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Putative measurement for alarming orthopantomogram relationship between mandibular third molar and inferior alveolar canal proved by CBCT: A cross-sectional study

Abstract. Cone-beam computed tomography (CBCT) provides three-dimensional assessment of the relationship between mandibular third molars (MTMs) and the inferior alveolar canal (IAC). It is crucial for reducing post-operative surgical complications. However, it might not be always available. However, orthopantomograms (OPG) remain the first-line investigation and help determine the need for further CBCT evaluation. Objective — to determine possible alarming OPG radiographic features in terms of the relationship between impacted lower third molar and IAC. **Materials and methods.** Total 85 patients with 113 mandibular third molars were evaluated. OPG images were examined according to Rood and Shehab's criteria. Root deflection, root darkening, and interruption of the white line were identified. Then, all cases underwent further examination with CBCT to determine the spatial relationship between MTMs and IAC and measure the distance between them. The results were classified into safe (≥ 2 mm) and high-risk (< 2 mm) groups. **Results.** According to OPG results, root deflection was the most common radiographic sign (53.1%), followed by root darkening (38%) and interruption of the white line (8.8%). The IAC was most frequently positioned buccally (49.5%), followed by inferiorly (31.8%) and lingually (18.5%) in CBCT imaging. A strong connection was noticed between the OPG radiographic signs and CBCT-measured distances. Of the 113 MTMs, 59.3% were categorized as high risk (< 2 mm), comprising 47.8% root deflection. The root darkening was more frequently correlated with the safe distance group (33.6%). **Conclusion.** Despite that OPG findings can predict the nature of the relationship between IAC and MTM, it is not useful in assessing the distance. However, it can be suggested that root deflection in the OPG radiograph might carry more nerve injury risk than other radiographic findings. This is based on the fact that distance of ≤ 2 mm between the MTM and the IAC would increase the risk of nerve injury.

Key words: mandibular third molars, inferior alveolar nerve, orthopantomogram, OPG, cone-beam computed tomography, CBCT

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Оценка риска взаимоотношения нижнего зуба мудрости и нижнечелюстного канала на ортопантограмме с подтверждением методом КЛКТ: одномоментное исследование

Реферат. Конусная лучевая компьютерная томография (КЛКТ) обеспечивает трехмерную оценку связи между третьими молярами нижней челюсти и каналом нижней челюсти. Это имеет решающее значение для снижения послеоперационных хирургических осложнений. Однако она может быть не всегда доступна. Тем не менее ортопантограммы (ОПТГ) остаются первоочередным методом исследования и помогают определить необходимость дальнейшей оценки с помощью КЛКТ. Цель — определить рентгенологические признаки взаимоотношения корней третьих моляров нижней челюсти и канала нижней челюсти по данным ОПТГ. **Материалы и методы.** Было обследовано 85 пациентов с 113 нижними третьими молярами. Полученные ОПТГ были изучены в соответствии с критериями Rood и Shehab. Были выявлены отклонение корня, потемнение корня и прерывание белой линии. Затем все случаи прошли дополнительное обследование с помощью КЛКТ для определения пространственного

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отношения между МТМ и ИАС и измерения расстояния между ними. Результаты были классифицированы на безопасные (≥ 2 мм) и высокорисковые группы (< 2 мм). **Результаты.** На ОПТГ отклонение корня было наиболее распространенным рентгенологическим признаком — 53,1% случаев, за ним следовали потемнение корня (38%) и прерывание белой линии (8,8%). На КЛКТ ИАС чаще всего, в 49,5% случаев, располагался в буккальной области, за ним следовали нижняя (31,8%) и лингвальная (18,5%) области. Была отмечена сильная связь между рентгенологическими признаками на ОПТГ и расстояниями, измеренными с помощью КЛКТ. Из 113 третьих моляров 59,3% были отнесены к группе высокого риска (< 2 мм), включая 47,8% случаев отклонений корня. Потемнение корня чаще коррелировало с группой безопасного расстояния (33,6%). **Заключение.** Хотя результаты ОПТГ могут предсказать характер взаимосвязи между ИАС и МТМ, они не полезны для оценки расстояния. Однако можно предположить, что отклонение корня на ОПТГ может нести больший риск повреждения нерва, чем другие рентгенологические признаки. Это основано на том факте, что расстоянием ≤ 2 мм между МТМ и ИАС увеличивает риск повреждения нерва.

Ключевые слова: нижние третьи моляры, нижнечелюстной нерв, ортопантомограмма, ОПТГ, конусно-лучевая компьютерная томография, КЛКТ

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INTRODUCTION

Extraction of mandibular third molars (MTMs) is a common surgical procedure dentists and maxillofacial surgeons perform in dental clinics [1, 2]. Like any other surgical intervention, it has different kinds of postoperative complications. Generally, these complications are considered minor and infrequent, with varying incidences and severity [3]. The minor complications are pain, edema, and a decrease in the opening of the mouth; however, these symptoms usually disappear within a few days after the surgery [4].

