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Evaluation of Impacted Mandibular Third Molars with CBCT: A Cross-Sectional Study

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Aim: The purpose of this study to evaluate and categorize the complexity of extracting impacted mandibular third molars (IMTMs) using cone beam computed tomography (CBCT).

Materials and methods: CBCT used to analyze 315 lower third molars from 182 patients who met the inclusion criteria. CBCT scans were acquired with a CS 9300 Premium 3D machine. Patient demographics and IMTM details were recorded by two observers using CS 3D Imaging Software for image analysis. Descriptive statistics were applied to assess criteria for impaction and extraction difficulty. Differences in surgical risk indicators for IMTM extraction were statistically examined between age groups, gender, and ethnicities using Fisher's exact test.

Results: Patients aged 18-75 years showed that mesioangular impaction was most common at 41.90%, followed by horizontal at 30.79%, vertical at 25.72%, distoangular at 0.95%, and inverted at 0.63%. Class IA and IIA classifications were most prevalent at 27.30% and 23.49%, respectively, with Class IIIA being the least common at 1.58%. significantly higher surgical difficulty indicators seen in patients under 40 compared to older patients for right and left IMTMs ($p = 0.026$ and 0.011, respectively), but no statistically significant differences in these indicators were observed between genders or ethnicities.

Conclusion: CBCT examination revealed that mesioangular impaction was the most frequent occurrence, followed by horizontal, vertical, distoangular, and inverted impactions. Class IA and IIA prevalent; Class IIIA least common. Surgical difficulty indication more in younger than 40 years old patients, no gender or ethnicity differences.

Keywords: Cone-beam computed tomography, impacted mandibular third molar; Angulation; Pell and Gregory classification; Inferior alveolar canal.

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Introduction

Third molar extraction is a prevalent surgery performed by dental surgeons around the world.[1] Impaction occurs when teeth are unable to erupt or when the eruption path is obstructed. Extraction of impacted mandibular third molars (IMTMs), also known as wisdom teeth, has proven to be difficult. The position of the impacted tooth with respect to the inferior alveolar nerve (IAN) determines the injury risk of extraction. The complexity of IMTM extraction is also influenced by its position, classification, and angulation, among other factors.[1,2]

Inferior alveolar nerve injury (IANI) associated with third molar extraction has been documented to occur permanently in up to 3.6% of patients and temporarily in up to 8%.[3] If proximity of the tooth to the IAN is proven radiographically, 20% of patients will experience temporary IANI after extraction, and 1-4% will experience permanent damage.[3] The relationship between the molar roots and the IAN can frequently be assessed radiographically, primarily with a panoramic radiograph,[4,5] allowing for a far more precise prediction of the possibility of IANI.[5] The use of radiographic indicators other than computed tomography (CT) to suggest probable IAN risk is not justified due to high radiation exposure.[6]

If, according to the Howe and Poyton criteria,[7] radiographic indicators (diversion of inferior alveolar canal (IAC), narrowing of IAC, and interruption of the canal's white line; darkening of the root) arise in orthopantomography that suggest a risk for nerve damage, most studies advise using CT scans because they show a clear connection between the inferior alveolar canal and the lower third molar.[7,8] Cone beam computed tomography (CBCT), a specialized CT dental imaging method, is influenced by the field of view (FOV) and voxel size.[9,10] It offers detailed information across anatomical planes and reveals precise anatomical relationships in cross-sectional images, surpassing traditional 2D imaging by minimizing FOV. It can thus enhance image quality and decrease patient radiation exposure. CBCT has been reported in the literature to be a reliable method of assessing IMTMs before extraction.[11]

With the aid of CBCT, the precise location of the mandibular canal with respect to the mandibular third molar can be determined in all three planes for patients exhibiting high risk indicators of IAN injury. In complex cases, CBCT has been shown to be a useful diagnostic technique for IAN and mandibular third molar tooth evaluation prior to surgery.[11] Nonetheless, only few studies have investigated these indicators by using CBCT,[12-15] in particular to investigate the impacted third molar and its relation to the inferior alveolar canal.[16-18]

In Saudi Arabia, few studies have used CBCT to describe the relation of the mandibular third molar with respect to the inferior alveolar canal[10,19] or the pattern of mandibular impaction.[20,21] To our knowledge, no study has examined radiographic and surgical classification indicators of lower IMTMs for suspected difficulty of extraction, together with their relation to the inferior alveolar canal, roots, and adjacent structures, using CBCT. An exploration of IMTMs in patients in Al Madinah Almunawwarah, Saudi Arabia, will add clinical value to the present literature while also shedding light on features of IMTMs such as shape, size, location, and distribution pattern. Therefore, in the current study, we aimed to use CBCT to evaluate and categorize the complexity of extracting IMTMs.

