Does the Winter or Pell and Gregory Classification System Indicate the Apical Position of Impacted Mandibular Third Molars?

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Purpose: The present study investigated the relationship of impacted mandibular third molars to the cortical plates and inferior alveolar canal (IAC) using cone-beam computed tomography (CBCT).

Materials and Methods: The present study included CBCT images of 386 lower third molars in 226 patients, for whom the initial panoramic radiographs had revealed a close relationship between the third molars and IAC. The coronal images were prepared to determine the position of apex about the buccal and lingual cortexes and IAC. The impacted third molars were categorized using the Winter and the Pell and Gregory classifications. The relationship between the third molars and buccal/lingual cortexes and IAC was determined in the different classes of the Winter and the Pell and Gregory systems.

Results: The mesioangular position was more prevalent in the present sample. Most teeth were Class I concerning the ascending ramus and level C in depth. Generally, the impacted mandibular third molars showed a lingual position and were in contact or intersecting into the IAC. A significant association was found between the type of tooth impaction using the Winter and the Pell and Gregory classifications and the position of the third molar teeth concerning the cortical plates and IAC.

Conclusions: The possibility of the buccal position of the tooth and the chance of an intersection of the apex into the IAC was greater in teeth that were mesioangular and were Class III concerning the ascending ramus and level C in depth. These data should be considered during the preoperative assessment of third molars to reduce postoperative complications.

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The removal of impacted mandibular third molars is one of the most routine surgical procedures performed in the oral and maxillofacial field.[1] However, this process can be associated with detrimental effects such as mandibular cortical plate perforation or fracture and paresthesia or dysesthesia resulting from damage to the inferior alveolar nerve (IAN) or lingual nerve.[2-4] During extraction of fully impacted

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mandibular third molars, a tremendous amount of alveolar bone will be removed. The lack of knowledge regarding the thickness of the alveolar bone in different areas of the tooth can lead to an inappropriate extraction protocol and, thus, postoperative complications. The incidence of IAN injury after third molar extraction has varied from 0.4 to 13.4%.[5] However, in most cases, the sensational disturbances will be reversible, and fewer than 1% of patients will experience permanent IAN injury.[3,6-8] Although several factors can influence the incidence of IAN damage, it is believed that a major risk factor is the proximity of the impacted third molar to the inferior alveolar canal (IAC).[4,6,9] The overall risk of lingual nerve injury has been reported to range from 0.5 to 2.6%, reaching up to 6.6%.[10] However, the results from most studies have implied that the loss of sensation will be temporary and will resolve within a few months after extraction.[6] Renton and McGurk[11] reported lingual plate perforation and nerve exposure were the main risk factors for lingual nerve damage during third molar surgery. To prevent iatrogenic damage, a careful examination should be performed during treatment planning and before surgical removal of impacted third molars. The proximity between the impacted third molar tooth and IAC should be evaluated to minimize the risk of traumatizing the IAN during simple or surgical extraction of the tooth.[4] The surgical approach for extraction of mandibular third molars should be selected with great care in complicated cases because it can affect the risk of cortical plate perforation or fracture and lingual nerve damage.

The difficulty of mandibular third molar surgery has been assessed by 4 groups of radiographic, anatomic, demographic, and operative risk factors.[12-14] Of these, the radiographic evidence has remained the reference standard[15] and has traditionally been used as a measure of extraction difficulty.[16-18] Generally, conventional 2-dimensional (2D) images, such as panoramic radiographs, will be used as the standard diagnostic method for preoperative assessment of the impacted third molars concerning the surrounding structures.[19] However, 3-dimensional (3D) modalities such as computed tomography (CT) or cone-beam CT (CBCT) will provide more accurate information with less distortion compared with conventional 2D images.[4,8] To avoid extra radiation exposure, CBCT should be performed for cases with signs of a close relationship between the mandibular third molars and IAC on the panoramic images.[4,20] These signs have been defined as darkening of the roots, narrowing of the roots, diversion of the canal, and interruption in the white line of the canal.[19,21-23]

For preoperative evaluation of mandibular third molars, several classifications have been proposed using the findings from 2D radiographic images. The Winter and the Pell and Gregory classifications are among the most predominant systems used for predicting the difficulty of the surgical procedures.[24,25] The Winter system is based on the inclination of the impacted third molar tooth to the long axis of the second molar. The Pell and Gregory system classifies the third molars into Class I, II, or III according to the relationship between the impacted third molar tooth and the ascending mandibular ramus (the space available distal to the second molar). This classification also considers level A, B, and C for third molars according to the relative depth of the impacted tooth in the bone (concerning the occlusal plane).

