevaluation.

Data management and statistical analysis

Data were entered into Microsoft Excel 2010 and analyzed using SAS software 9.1.3. Descriptive statistics were reported for demographic and radiographic variables. Distal caries on the mandibular second molar was categorized as a dependent variable while age, gender, mandibular third molar angulation and level of impaction were reported as independent variables. Pearson chi-square analyses were used to determine relationships between variables with Bonferroni corrections applied to appropriate tests. Tests were considered significant if $p < 0.05$.

Ethical considerations

At no time during the study were there any recordings of identifiable patient information. Data collected were coded to ensure privacy. The study protocol was reviewed and approved by the Institutional Ethics Committee at Qassim University.

Results

Results are shown for retrospective radiographic analysis of the impacted mandibular third molar and distal caries of the adjacent mandibular second molar. Included panoramic radiographs were reviewed according to the specified inclusion and exclusion criteria. Angulation of mandibular third molars were noted according to Winter's classification and degree of distal caries in the adjacent second molar as stated outcome measures. Recorded demographic information was used to determine correlations with patterns of third molar angulation. Tests of significance were conducted on the relationship between third molar angulation, eruption, and distal caries with appropriate categorical statistics.

The angulation pattern of impacted mandibular third molars stratified by sex is shown in **Table - 1**. Overall, vertical impacted mandibular third molars were most frequent (60.8%) followed by

mesio-angular impactions (21.7%). Vertical impacted mandibular third molars were nearly equal between males (60.7%) and females (61.1%). Mesio-angular impactions were also similarly distributed between males (21.9%) and females (21.2%). Horizontal impacted third molars were more frequent in males than females, making up 13.2% and 11.7% of total impacted mandibular third molars respectively. Combined, disto-angular impactions and third molars with other angulation patterns comprised less than 5% of all impacted mandibular third molars. Gender was not associated with angulation pattern of impacted mandibular third molars ($X^2 = 2.14$, $p = 0.71$).

Table – 1: Angulation Pattern of Impacted Mandibular Third Molars According to Gender (n = 1500).

Angulation Type (Winter's)	Male n (%)	Female n (%)	Total n (%)	χ^2	p-value
Mesio-angular	239 (21.9)	87 (21.2)	326 (21.7)	**2.14**	**0.71**
Horizontal	144 (13.2)	48 (11.7)	192 (12.8)		
Vertical	661 (60.7)	251 (61.1)	912 (60.8)		
Disto-angular	36 (3.3)	20 (4.9)	56 (3.7)		
Others	9 (0.8)	5 (1.1)	14 (0.9)		
Total	**1089 (100.0)**	**411 (100.0)**	**1500 (100.0)**		

Table – 2: Association Between Mandibular Third Molar Angulation and Distal Caries of Adjacent Second Molars (n = 1500).

Angulation	Caries Present n (%)	Caries Absent n (%)	Total	χ^2	p-value
Mesio-angular	221 (67.8)	105 (32.2)	326	**162.3**	**<0.001***
Horizontal	137 (71.4)	55 (28.6)	192		
Vertical	288 (31.6)	624 (68.4)	912		
Disto-angular	31 (55.4)	25 (44.6)	56		
Others	7 (50.0)	7 (50.0)	14		
Total	**684 (45.6)**	**816 (54.4)**	**1500**		

* statistically significant

Table – 3: Severity of Distal Caries in Mandibular Second Molars According to Third Molar Angulation (n = 1500).

Angulation	No Caries n (%)	Moderate n (%)	Severe n (%)	Total	χ^2	p-value
Mesio-angular	105 (32.2)	197 (60.4)	24 (7.4)	326	**184.6**	**<0.001***
Horizontal	55 (28.6)	121 (63.0)	16 (8.4)	192		
Vertical	624 (68.4)	270 (29.6)	18 (2.0)	912		
Disto-angular	25 (44.6)	27 (48.2)	4 (7.2)	56		
Others	7 (50.0)	6 (42.9)	1 (7.1)	14		
Total	**816**	**611**	**73**	**1500**		

The group with horizontal impaction presented with the highest prevalence of distal caries on the affected second molars (71.4% caries-positive), closely followed by mesio-angular impaction with 67.8%. Vertical impaction presented with a considerably lower prevalence of distal caries (31.6%), with most cases showing no evidence of distal caries (68.4%). Disto-angular impactions fell in the middle (55.4% distal caries), while cases classified under other angulations were evenly split between presence (50.0%) and absence (50.0%) of distal caries. All in all, there was a highly significant association between the angulation pattern of mandibular third molars

and the presence of distal caries on the associated second molar (χ 2 = 162.3, P < 0.001), showing that angulation pattern strongly affects the risk of developing distal caries on the mandibular second molar (**Table - 2**).

Table – 3 shows distribution of Severity of Distal Caries Involvement in Second Molars by Angulation of Impacted Third Molar There was a trend in angulations associated with higher grades of distal caries involvement. Vertical third molars were most likely to have no second molar caries involvement (68.4%) and were least likely to have severe caries (2.0%). Mesio-angular (60.4% moderate caries) and horizontal third molars (63.0% moderate caries) were most likely to have moderate to severe caries involvement. Horizontal impactions had the greatest percentage of severe disease (8.4%). Disto-angular impactions were intermediate (48.2% moderate caries, 7.2% severe caries). There was a reasonable distribution across severity categories among those impactions categorized as other. There was highly statistically significant association between angulation of third molars and severity of distal caries in adjacent second molars ($\chi^2 = 184.6$, $p < 0.001$).