Material and Methods

Study design and setting

A cross-sectional study was performed by reviewing and examining CBCT images of patients with IMTMs, as determined by archived CBCT scans acquired for these patients at the College of Dentistry, Taibah University, Al-Madinah Almunawwarrah, Kingdom of Saudi Arabia, between January 2017 and December 2021. This study received ethical approval from the Research Ethics Committee of the College of Dentistry at Taibah University (TUSDREC/200223, dated 23/3/2023).

Study population and inclusion and exclusion criteria

Sample size calculation

The required sample size was calculated as 227, based on the following parameters: 95% confidence interval, 5% margin of error, 18% estimated prevalence[22], and a Z-score of 1.96. In this study, a total population size of 315 IMTMs were obtained from 182 CBCT scans.

Inclusion and exclusion criteria

CBCT scans that covered the entire mandible (medium and large FOVs) with at least one IMTM met the inclusion criteria. The following exclusion criteria were applied: patients under 18 or over 75 years old, patients not treated at university clinics in the last 5 years, scans with small FOVs, and scans with radiographic artifacts. Ultimately, 182 CBCT scans of patients met the eligibility criteria of the original 1000 scans.

Technique and data collection

All CBCT scans were obtained from the records stored in the Carestream (CS) R4 Clinical and Practice Management Software database (CS Health, Inc., Rochester, NY, USA) of Taibah University Dental Clinic. The scans were acquired with a CS 9300 Premium 3D CBCT machine (CS, NY, USA) operating at 73 KV and 12 mA. The machine uses a flat panel detector for image acquisition.

All quadrant arch CBCT scans were excluded from this study, whereas mandibular arch or double arch (Maxilla and Mandible) CBCT scans were included which operated at voxel size ranges from 150 µm to 200 µm respectively.

The number of patient files, ethnicity, age, and gender of all included patients were recorded. The accurate documentation of IMTM location, angulation, distribution, proximity to neighboring structures, and classification was recorded in an Excel file. To evaluate impaction and compile suggestive criteria regarding the difficulty of extraction of lower third molar impactions, two observers – a surgeon with 11 years of experience and a radiologist with 13 years of experience – concurrently used the CS 3D Imaging Software to view, manipulate, and analyze the 3D images.

Data analysis

The data entered into the Excel sheet were imported into Stata 18.0 software (Stata/BE 18.0 for Mac, Revision 15 Nov 2023, StataCorp LLC). Descriptive statistics and cross-tabulations were performed to summarize and display the distribution of each risk classification, as well as the distribution of class with the position of the IMTMs. Differences in surgical risk indicators for IMTM extraction were statistically examined between age groups, genders, and ethnicities by using Fisher's exact test. A P-value of < 0.05 (5%) was considered statistically significant.

Study outcome variables

Three classification variables were used in this study: 1) Impaction depth classified according to the Pell and Gregory classification with respect to the occlusal plane,[23] 2) the relationship of the IMTM with the ramus according to the Pell and Gregory classification,[23] and 3) Winter's classification.[24]

For depth classification, the Level A position indicates that the highest point on the occlusal surface of the IMTM is above or at the level of the adjacent second molar's occlusal plane (Figure 1 (b)). The Level B position indicates that the occlusal surface of the IMTM is at the highest point between the cementoenamel junction (CEJ) and the occlusal plane of the neighboring second molar. The highest point on the occlusal surface of the IMTM is below the CEJ of the neighboring second molar when it is in the Level C position (Figure 2 (c)).