Little information is available regarding the position of mandibular third molars relative to the cortical plates and IAC in the different classes of the Winter and the Pell and Gregory classification systems. Knowledge of these factors can minimize the risk of nerve damage and guide the clinicians in selecting the appropriate extraction protocol. Therefore, the present observational cross-sectional study investigated the relationship of impacted mandibular third molars to the buccal/lingual cortical plates and IAC using CBCT scans and determined any association between these variables and the Winter and the Pell and Gregory classification systems for impacted third molars.

Materials and Methods

STUDY DESIGN AND SAMPLE

The sample of the present study consisted of CBCT data for 386 mandibular third molars with developed apices belonging to 226 Iranian patients who had been referred for surgical removal of third molars. All the patients showed signs of a superimposed relationship between the third molars and the mandibular canal on the initial panoramic radiographs, including darkening of the root, deflection of the root, diversion of the canal, and interruption in the white line of the canal. Thus, CBCT images were taken to allow for a better examination of the mandibular canal. The mandibular third molars that were accompanied by cysts or tumors were excluded from the present sample. The ethics committee of Shiraz University of Medical Sciences, Shiraz, Iran, reviewed and approved the study protocol (project no. 5678). The study complied with the tenets of the Declaration of Helsinki for research involving human subjects, and all the participants provided written informed consent.

CBCT IMAGING

The CBCT scans were taken using the New Tom VGi machine (Quantitative Radiology, Verona, Italy) at a

FIGURE 1. *Left,* Reformatted panoramic, *Middle,* axial, and *Right,* coronal cross sections of 3 impacted third molars representing the lingual (A-C), buccal (D-F), and central (G-I) positions of the apices.

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clinically standard resolution. The impacted third molars were scanned at a tube voltage of 110 kV, tube current of 1 to 20 mA, scan time of 18 to 26 seconds, X-ray emission time of 3.6 to 5.6 seconds, voxel size of 0.3 mm, focal spot of 0.3 mm, and a detector of amorphous silicon flat panel measuring 20 cm × 25 cm. The Frankfort horizontal plane of the patient was kept parallel to the ground, and the facial midline was in line with the long axis of the machine during the scanning process.

EVALUATION OF IMAGES

The CBCT data were transmitted for analysis to the NNT Viewer software program (NNT Software Corporation, Yokohama, Japan) associated with the

Table 1. WINTER CLASSIFICATION FOR IMPACTED THIRD MOLAR TEETH

Impaction Class	Definition
Mesioangular	Impacted tooth is tilted toward the second molar in a mesial direction
Distoangular	Long axis of the third molar is angled distally or posteriorly away from the second molar
Horizontal	Long axis of the third molar is horizontal
Vertical	Long axis of the third molar is parallel to the long axis of the second molar
Buccal/lingual obliquity	Combined with the previous factors, the tooth can be buccally (tilted toward the cheek) or lingually (tilted toward the tongue) impacted
Transverse	The tooth is, in effect, horizontally impacted but in a cheek–tongue direction
Inverse	The tooth is reversed and positioned upside down