Injury to the inferior alveolar nerve (IAN) is considered the most serious complications that arise after extraction of the mandibular third molar (MTM) with potential long-term consequences [5]. The reported incidence of temporary IAN injury varies from 0.4% to 8.4% [6], with a permanent injury rate of less than 1% [7]. These complications will affect patients physically and psychologically, so it is crucial to assess the risk of IAN damage accurately and explain these unpleasant events to the patients before surgery verbally or by obtaining consent.

The outcomes of surgical extraction of third molars are significantly affected by the anatomical variations of the IAN. Nerve injuries can occur due to altered nerve position or close proximity between the IAN and mandibular third molars (MTMs) resulting in sensory disturbances like, hypoesthesia, paresthesia or even permanent numbness. Several studies used radiographic signs on panoramic radiographs to prevent these complications, which may suggest a close relationship between the mandibular canal and mandibular third molars [8, 9].

Because panoramic radiography has limitations in that it provides information in only two dimensions, its images would not be accurate in assessing the proximity of the inferior alveolar canal (IAC) to the roots of the mandibular third molar teeth [10, 11]. Suppose the panoramic radiograph reveals a close relationship (direct contact) between the root

of the third molar and the IAC. In that case, CBCT is recommended to verify the anatomical relationship in a three-dimensional view [12].

The 3-dimensional views provided by CBCT will help the surgeons have more information about direct contact, whether accurate or not. In addition, it will provide accurate measurements of the distance between the root of the third molar and the canal. Several CT radiographic features such as distance between MTM and IAC cortication status of IAC, IAC position of IAC to MTM, and type of contact are associated with increased risk of IAN damage [13—15]. The present study aims to reveal the role of CBCT in accurately assessing the direct contact seen by OPG, helping the surgeon set a proper treatment plan, and avoiding injury to the IAN.

MATERIALS AND METHODS

Patients attended Alfalah Secondary Center (Baghdad, Iraq) between June 2023 to December 2024 (18 months) were examined. There were 85 patients with 113 lower third molars were included. These patients were referred by dentists from the surrounding dental health centers or came directly with symptoms like pain, swelling, infection, difficulty in mouth opening. Based on patient availability over an 18-month year age group, the sample size of our study was established. The age range for the included sample was 19—32 years with a mean of 24.3 year. The study sample comprised 62 females and 23 males.

All patients underwent through the same orthopantomography (OPG) imaging, which revealed a close relation between the MTM and the IAC. Based on these findings, CBCT was needed for further assessment before referral to the oral surgeon. Based on a previous study with a sample of 308 from the same population, the included sample size achieves 80% level of confidence.

The cone beam computed tomography (CBCT) used in the study is a Kodak 9500 cone beam 3D system. The field

of view was “Large” mode (18 cm height and 20.6 cm diameter). The tube of current is 10 mA with a tube voltage of 90 kV and exposure time of 10.08 seconds with a voxel size of 300.

Two radiologists with at least two years of experience in OPG and CBCT diagnosis evaluate both the OPG and CBCT findings. If there are any disagreements between them, this would be resolved after a discussion till they reach a consensus. After 30 days; half of the panoramic radiographs and CBCT images were collected and re-assessed by both examiners randomly.

Criteria that determine the relationship of MTM to IAC followed Rood and Shehab's established signs [7, 8]. Four of these signs were tooth-related (darkening, root deflection, root narrowing, and a bifid apex). The other three were canal-related signs (diversion, narrowing, and interruption in the canal white line) [9] (fig. 1). On the CBCT images, the position of the mandibular canal IAV in relation to the MTM was evaluated and classified as: buccal, lingual, and inferior position.

The images were evaluated in all three dimensions: sagittal, coronal, and axial plane.

We selected a radiographic relationship of the mandibular third molar to the IAC that we obtained in panoramic radiographs. Our first primary variable was both tooth-related and canal-related criteria. The secondary variable was CBCT-related. All the OPG 7 signs were examined against the actual CBCT findings. The focus of the CBCT examination was to establish the actual distance between MTM and IAC. Two millimeters were set as a demarcation between what is dangerous or safe in terms of distance relationship.

In our study we considered 2 mm or more between the MTM and IAC as a “safe distance”. Existing literature indicated that distance greater than 2 mm minimize the risk of (IAN) injury during extraction [16].

Both descriptive and inferential statistics were used in this study. Pearson correlation was used to determine the relationship between continuous variables, whereas Chi-Square Test was used to assess the relationship between nominal variables. P value < 0.05 was considered for significant relationship.

RESULTS

The patients were referred with panoramic images indicating possible contact between mandibular third molars and inferior alveolar canal. These images were evaluated according to Rood's criteria [17]. The root deflection was the most common among the radiographic signs observed, suggesting a substantial likelihood of a close relationship between MTMs and the IAC, which was observed in almost half (60) of the cases. Darkening of the root was the second most frequent radiographic sign that was found in 43 cases. Meanwhile, the interruption of the white line of the canal was the least frequent, and it was found in 10 cases only. There was no significant relationship (chi-square test) between the patient's gender and OPG signs ($p=0.705$; table 1).