The relationship between the distal surface of the IMTM and the anterior border of the ascending ramus is classified as follows by Pell and Gregory: Class I, crown is not covered by anterior border; Class II, the anterior border partially covers the crown; Class III, the anterior border totally covers the crown (Figure 2 (a),(b), and (c)). According to Winter's categorization, the angle between the second and third molars is divided into six categories: (a) vertical impaction: 10° to −10°(Figure 3 (h)), (b) mesioangular impaction: 11° to 79° (Figure 3 (g)), (c) horizontal impaction: 80° to 100°, (d) distoangular impaction: −11° to −79°, (e) buccolingual impaction: when the crown and roots are superimposed, and (f) other: 111° to −80° (Figure 3). Any other cases with suspected difficulty in extraction were identified, such as proximity to neighboring teeth, the presence of hypercementosis,[25] and root relationship to the inferior dental canal, including diversion of the canal, darkening of the root, deflection of the root, narrowing of the IAC (Figure 1(a)) narrowing of the root (Figure 1(c)), and interruption of the canal cortical, bifid root apex, and juxta-apical area.[26]

Results

We examined 315 IMTMs from 182 CBCT patient scans, representing an mpaction prevalence of 18.2%. The age range of the sample was 18 to 75 years, with a mean of 33.55 years and a standard deviation of 9.95 years. Of the 182 patients, 119 (65.38%) were male and 63 (34.62%) were female. 129 (70.88%) were Saudi and 53 (29.12%) were non-Saudi. Furthermore, 133 patients (73.08%) exhibited bilateral IMTMs, whereas 49 (26.92%) displayed unilateral IMTMs.

Mesioangular impaction (Figure 3 (g)) was the most prevalent angulation of impaction in the IMTMs, accounting for 41.90% of cases. This was followed by horizontal impaction at 30.79% (Figure 3 (c), (d), and (e)), vertical impaction at 25.72% (Figure 3 (h)), and distoangular impaction at 0.95% (Figure 3(f)). In addition, inverted impaction was observed in 0.63% of cases (Figure 3 (a) and (b)) (Table 1). The majority of patients presented with Class IA (Figure 1 (b)) and Class IIA at 27.30% and 23.49%, respectively, whereas Class IIIA was the least common classification, observed in only 1.58% of cases (n = 5) (Table 2).

Table 3 provides a detailed overview of additional impaction risks depicted in images, such as those related to the inferior alveolar canal and those related to other surgical complexities, such as hypercementosis of the roots of the IMTMs.

Statistically significant indicators of surgical difficulty were found among patients under age 40 than among older patients in both right and left IMTMs ($p = 0.026$ and 0.011, respectively). On the other hand, no statistically significant differences in indicators of surgical difficulty were

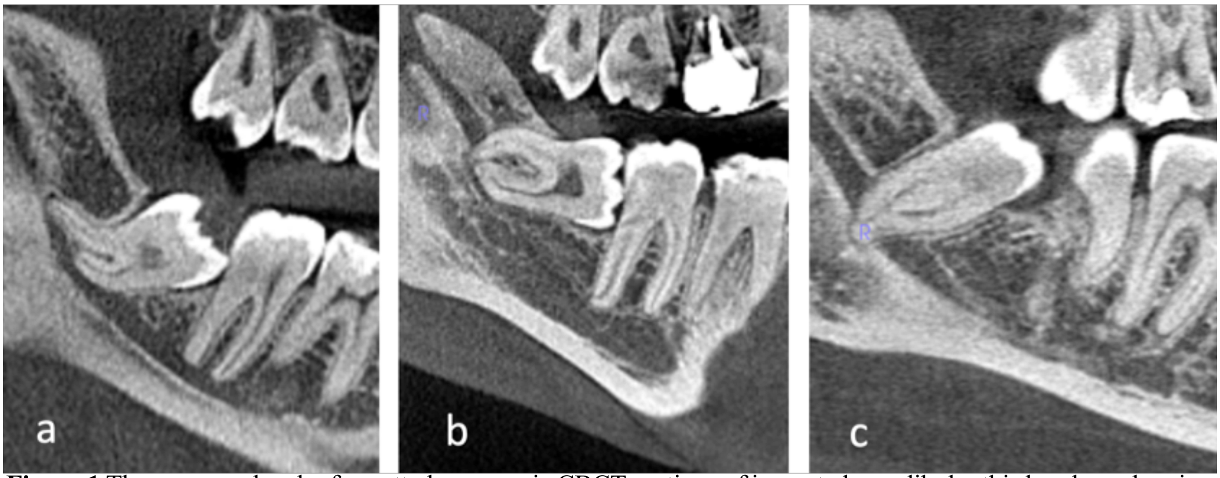

Figure 1 Three cropped and reformatted panoramic CBCT sections of impacted mandibular third molars, showing angulation, class, and position. (a) Mesioangular, Class I, Position B, with deflected roots and narrowing of the inferior alveolar canal. (b) Horizontal, Class I, Position A, showing a divergent inferior alveolar canal. (c) Mesioangular, Class I, Position B, with a darkening inferior alveolar canal and narrowing of the roots.