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imaging device. The number of roots of the impacted third molars and the presence of pathologic conditions in second molar teeth, such as root resorption and impaction, was recorded. The coronal cross-section images were then prepared perpendicular to the dental arc. The position of the apex relative to the buccal and lingual cortexes was evaluated using the coronal images. For classification, the distance between the buccal and lingual cortexes was divided into 3 parts. Next, the impacted third molars were classified into 3 position types as follows: *1)* lingual position (apex of the root located in the lingual one third of the buccolingual distance; Fig 1A-C); *2)* buccal position (apex of the root located in the buccal one third of the buccolingual distance; Fig 1D-F); and *3)* central position (apex of the root located in the central one third of the buccolingual distance; Fig 1G-I). Furthermore, the thickness of the bone around the impacted third molar was assessed at the apex of the root. If the bone between the apex and cortex was less than 1 mm thick, the condition was defined as "thinning." In contrast, a bone thickness of 1 mm or greater was considered to indicate the normal condition. Fenestration or dehiscence of the cortical bone (perforation) was also recorded where a disruption in the white line of the bone cortex was present and root protrusion had occurred into the soft tissue.

On the cross-sectional CBCT images, the relationship between the third molars and IAC was described as follows: *1)* the third molar was separate from the IAC; *2)* the third molar was in contact with the IAC (no bone between the IAC and the third molar); and *3)* the third molar was intersecting with the IAC (impinging on the IAC).

The data were assessed by a trained oral and maxillofacial radiologist using a personal computer monitor in a darkened room. A total of 100 images were randomly selected and reassessed at a 2-week interval to determine the intrareliability estimate. The intrarater agreement was evaluated using the Spearman correlation test.

IMPACTION CLASSES AND THEIR RELATIONSHIP WITH THE CORTICAL PLATES AND IAC

The panoramic view was used to categorize the impacted third molars according to the Winter and

Table 2. PELL AND GREGORY CLASSIFICATION FOR IMPACTED THIRD MOLAR TEETH

Variable	Description
Available space (concerning ascending mandibular ramus)	
Class I	Sufficient space between the anterior border of the ascending ramus and the distal aspect of the second molar for eruption of the third molar
Class II	The space available between the anterior border of the ramus and distal aspect of the second molar is less than the mesiodistal diameter of the crown of the third molar
Class III	The third molar is totally embedded in the bone of the anterior border of the ascending ramus because of the absolute lack of space
Depth (concerning the occlusal plane)	
Level A	Highest portion of the impacted third molar is level with or above the occlusal plane
Level B	Highest portion of the impacted third molar is below the occlusal plane but above the cervical line of the second molar
Level C	Highest portion of the impacted third molar is below the cervical line of the second molar

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the Pell and Gregory classifications[24,25] (Tables 1 and 2). The relationship between the third molars and buccal/lingual cortexes and IAC was determined in the different classes of the Winter and the Pell and Gregory classification systems.

STATISTICAL ANALYSIS

Intraobserver reliability was assessed using the Spearman correlation test. The χ^2 test was applied to determine any relationship between third molars with cortical plates and IAC in the Winter and the Pell and Gregory classifications. Statistical analysis was performed using SPSS software, version 16.0 (IBM Corp, Armonk, NY), and P values < .05 were considered to indicate statistical significance.

Results

In total, 386 impacted third molars from 226 Iranian patients fulfilled the inclusion criteria. Of the 226 patients, 71 were men and 155 were women, with an age range of 18 to 51 years and mean age of 26.7 ± 6.2 years. The Spearman correlation coefficient was 0.97 for the repeated measurements by the same investigator.

On the CBCT images, 320 third molars had 2 roots (82.9%), 64 had 1 root (16.6%), and only 2 had 3 roots (0.5%). Of the 2-root third molars, 33 showed fused roots. Regarding the effect of the third molar on the second molar teeth, the examination revealed that 2 second molars (0.5%) had become impacted owing to the improper position of the third molars and 1 second molar (0.25%) had had root resorption as a result of pressure from the neighboring third molar.

The distribution of the impacted third molars in relation to the buccal and lingual cortexes and the thickness of the alveolar bone around the apex of the third molars are shown in Figure 2. In most subjects, the impacted third molars were in the lingual position without perforation of the cortex. The bone around the lingually positioned teeth was more likely to be thin compared with that of the buccally or centrally placed molars. The occurrence of bone cortex perforation was low, overall, in the sample.

When the relationship of the root apex to the IAC was evaluated in the sample, it was revealed that most third molars were in contact with (39%), or intersecting into (56%), the canal, and the proportion of patients with a separate position of the apex from the IAC was very low (5%).

