Classification of Impacted Mandibular Third Molar Utilizing Cone Beam Computed Tomography in Saudi Arabia 2024

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Abstract:
Background:A radiographic examination of mandibular third molars is meant to support the surgeon in establishing a treatment plan. Risks of lower third molar surgery like the inferior alveolar nerve injury may result in permanent consequences. Risk assessment is important prior to the surgery and forms part of the informed consent process. Traditionally, plain radiographs have been used routinely for this purpose. Cone beam computed tomography (CBCT) has offered more information from the 3D images in the lower third molar surgery assessment. The proximity of the tooth root to the inferior alveolar canal, which harbors the inferior alveolar nerve, can be clearly identified on CBCT. This study aimed: To assess the relationship between an impacted third molar and mandibular canal on cone beam CT (CBCT) images.**Methods:** In order to create a categorization that could explain every potential association between the third molar and IAN on the cross-sectional images, three members of the surgical team independently examined the CBCT images of 80 individuals (133 mandibular third molars). The study population was then split up based on this classification. The statistical analysis was conducted using SPSS software, version 28.0.**Results:** Six classes (classes 1-6) were further separated into two subtypes (subtypes A-B), out of the eight proposed classes (classes 0-7). The distribution of classes revealed that the mandibular canal's buccal or apical path was more common than its lingual and inter-radicular courses. Apart from a higher likelihood of actual contact without corticalization of the canal when the IAN had a lingual course for the female group, there have been no changes in the anatomical relationships between males and females. Younger individuals had a higher frequency of direct contact without corticalization and/or with a lower canal diameter.**Conclusion:** In practical practice, this classification could be a useful tool for establishing a standard language across operators to describe the potential connections between the mandibular canal and an impacted third molar on CBCT pictures.
Keywords: Cone-beam computed tomography, impacted mandibular third molar; Angulation; Pell and Gregory classification; Inferior alveolar canal.

Introduction:

The most prevalent oral surgical treatment has been found to be third molar surgery[(1)]. Impaction of the lower third molar is frequent and frequently results in benign cysts or tumors, as well as oral conditions such pericoronitis, dental caries, and localized periodontal disease [(2)]. The only treatment for these disorders is surgical extraction of the causing third molar; if the pathologies are anticipated to worsen over time, preventative extraction is warranted [(3)][3]. There are a number of possible dangers unique to lower third molar surgery in addition to the standard surgical concerns, such as post-operative pain and swelling. One possible long-term consequence of lower third molar surgery is neurosensory loss due to trigeminal nerve injury [(4-7)].

A branch of the trigeminal nerve's mandibular branch, the inferior alveolar nerve (IAN), is especially vulnerable due to its close proximity to the lower third molar root or roots[(8)]. According to anatomy, IAN provides an ipsilateral cutaneous sensation of the lower lip by entering the mandibular foramen at the medial aspect of the mandibular ramus, moving through the inferior alveolar canal (IAC) inside the jaw, and leaving at the mental foramen[(9)]. Some IAN may touch the third molar's root or even groove onto it along its path, depending on the depth of the impacted lower third molar and the path of the IAC[(8, 9)].

The instrument's force during the root elevation procedure may unavoidably result in an indirect compression onto the IAN, which could induce nerve crush damage[(8)]. The IAN may potentially be traumatized by the rotating tool used to remove bone or section the root[(9)]. A portion of the neurosensory impairment may be permanent, and symptoms and duration vary depending on the severity of IAN injury. It has also been demonstrated that trigeminal nerve damage after lower third molar surgery may result in decreased quality of life and even depression in those who are impacted, in addition to sensory abnormalities and possible persistent neuropathic pain[9, 10].

Therefore, predicting the likelihood of nerve injury and taking preventative measures into account are crucial for the pre-operative evaluation of third molar surgery. It is also medically and legally required in many nations to provide adequate risk assessment in order to obtain fully informed consent for the surgical procedure[11, 12]. A primary reason for lower third molar surgery is to protect the neighboring second molar, which may be impacted by the third molar impaction due to ongoing food trapping and recurring infections[13].

The risk of current periodontal bone loss must be evaluated, and future periodontal attachment regeneration must be anticipated. Root resorption and the possibility of a microbial portal leading to per-apical infection of the functional second molar can result from an impacted third molar's persistent eruption onto the root surface of the neighboring second molar. Keeping all of these factors in mind, the risk evaluation of lower third molar surgery requires the use of appropriate imaging modalities[13, 14]. Few studies in Saudi Arabia have employed CBCT to characterize the pattern of mandibular impaction or the relationship between the mandibular third molar and the inferior alveolar canal[15-18].