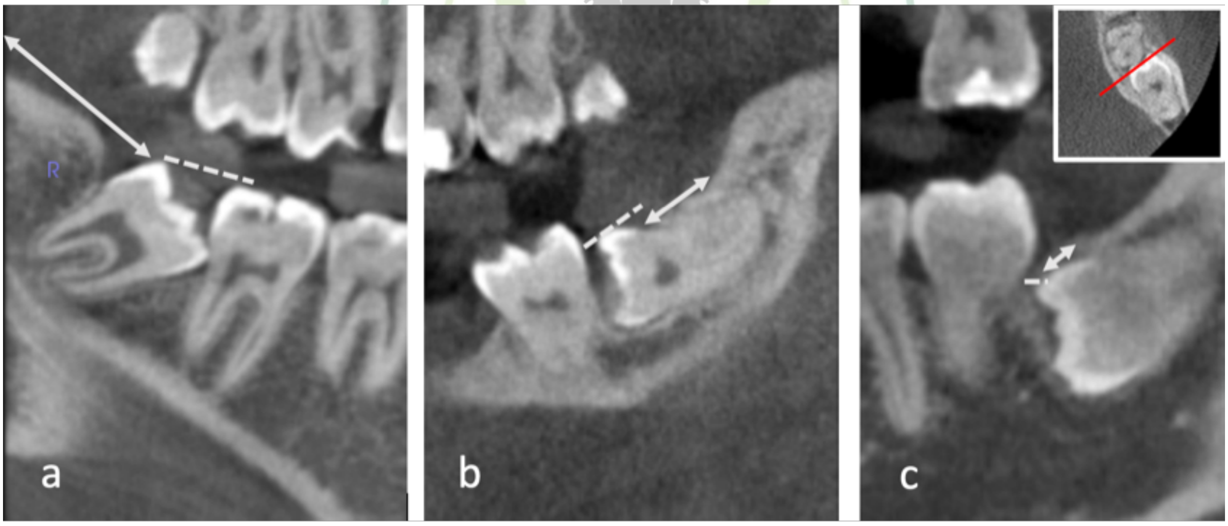

Figure 2 Three cropped and reformatted panoramic CBCT sections of impacted mandibular third molars. The double arrow represents class and the dashed line position. (a) Class I: enough space from the mandibular molar to the ramus; Position A: height of the highest point of the impacted third molar is at the level of the occlusal plane of the second molar. (b) Class II: short space from the mandibular molar to the ramus; Position B: height of the highest point of the impacted third molar is below the level of the occlusal plane of the second molar. (c) Class III: minimum space from the mandibular molar to the ramus; Position C: height of the highest point of the impacted third molar is at the cementoenamel junction of the second molar, the "axial view" shows that the impacted tooth is within the bulge of the ramus.

observed between men and women for both right and left IMTMs ($p = 0.835$ and 0.588, respectively) or between ethnicities ($p = 0.877$ and 0.924, respectively).

Discussion

Through the use of CBCT imaging, we aimed to comprehensively assess the complexity of IMTM extraction procedures. CBCT allows for detailed 3D imaging of the impacted teeth and surrounding structures by