The different positions of the apex in relation to the cortical plates and IAC in the Winter and the Pell and Gregory classifications are presented in Tables 3 to 5. The frequency of the lingually positioned third molars was high in all groups of the Winter and the Pell and Gregory systems. In most patients, the root apices of the impacted third molars were in contact with, or had impinged on, the IAC.

The χ^2 test revealed a significant association between the type of tooth impaction using the Winter and the Pell and Gregory classifications and the position of third molar apexes concerning the buccal/lingual cortexes and IAC (P < .05; Tables 3 to 5). The possibility of buccally positioned third molars was greater for the mesioangular third molars that were Class III in relation to the ascending ramus and level C in depth. The "intersecting" condition was more frequent in the mesioangular third molars than with other angulations. The frequency of an "intersecting" condition also became greater as the depth of impaction increased (level C) and the space for accommodation of the third molar decreased (Class III).

Discussion

The present study used CBCT scanning, a 3D radiographic method, to determine the relationship of impacted mandibular third molars to the external cortical plates and IAC. The CBCT data were from patients who had shown a close relationship between the third molar and IAC on the initial panoramic radiographs. Some anatomic and pathologic information was also obtained from the CBCT images. We found that 0.5% of the second molars had impaction and 0.25% had root resorption due to the improper position of the impacted third molars. Several studies have reported the occurrence of impaction, root resorption, and caries in second molar teeth next to impacted third molars.[26-28]

Evaluating the relationship of the third molar apex to the buccal/lingual cortex will reveal the risk of cortical plate fracture and the risk of accidental displacement of the tooth or root fragments into the lingual or facial spaces. In the present study, most impacted third molars were in a lingual position (74%). This finding is in agreement with the outcomes reported by Ge et al,[29] who found that the lingual position constituted most deeply impacted mandibular third molars, followed by the central and buccal positions. They attributed this finding to the presence of an external oblique ridge on the buccal plate, which will make the thickness of the alveolar bone greater in the buccal than in the lingual side in most cases.[29]

The present study revealed that the bone around lingually positioned teeth was more likely to be thin or perforated than that of the buccally placed molars. Thus, the most thinning or perforation of the cortex occurred in the teeth with a lingual position. Because the bone on the lingual side of impacted third molars protects the lingual nerve, thinning and perforation of the lingual plate can reduce the distance between the tooth and the nerve, increasing the possibility of

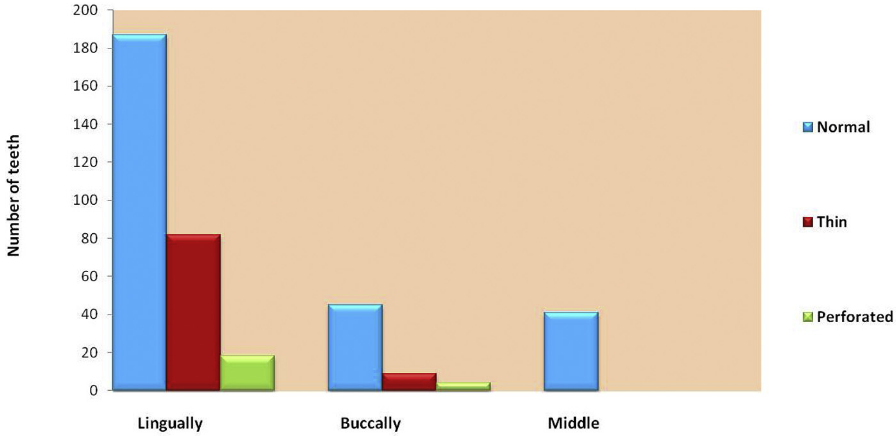

FIGURE 2. Distribution of impacted third molars in relation to the buccal and lingual cortexes and the thickness of the alveolar bone around the apices of the third molar teeth.

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lingual nerve damage during the surgical process.[10,11] Previous studies have proposed that the lingual position of an impacted mandibular third molar, impaction depth, and lingual plate morphology (eg, a thin lingual cortical plate) are the risk factors for contact and perforation between the root apex and lingual plate,[30,31] which can lead to root fragment displacement and lingual nerve damage.