Despite the increasing application on CBCT, any radiological classification was introduced to define the possible relationships between third molar roots and IAN course in the buccal/lingual direction. For this reason, the first aim of this technical report was that of introducing a new radiological classification that could be normally used in clinical practice to assess the relationships between an impacted third molar and the mandibular canal on CBCT images. The classification was then applied to study CBCT images of mandibular impacted third molars on a sample of patients that needed extraction. The second aim of this work was that of studying the distribution of impacted third molars in the newly introduced classification.

Methods

The observational study was carried out in compliance with the 1975 Helsinki Declaration's standards, which were updated in 1983. Every patient provided written, informed consent. The study was conducted in Jeddah, Saudi Arabia, between January and August of 2024. All 213 patients who were consecutive candidates for the surgical extraction of one or both mandibular third molars and who, on orthopantomography (OPG), had a close association with the mandibular canal were included in this study without regard to age or gender. When a real contact between mandibular canal and third molar roots was suspected, in presence of Rood’s signs, the choice of performing CBCT examination was made. Exclusion criteria were pregnancy or impossibility to maintain standing or sitting position.

Finally, 80 patients involved in this study, 33 males and 47 females with a mean age of 34. 31 years and an age range of 16-80 years performed the second level radiological examination (CBCT). An oral and maxillofacial surgeon, with an oral surgeon and a clinical radiologist with experience in the field of oral and maxillofacial radiology, analyzed the CBCT images of the patients for a total of 133 mandibular third molars. The images were acquired by using a CBCT scanner. The technical parameters used were: 110 kV, 0.3-2 mA, range mAs 2.5- 6.7, scan time <12 s, FOVof 12 x 8 cm or 12 x 15 cm. Voxel size was 0.25 mm and slice thickness of axial images was 0.25 mm. The delivered dose was 2.0-2.2 mGy ± 30%. The images were created in DICOM format and evaluated by axial, cross-sectional and sagittal reconstructions with a thickness of 1 mm and a cutting interval of 1 mm. Images were processed with dental software to create panoramic and sagittal oblique (cross-sectional) reformatted images of the maxilla and mandible.

Subsequently, the images were independently studied by the three members of the surgical team. All the clinicians agreed that the classification had to meet the following requirements (7) thus being:***Comprehensive:*** it must cover all possible relationships between IAN and third molar that may be examined.***Easy to use:*** it has to be simple, logical and reasonable.***Acceptable:*** it should use simple and easy recognizable anatomic landmarks.***Reasonable:*** it has to be mainly designed to estimate the risk of IAN injury and optimize surgical technique. ***Scientifically based:*** it has to consider the most recent literature knowledge especially the one regarding radiographic signs that are more significantly associated with a IAN injuries (radiographic risk factors).***Widely used in clinic:*** it should be helpful to determine the prognosis and treatment guidelines.***Repeated sessions*** of discussion have been planned to compare the proposals and to define the final version of the CBCT radiological classification.

The final classification describing the possible IAN/third molar relationships in the buccal/lingual direction were defined as follows:**Class 0:** the mandibular canal is not visible on the images (plexiform canal);**Class 1:** the mandibular canal runs apically or buccally with respect to the tooth but without touching it (the cortical limitations of the canal are not interrupted).Subtype 1A: the distance IAN/tooth is greater than 2 mm; subtype 1B: the distance IAN/tooth is less than 2 mm;**Class 2:** the mandibular canal runs lingual to the tooth without touching it (the cortical limitations of the canal are not interrupted).Subtype 2A: the distance IAN/tooth is longer than 2 mm; subtype 2B: the distance IAN/tooth is less than 2 mm;

Class 3: the mandibular canal runs apical or buccal touching the tooth.Subtype 3A: in the point of contact the mandibular canal shows a preserved diameter; subtype 3B: in the point of contact the mandibular canal shows a smaller calibre and/or an interruption of the corticalization;**Class 4:** the mandibular canal runs lingually touching the tooth.Subtype 4A: in the point of contact the mandibular canal shows a preserved diameter; subtype 4B: in the point of contact the mandibular canal shows a smaller calibre and/or an interruption of the corticalization;

Class 5: the mandibular canal runs between the roots but without touching them.Subtype 5A: the distance IAN/tooth is greater than 2 mm; subtype 5B: the distance IAN/tooth is less than 2 mm;**Class 6:** the mandibular canal runs between the roots touching them.Subtype 6A: in the point of contact the mandibular canal shows a preserved diameter; subtype 6B: in the point of contact the mandibular canal shows a smaller calibre and/or an interruption of the corticalization;**Class 7:** the mandibular canal runs between fused roots.

Finally, the study population was subdivided according to the classification.The SPSS software, version 28.0 was used for the statistical analysis.The Cohen K values were calculated for inter-observer agreement.To assess the difference in the frequency of the classification classes and subtypes between male and female groups the exact Fisher's test was used. The difference in age distribution among classes was tested by univariate ANOVA and post-hoc Bonferroni test was used for the pairwise comparisons. The exact Fisher's test wasused to find differences in the distribution of cases with contact between IAN and roots when the course of the IAN was buccal/apical, lingual or inter-radicular.