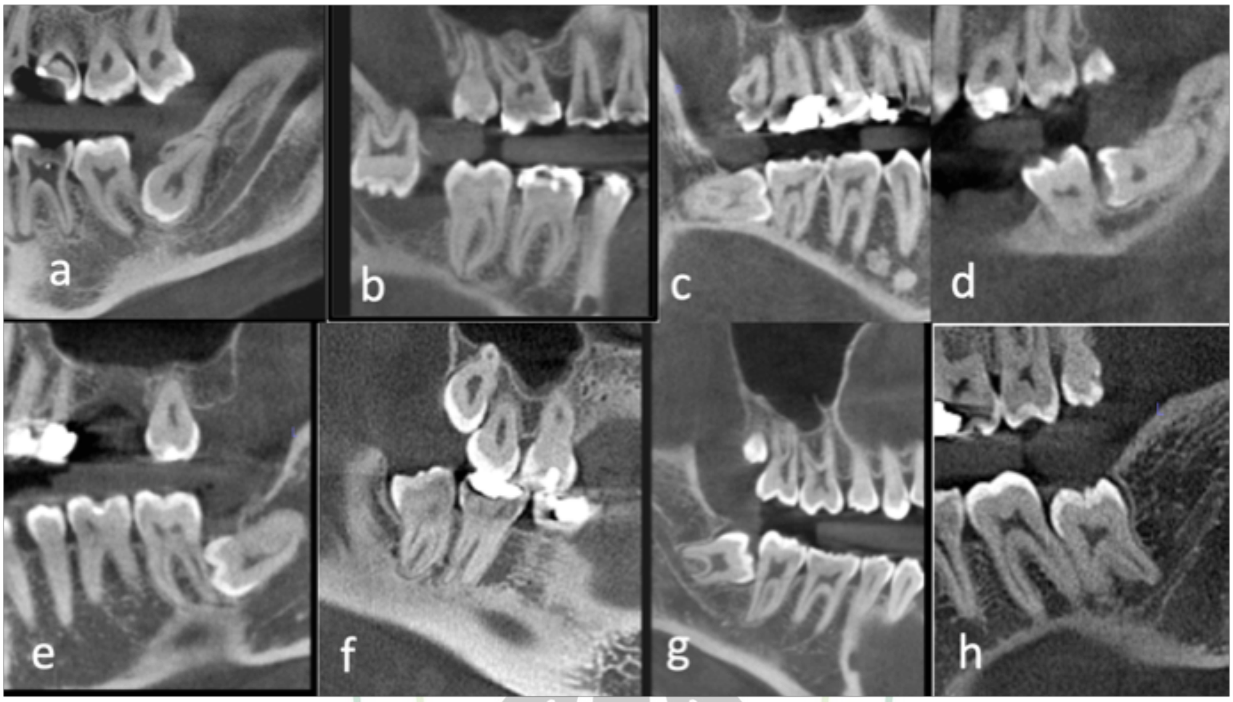

Figure 3 Eight cropped and reformatted panoramic CBCT sections of impacted mandibular molars, showing Winter's angulations and positions. (a) and (b) Inverted angulation. (c) Horizontal angulation with hypercementosis. (d) Position B; horizontal angulation. (e) Position C; horizontal angulation. (f) Position A; distoangular. (g) Position B; mesioangular. (h) Position B; vertical angulation.

accurately assessing the position, orientation, and proximity of the impacted teeth relative to vital structures such as nerves and adjacent teeth. With this valuable information for preoperative planning, surgeons can develop precise treatment plans and minimize the risk of intraoperative complications.

Table 1 Winter's categorization, the angle between the second and third mandibular molars

Angulation	Right molar (%)	Left molar (%)	Total (%)
Mesioangular	70 (44.30)	62 (39.49)	132 (41.90)
Vertical	39 (24.68)	42 (26.75)	81 (25.72)
Horizontal	45 (28.48)	52 (33.12)	97 (30.79)
Distoangular	3 (1.90)	0 (0)	3 (0.95)
Inverted	1 (0.63)	1 (0.64)	2 (0.63)
Total	158 (50.15)	157 (49.84)	315 (100)

Table 2 Distribution (%) of third molar impaction by level and depth of impaction

Side	IA	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC	Total
Left molar	42 (26.75)	20 (12.74)	9 (5.73)	35 (22.29)	22 (14.01)	15 (9.55)	1 (0.64)	7 (4.47)	6 (3.82)	157 (49.84)
Right molar	44 (27.85)	20 (12.66)	7 (4.43)	39 (24.68)	25 (15.82)	10 (6.33)	4 (2.53)	6 (3.80)	3 (1.90)	158 (50.15)
Total	86 (27.30)	40 (12.70)	16 (5.1)	74 (23.49)	47 (14.92)	25 (7.94)	5 (1.58)	13 (4.12)	9 (2.85)	315 (100)

Another objective was to categorize the complexity of IMTM extractions into different levels or types based on specific criteria identified from the CBCT images.[27] This categorization may help oral surgeons better understand the challenges associated with each case and tailor their treatment approach accordingly. In addition, the findings may contribute to the development of standardized guidelines or protocols for managing different levels of complexity, thereby improving the quality of surgical training and patient care.[27] The study results may also have educational value for training programs in oral and maxillofacial surgery. By categorizing the complexity of IMTM extractions, enhancing patient care, and improving surgical outcomes, the findings of this study have the potential to inform clinical practice and guide treatment decisions.