The relation of the tooth apex to the mandibular canal will indicate the risk of damage to the IAN, which is a serious complication of third molar removal. In the present study, most third molars were in contact with (39%), or had impinged on (56%), the mandibular canal. Also, the proportion of patients who showed a separate position of the apex from the canal was very low (5%). This finding might be related to the inclusion criteria of the present study, because only those subjects who showed signs of a close relationship between the root apex and IAC on the initial panoramic radiographs were selected. Careful attention should be given to the location of the IAN when designing the surgical process, because it has been demonstrated that the risk of IAN injury and paresthesia is increased in cases with contact or an intersecting relationship between the mandibular third molar and IAC.[9] In such cases, movement of the third molar roots during extraction can lead to compression and traction on the nerve and, thus, IAN injury.

The present study found a significant association between the type of tooth impaction using the Winter and the Pell and Gregory classification systems and the position of the third molar teeth relative to the cortical plates and IAC. Considering the Winter classification, the outcomes in the present study exhibited

Table 3. FREQUENCY OF DIFFERENT POSITIONS OF THE APEX TO THE MANDIBULAR CORTEX AND INFERIOR ALVEOLAR CANAL IN VARIOUS THIRD MOLAR ANGULATIONS USING THE WINTER CLASSIFICATION

Root Apex Position	Mesioangular	Distoangular	Horizontal	Vertical	Other	*P* Value*
Apex to cortex						.002
Lingual	138 (67.3)	21 (87.5)	39 (81.3)	81 (82.7)	7 (63.6)	
Buccal	46 (22.5)	0 (0)	5 (10.4)	4 (4.1)	2 (18.2)	
Central	21 (10.2)	3 (12.5)	4 (8.3)	13 (13.2)	2 (18.2)	
Total	205 (100)	24 (100)	48 (100)	98 (100)	11 (100)	
Apex to IAC						.003
Separate	5 (2.4)	2 (8.3)	2 (4.2)	7 (7.1)	2 (18.2)	
In contact	65 (31.7)	12 (50)	19 (39.6)	49 (50)	4 (36.4)	
Intersecting	135 (65.9)	10 (41.7)	27 (56.2)	42 (42.9)	5 (45.4)	
Total	205 (100)	24 (100)	48 (100)	98 (100)	11 (100)	

Note: Data presented as n (%).

Abbreviation: IAC, inferior alveolar canal.

* Statistically significant difference ($P < .05$).

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Table 4. FREQUENCY OF DIFFERENT POSITIONS OF THE APEX TO THE MANDIBULAR CORTEX AND INFERIOR ALVEOLAR CANAL AT VARIOUS POSITIONS OF IMPACTED THIRD MOLARS TO ASCENDING MANDIBULAR RAMUS USING THE PELL AND GREGORY CLASSIFICATION

	Class			
Root Apex Position	I	II	III	*P* Value*
Apex to cortex				.021
Lingual	163 (80.3)	107 (67.7)	15 (60)	
Buccal	24 (11.8)	26 (16.5)	8 (32)	
Central	16 (7.9)	25 (15.8)	2 (8)	
Total	203 (100)	158 (100)	25 (100)	
Apex to IAC				.049
Separate	11 (5.4)	7 (4.4)	0 (0)	
In contact	91 (44.8)	52 (32.9)	7 (28.0)	
Intersecting	101 (49.8)	99 (62.7)	18 (72.0)	
Total	203 (100)	158 (100)	25 (100)	

Note: Data presented as n (%).
Abbreviation: IAC, inferior alveolar canal.
* Statistically significant difference ($P < .05$).

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that the possibility of perforation or fracture of the lingual cortex was greater for distoangular, vertical, and horizontal angulations. The frequency of a buccal position of the tooth, in contrast, was highest in mesioangular teeth than other angulations. The occurrence of an "intersecting" position of the apex into the IAC was greater for mesioangular third molars (65.9%), which constitute the major type of impaction according to the Winter classification system.