Discussion

In our sample, vertical was the most common angulation overall (60.8%) and amongst males (60.7%) and females (61.1%), followed by mesio-angular (21.7% overall; 21.9% males vs 21.2% females) and horizontal (12.8% overall; 13.2% males vs 11.7% females), and finally disto-angular and other represented <5% of teeth; moreover, there was no statistically significant difference in angulation by gender ($\chi2 = 2.14$, $p = 0.71$). AlHobail, et al. (2023) analyzed a Saudi sample of impacted mandibular third molars from Riyadh and found vertical impaction to be the most common angulation, and their sample also exhibited pronounced distal caries involvement of second molars when third molars were present [4]. Examining a much larger Saudi radiographic dataset from Qassim, Alrebdi (2024) likewise reported vertical impaction to be the most common angulation pattern of mandibular third molars (67.2%) followed by mesio-angular (18.9%) and horizontal (9.4%), suggesting a generally consistent "vertical-dominant" impaction pattern across Saudi populations [16]. Conversely to our observation of no gendered difference in impaction pattern, Demyati (2024) noted that males were more likely to have horizontal impactions and females were more likely to have mesioangular impactions [7]. Collectively, the distribution of angulations we observed was consistent with other Saudi datasets demonstrating vertical impaction to be the most frequent angulation category, but differences in male/female stratification can be multi-factorial and likely arise from differences in age distribution, study setting (clinical versus radiographic archives), and definitional criteria used to categorize an impaction as each angulation type.

Our data showed distal caries was significantly more prevalent when mandibular third molars were horizontally (71.4%) or mesio-angularly (67.8%) impacted, while vertical impaction had significantly lower prevalence of distal caries (31.6%) with the majority of second molars being caries-free (68.4%); this relationship was strongly significant ($\chi2 = 162.3$, $p < 0.001$). Among their Saudi clinical–radiographic sample, AlHobail, et al. (2019) described a mean distal caries prevalence of 48.6% among second molars with third molars, and after performing subgroup analyses they found that distal caries prevalence differed significantly across eruption/ angulation groups, highlighting both eruption status and angulation as statistically significant predictors of second molar distal caries [4].

Mirroring our findings, Alrebdi (2024) conducted a Saudi panoramic-radiograph investigation from patients in Qassim and determined that third molar angulation type was statistically significantly associated with distal surface caries rates of second molars, noting that distal caries prevalence was unequal across Winter's angulation classification groups [16]. Madfa, et al. (2025) conducted a Saudi study

based on CBCT imaging and concluded that distal caries affecting mandibular second molars was significantly associated with mesioangularand horizontal impactions, providing evidence that supports a plausible mechanism of increased caries risk when third molars form plaque-retentive contact points that hinder cleansability at the distal cervical portion of second molars [12]. The results of our investigation agree with the consistent direction of evidence that mesioangular/horizontal positions pose higher risk for developing distal caries lesions; the reason our sample exhibited a stronger caries association for horizontal and mesioangular impactions could be due to longer/more intimate molar-to-molar contact surfaces that restrict access for oral hygiene efforts and promote early non-cavitated lesions at the distal cervical second molar which can go undetected and restorable if the third molar is partially erupted.

We found that vertical angulation was strongly associated with no distal caries (68.4% had no caries) and low severe caries prevalence (2.0%), while mesio-angular and horizontal impactions were associated with mostly moderate lesions (60.4% and 63.0%, respectively) and relatively high severe lesions (7.4% and 8.4%, respectively); there was a highly significant association between angulation and severity group ($\chi 2 = 184.6$, $p < 0.001$). Alrebdi (2024) similarly observed in a large Saudi retrospective sample that moderate distal caries was much more prevalent than severe distal caries on mandibular second molars adjacent to third molars (moderate 61.9% vs severe 1.7% of teeth in the mandible), suggesting that when distal caries of second molars is present around impacted third molars, lesions will more likely be moderate rather than already be severe at time of detection [16]. Though some Saudi studies did not break down caries severity by angulation subtype, the Saudi CBCT study by Madfa, et al. (2025) concluded that distal caries was significantly associated with both mesioangular and horizontal impactions of the third molar, further validating our finding that less favorable angulations (mesioangular and horizontal) lead to greater risk of both high-frequency distal caries and severe distal caries lesions [12]. Chang, et al. [17] and Falci, et al. [18] each found that the third molar was significantly more likely to have distal caries when its angle of impaction was between 40-80 degrees, and similarly found that distal caries was more common when its angle was over 31 degrees. Distal caries of the second molars is different from other root surface caries because it begins at the cementoenamel junction. Distal cervical caries is another term used to describe this type of root surface caries [19]. The second molar's distal surface can be affected by both proximal surface caries and root surface caries.

While seated among these findings from Saudi Arabia, our results add to the collective understanding that more "high-risk" angulations (predominantly mesioangular/ horizontal) confer higher risk of both caries presence and severity; variations in the distribution of severe lesions across our study and others can be attributed to methodological discrepancies in detection threshold (OPG versus CBCT; visual grading), diagnosis timing (routine screening versus symptomatic case), and frequency of preventive recall for patients with known third molar impactions.

Conclusion

The study showed statistically significant results that state the eruption angle of the mandibular third molar affected the prevalence and severity of distal caries on mandibular second molars. Mesio-angular and horizontal impacted third molars presented a high prevalence and high mean scores of distal caries when compared to vertical impacted teeth which had a lower rate of caries. Therefore, risk assessment of eruption angle should be taken into consideration to identify high-risk third molars at an early stage, which might prevent distal caries development and help preserve the health of mandibular second molars in Saudi population.

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