Table 3 Impaction difficulty indicators related to the inferior alveolar canal, roots, and adjacent structures

Inferior alveolar canal risk	Right IMTM	Left IMTM	Total
Away from IAC	56(35.44)	62 (39.49)	118 (37.46)
Diversion of the canal	9 (5.70)	13 (8.28)	22(6.98)
Darkening of the root	24 (15.19)	14 (8.92)	38(12.06)
Deflection of the root	5 (3.16)	5 (3.18)	10 (3.18)
Narrowing of the canal	35 (22.15)	24 (15.29)	59 (18.73)
Interruption of the canal cortical	18 (11.39)	21 (13.38)	39 (12.38)
Bifid root apex	6 (3.80)	2 (1.27)	8(2.54)
Narrowing of the root	1 (0.63)	5 (3.18)	6 (1.91)
Juxta-apical area lateral to the root	4 (2.53)	11 (7.01)	15 (4.76)
Total	158 (50.15)	157(49.84)	315 (100)
Surgical difficulty criteria	Right IMTM	Left IMTM	Total
Not adjacent to neighboring structures (easy)	9 (5.70)	11 (7.01)	20 (6.35)
Periodontal and follicular space present (slight difficulty)	23 (14.56)	26 (16.56)	49 (15.56)
Proximity to adjacent second tooth (moderate difficulty)	121 (76.58)	118(75.16)	239 (75.87)
Hypercementosis of the root (challenging)	5 (3.16)	2 (1.27)	7 (2.22)
Total	158 (50.15)	157(49.84)	315(100)

IAC = inferior alveolar canal; IMTM = impacted mandibular third molar.

In this study, the most common angulation of impaction in the mandible was mesioangular impaction (42%), followed by horizontal impaction (Table 1). These results were similar to those of another study,[28] which reported that mesioangular impaction was most common (50%) in a Malaysian population, but that the second most common angulation was vertical angulation. Another study also reported that mesioangular angulation was the most common impaction (35%) in an Omani population, but reported that distoangular angulation (33%) was the second most common, followed by vertical angulation (30%).[29] These results were similar to those of another study conducted on the Saudi population[30] in which mesioangular angulation was reported as the most common pattern of impaction (65%), followed by vertical angulation. The direction of eruption, lack of room in the mandible at older ages, and late development and maturity appear to make mesioangular impactions the most common type. Nonetheless, some research indicates that vertical impaction is the most prevalent. These differences may be because different angulation categorization techniques were applied in these investigations.[31]

Impaction depth classifications and relation to the ramus of IA and IIA are the most common in this study, and these classifications, next common classification in this study is IIB. The results of the present study were in agreement with those of a 2023 study by Zain-Alabdeen[20] that showed Level A classification to be the most common level of impaction. Hassan,[32] Blondeau and Daniel,[33] and Zain-Alabdeen[20] reported Class II to be the most common classification. Other studies contradict these results, reporting class B to be the most common type.[34,35] The disparity in results among various studies can be attributed to differences in the methods of classification.[31] In the present study, impaction level was evaluated by examining the alignment between the occlusal surfaces of the third molar and the adjacent second molar. In contrast, previous studies determined the impaction level from the position of the CEJ in relation to the alveolar bone level. Studies that identified class A as the predominant type used the same classification criteria.