Using the Pell and Gregory classification, the frequency of a lingual position of the tooth was high in all 3 classes of third molar impaction concerning the ascending ramus (Class I, II, and III). In these cases, the decision to use a lingual split technique would result in a high risk of nerve damage during surgical extraction of the third molar. Thus, the lingual split technique has seldom been used for surgical removal of third molars. The probability of a buccal position of the tooth was greater for Class III cases (all or most of the third molar will be located within the ramus) compared with the other classes. It seems that as the space decreases for accommodation of the third molar, the tooth will be positioned more buccally. The frequency of an intersecting position of the apex into canal increased with the decreasing distance between the second molar and the ascending ramus. Thus, in Class I cases, the most separate condition will be present, but in Class III cases, the most

Table 5. FREQUENCY OF DIFFERENT POSITIONS OF THE APEX TO THE MANDIBULAR CORTEX AND INFERIOR ALVEOLAR CANAL AT VARIOUS DEPTHS OF IMPACTED THIRD MOLARS (CONCERNING THE OCCLUSAL PLANE) USING THE PELL AND GREGORY CLASSIFICATION

Root Apex Position	Level A	Level B	Level C	*P* Value*
Apex to Cortex				<.001
Lingual	84 (87.5)	85 (83.3)	116 (61.7)	
Buccal	3 (3.1)	7 (6.9)	48 (25.5)	
Central	9 (9.4)	10 (9.8)	24 (12.8)	
Total	96 (100)	102 (100)	188 (100)	
Apex to IAC				<.001
Separate	12 (12.5)	3 (2.9)	3 (1.6)	
In contact	58 (60.4)	43 (42.2)	49 (26.1)	
Intersecting	26 (27.1)	56 (54.9)	136 (72.3)	
Total	96 (100)	102 (100)	188 (100)	

Data presented as n (%).
Abbreviation: IAC, inferior alveolar canal.
* Statistically significant difference ($P < .05$).

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intersecting condition of the apex into the canal will be observed.

The other portion of the Pell and Gregory classification is used to determine the relative depth of the third molar in the bone. Accordingly, the outcomes of the present study revealed that the frequency of a buccal position of the tooth was greater for teeth located at level C (the highest portion of the tooth will be below the cervical line of the second molar). Thus, the deeper the tooth, the more buccal the position. Regarding the position of the apex to the canal, the frequency of an intersecting condition was greater for teeth that were level C in depth. In contrast, the possibility of a separate relationship of the root apex from the IAC was greater for level A. Therefore, as the depth of third molar impaction increases, the possibility of IAN injury will be greater.

Overall, the outcomes of the present study have indicated that most third molars in the study sample were in a lingual position. However, the possibility of a buccal position of the impacted tooth was greater for teeth that were mesioangular, Class III concerning the ascending ramus, and level C in depth. Furthermore, the possibility of an intersecting relationship between the mandibular third molar and IAC, which increases the risk of IAN injury, was greater for the mesioangular teeth that were Class III in relationship to the ascending ramus and level C in depth. These data should be considered in the preoperative assessments of impacted third molars to reduce the risk of postoperative complications. Further research is warranted to validate the outcomes of the present study in a larger population.

In conclusion, in the present study, we found the followings:

1. The lingual position ranked first among impacted mandibular third molars, and the bone around lingually positioned teeth was more likely to be thin or perforated than was that of the buccally placed molars.
2. Most third molars were in contact with (39%), or intersecting into (56%), the mandibular canal, and the proportion of patients with a separate position of the apex from the canal was very low.
3. The mesioangular position was more frequent in our sample, followed by vertical and horizontal impaction. Also, using the Pell and Gregory classification, most teeth were Class I in relation to the ascending ramus and level C in depth.
4. We found a significant association between the type of tooth impaction using the Winter and the Pell and Gregory classification systems and the position of the third molar teeth in relation to the cortical plates and IAC.
5. The possibility of a buccal position of third molars and the risk of an intersecting relationship between the mandibular third molars and IAC was greater for the teeth that were mesioangular, class III concerning the ascending ramus, and level C in depth. These factors should be considered during the preoperative assessment of third molars to reduce the incidence of postoperative complications.

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