Results

In the assessment of classes and subtypes on CBCT images, inter-observer agreement ranged from good to excellent (K value range: 0.67-0.88).

Table (1) displays the distribution of classes and subtypes in the whole study population. The most represented classes were 3B (24%), 4B (21%) and 3A (19.5%). When data were split by gender, the most populated class was 3B for males (42.4%) and 4B for females (46.8%). No differences were observed in the distribution of classesin male and female groups, except for class 4B (Fisher exact test; $p<0.005$). No cases were found for classes0 and 7.

The highest mean age was observed for class 1A (42.9 ± 2.7 years) while the lowest one was found in class 6A (18 years). Statistical analysis showed a significant difference for classes 6B (20.5 ± 0.9 years) and 1B (23.9 ± 0.9 years) in respect with class 1A (post-hoc Bonferroni test, $p<0.001$). (**Table 1**)

Table (1): Frequency of Classes and Subtypes of the CBCT Radiological Classification in the study sample

CBCT Radiological Classification	Frequency(n,%)in thestudypopulation (n= 133)	Frequency(n,%) in males group (n= 55)	Frequency(n,%) in females group (n= 78)	Age (mean±SD)*
0	0 (0%)	0 (0%)	0 (0%)	-
1A	19 (14.3%)	8 (24.2%)	11 (23.4%)	42.9 ± 2.7
1B	21 (15.8%)	11(33.3%)	10 (21.3%)	23.9± 1.5[b]
2A	0 (0%)	0 (0%)	0 (0%)	-
2B	1 (0.75%)	1 (3%)	0 (0%)	31
3A	26 (19.5%)	13 (39.4%)	13 (27.6%)	33.7 ± 2.7
3B	32 (24%)	14 (42.4%)	18 (38.3%)	31.8 ± 2.9
4A	1 (0.75%)	0 (0%)	1 (2.1%)	27
4B	28 (21%)	6 (18.2%)	22 (46.8%)[a]	34.4 ± 2.6
5A	0 (0%)	0 (0%)	0 (0%)	-
5B	0 (0%)	0 (0%)	0 (0%)	-
6A	1 (0.75%)	0 (0%)	1 (2.1%)	18
6B	4 (3%)	2 (6%)	2 (4.2%)	20.5± 0.9[b]
7	**0 (0%)**	**0 (0%)**	**0 (0%)**	**-**

[a]significantdifferenceinrespectwithmalesgroup(Fisherexacttest,$p<0.05$)
[b]significantdifferenceinrespectwith1A(post-hocBonferronitest,$p<0.001$)
*univariateANOVA,$p<0.001$

Table (2)displays that on a total of 133 third molars, 92 had a direct contact with IAN while 41 had not. The difference was statistically significant (Fisher exact test; $p< 0.05$). The presence or absence of a direct contact with roots was also matched with prevalence of buccal/apical, lingual and inter-radicular course of the mandibular canal.

The most frequent anatomical course of the IAN, when not in contact with the third molar, was buccal or apical. Only one case showed a lingual course and no cases were found for the inter-radicular one. When a direct contact between IAN and the tooth was observed, the course was mainly buccal or apical but a significant higher amount of cases showed a lingual course, compared to the "no contact" group (Fisher exact test; $p< 0.001$). (**Table 2**)

Table (2): Course of the mandibular canal in respect with the impacted third molar

Position	Nocontact IAN/third molar	Contact IAN/third molar	Total
Buccalorapical	40	58	98
Lingual	1	29[a]	30
Inter-radicular	0	5	5
Total	**41**	**92[b]**	**133**

[a] significant difference in respect with "No contact" group (Fisherexact test ,$p<0.001$).
[b] significant difference in respect with "No contact" group (Fisherexact test ,$p<0.005$).

Discussion

Many studies have examined the risk factors and outcomes associated with surgery for impacted third molars [(19–21)]. The IAN lesion is the one most commonly associated with patient pain and legal challenges, despite the very modest risk of post-operative complications. Before extraction, radiographic evaluation is frequently carried out in clinical practice to detect and anticipate the risk of nerve damage. In actuality, the first radiographic classificationintroduced by Winter in 1926and the secondintroduced by Pell and Gregory in 1933are the two most commonly employed to identify the grade of inclusion of upper and lower third molars on OPG[(19-21)].

The wisdom tooth can be mesio-inclined, vertical or typically inclined, disto-inclined, horizontal, or inverted, according to Winter, (1926)classification of the third molar based on its inclination with regard to the main axis of a regularly inclined second molar. According on the inferior third molar's location in relation to the mandibular bone and the second molar occlusal plane, the Pell and Gregory classification takes into account classes I, II, and III as well as A, B, and C. In terms of the second molar occlusal plane, upper molars are categorized as either class A, B, or C [(22)].