In this study, the mean age of the patients was 33.55 years, the majority being male patients and the minority female patients. Of note is that the higher percentage of CBCT scans for men with impactions does not necessarily indicate a higher prevalence of impaction in men. There are limitations on the availability of CBCT scans for women because of restrictions on radiation exposure during pregnancy or when anticipating pregnancy. Also worth mentioning is that sexual predilection in third molar impaction has not been widely reported in many IMTM investigations.[36]

Bilateral impactions were more common than unilateral impactions, with both men and women showing a higher prevalence of bilateral impactions, in agreement with the results of the study by Al-Anqudi et al.,[29] who reported a higher prevalence in bilateral impaction. Quek et al.[35] also found that bilateral cases were more common than unilateral cases. Nagaraj et al.,[37] however, concluded that both bilateral and unilateral cases occur with equal frequency. Notably, bilateral cases are more likely to present with difficult angulation, such as horizontal, vertical, and inverted. Iatrogenic displacement or mandibular angle fracture have both been documented in similar situations.[38]

The relationship between the IMTM and the IAN was categorized into high-risk and low-risk cases based on CBCT examination. This classification took into consideration the anatomy and configuration of the inferior dental canal and the roots of the IMTM, aiming to minimize the risk of nerve injury during surgical intervention. In our study, IMTM displayed a distant relationship of impaction to the IAC, while the remaining 62.54% of the impactions exhibited various characteristics such as canal diversion, root darkening, root deflection , canal narrowing , narrowing of the root, and interruption of the canal cortical lamina dura, bifid root apex, and juxta-apical area (Table 3).[26]

After conducting the descriptive statistics, we found that of the 315 IMTMs observed, 76% were classified as moderately difficult (Table 3) due to their proximity to the neighboring second molar, and lowest percentage were classified as difficult due to hypercementosis of the roots (Table 3). According to O'Riordan,[8] hypercementosis of the root is known to elevate the risk of IANI. These findings indicate an increase in the number of complex impactions, highlighting the necessity for a safer extraction approach, such as coronectomy.[25]

The results of our study showed that there were significantly more surgical difficulty indicators in the younger age group than in those 40 years or older. However, one study that examined complications after extraction of impacted third molars in patients younger than 40 years old compared with those in older patients did not find any significant differences between the two age groups.[39] Lastly, in our study, there were no differences in surgical risk indicators for IMTM extraction between genders or ethnicities. Previous studies did not report associations of surgical difficulty in extracting impacted teeth with the age, gender, or ethnicity of the patients, as much as with the position of the IMTM, root configuration, and its relation to the canal.[40]

The frequency of ectopic problematic impacted teeth has increased in recent case reports. The precise identification of the most likely teeth to be affected, the shape and location of the teeth, and the relationship of the ectopically impacted teeth with the adjacent structures are all important factors in the successful removal of these teeth and in understanding treatment options. The dental surgeon should therefore examine the radiographic images and acquire sufficient information to facilitate the extraction procedure.

Clinical implications

The study's findings of significantly higher surgical difficulties indications among patients aged under 40 suggest that age is an important factor to consider when assessing the complexity of extracting impacted mandibular teeth where teeth tend to be tightly adjacent to each other and/or to IAC before any drifting or over erupting of teeth by aging process which may cause surgical difficulties. Understanding the distribution of different impaction types, with mesioangular impaction being the most common, can help dental professionals anticipate the specific challenges associated with each type.The prevalence of Class IA and IIA classifications in impacted mandibular wisdom teeth indicates the need for a standardized classification system to categorize impaction extraction difficulties.

Limitations of the study

Like many previous studies on IMTMs, the present study relied on a sample from a university hospital, which lacks randomization and limits its generalizability. More accurate investigations are required to assess third molar impaction in a randomized sample that is representative of Saudi Arabia. In addition, the current study is constrained by limitations such as difficulty in accessing complete dental records and having both CBCT and orthopantomography available for the patient, as well as the exclusion of incomplete data from some dental records. Further research is needed to examine the patterns of third molars in various regions of Saudi Arabia.

Conclusion

CBCT findings revealed that mesioangular impaction was the most frequently observed impaction type, followed by horizontal, vertical, distoangular, and inverted impactions. Class IA and IIA classifications were predominant, while Class IIIA was the least common. Surgical difficulty indicators were notably higher among patients under 40 years of age compared to older patients, with no significant variations observed based on gender or ethnicity.

Author contributions

Ebtihal Z and Shadia E conceived and designed the study, conducted research, and provided research materials. Safa J, Ahmad S, and Monther A analyzed and interpreted data and wrote the initial and final draft of the article. Muath A, Hadeer A, and Hanan S collected and organized data. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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Data availability statement

Data are accessible from the corresponding author upon request.

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