The relationship between the tooth and the mandibular canal, as well as the possibility of neurological involvement, is not covered by these classifications, despite the fact that they can forecast the surgical complexity. The anatomical information acquired with OPG is adequate to plan the surgical procedure if no indications of a close connection are seen[(23)].

Otherwise, a CT or CBCT examination must be carried out whenever possible to confirm the actual presence and ultimately the type of the relationship on a buccal/lingual section when OPG reveals an anatomic intimacy between the third molar and the mandibular canal or when specific radiographic signs (darkening, narrowing or deflection of the root, dark and bifid apex of the root, interruption of the cortical outline of the mandibular canal, diversion or narrowing of the canal, island-shaped apex) are detected on the radiograph[(23-26)]. Although CT and CBCT can produce pictures in any orientation and direction, the coronal sections are thought to be the most helpful because they provide additional information that would not be noticeable on OPG, such as the number of roots and their morphology[(27-29)].

A new radiological categorization that applies to cross-sectional pictures was established in order to determine the many kinds of potential interactions between the third molar and the mandibular canal. This classification is justified by the need to investigate a limited number of categories that can adequately characterize all the anatomic deviations that a clinician may come across prior to surgery. The classification must, if at all possible, indicate to the oral surgeon the best surgical approach and give a progressive rate of IAN injury risk.

Finally, the anatomic landmarks have to be simply recognizable on the CT or CBCT images so that the classification types and subtypes can be easily identified. Three main argumentations of the recent literature were considered during the conceptualization of the classification. The first one regards the importance of the IAN as regards the tooth and to the vestibular/lingual plates on a buccal/lingual direction (vestibular, lingual, apical or inter-radicular localization). CT or CBCT cross-sectional reconstructions provide this fundamental information for a precise planning of the extraction. The best orientations and force entities to use during luxation, tooth sectioning, or ostectomy can, in fact, be suggested by knowledge of the canal path. With a significant risk for the lingual-sided canals, the spatial relationship between the third molar and mandibular canal has been identified as a potential predictor of IAN injury[(30)].

On a sample of 53 third molars extracted, Ghaeminia et al., (2009) [(31)]revealed that the IAN was more frequently exposed when the mandibular canal was situated at the lingual side or inter-radicular to the third molar roots than buccally ($p < 0.02$). Furthermore, they observed that in all patients with sensory impairments, the mandibular canal was positioned lingual to the third molar roots as seen on CBCT images ($p < 0.02$). This could be because the surgeon starts his surgical approach on the vestibular side, generating unfavorablelingual directed forces [(31)].

This background justified the choice of subdividing classes basing on IAN course (buccal/apical or lingual). The second point was the importance of the distance between IAN and third molar. Up to now, few studies have quantified the minimal distance between mandibular canal and the impacted third molar which significantly increases the risk of neurological damage. Jhamb et al., (2009) [(27)] divided the measured distance in 4 categories, > 1 mm, 0 to 1 mm, 0 mm and 0 mm with cortical break. They found cases of IAN paresthesia only for the 0 mm category with cortical break. However, a certain rate of risk can be observed also when the distance is higher.

In fact, physical, toxic, ischemic, inflammatory processes, act as principal factor or cofactor in developing of peripheral neuropathy [32, 33]. In particular, the laceration of vasa vasorum or compression of nerve fibres due to the force applied during extraction or to the postsurgical edema, can elicit a neuropraxia. Sammartino et al., (2013) [32] proposed a safety distance from IAN of 1.5 mm during implant placement to avoid indirect lesions of the nerve bundle. This is the reason why a cut-off of 2 mm was chosen in our classification as an acceptable distance to differentiate cases with higher risk of indirect lesion (distance > 2 mm) from those with a lesser one (distance< 2 mm).

Conclusion:

The aim of this study was to recommend a new classification for impacted mandibular third molars on CBCT images. This is classification that identifies all the possible relationships between third molar and IAN.However, the aim of the classification was not merely to detect if a real relationship between the mandibular canal and the roots of the third molar exists, but to intercept the individual anatomical relations for an optimized surgery. Classification has been applied to study an initial sample of 133 impacted third molars. The present study highlighted that no differences exist in terms of anatomic relationships between males and females apart from a major risk ofreal contact without corticalization of the canal when the IAN has a lingual course for female group. Younger patients showed an increased rate of direct contact with a reduced caliber of the canal and/or without corticalization. If taken as preliminary findings of an uncontrolled, exploratory study, we might conclude that the patients at high risk of developing a IAN damage are young woman belonging to the third decade with a lingual course of the mandibular canal.

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