All 85 patients underwent CBCT imaging to investigate the position of the IAC to the MTMs. The CBCT showed three kinds of positional relationship: the first group, where the majority of cases 56 were positioned buccally relative to MTMs. The second common relationship was the canal's

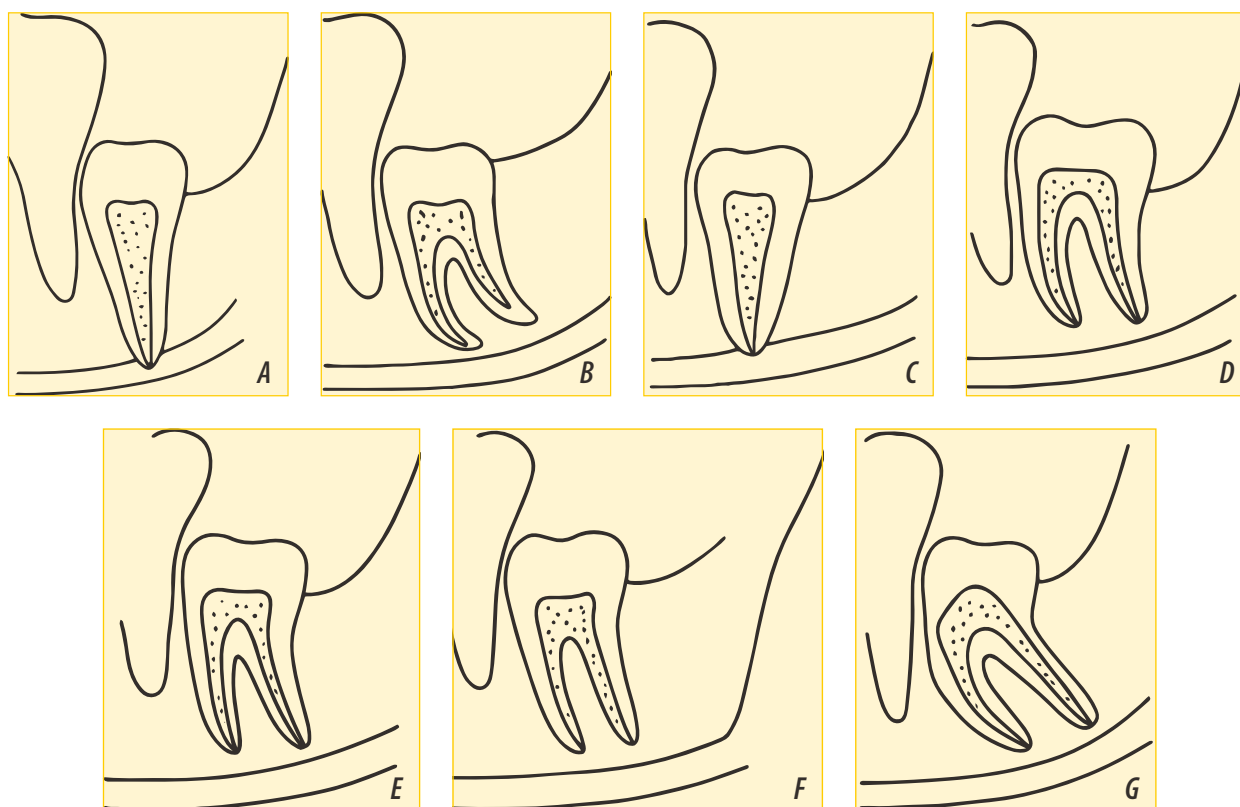


Fig. 1. Rood and Shehab classification of radiographic signs: A — root darkening, B — root deflection, C — root narrowing, D — dark line in apex, E — loss of white line, F — inferior alveolar nerve (IAN) narrowing, G — IAN diversion

inferior position, which was observed in 36 cases. Meanwhile, the least frequently identified was the lingual position in only 21 of the cases. These positional variations are essential for preoperative treatment plans, as they offer a good understanding of the locational relationship and possible surgical risks associated with the surgical extraction of MTMs (table 2).

To understand the relationship of OPG signs to the position of IAC in CBCT, all 85 cases were analyzed and divided into three groups:

The most common sign in the OPG was root deflection (fig. 2), which was reported in more than half of the cases. Twenty-nine cases were found in the CBCT with the buccal position of IAC. The inferior position of the canal in the CBCT was observed in 26 cases. Meanwhile, the lingual position was the least frequent. It was observed in only 5 cases of this group. These findings suggest that root deflection in the OPG is more likely associated with buccal and inferior canal position.

The root darkening is the second most common radiographic sign in the OPG (fig. 3). It was found in less than 40% of the cases. Again, the buccal position of the canal was the most common finding in the CBCT within this group. In this group, however, the lingual position of the canal was more common than the inferior position.

Interruption of the white line of canal (fig. 4) is the third group less common OPG finding in the study sample, with less than 10% of the cases. Contrary to the other OPG groups, in most cases, IAC was found lingual to the root of the tooth, followed by the inferior canal position. Less than 1% of the cases (within this group) were found to have a buccal canal position (table 3). Chi-Square test showed a highly significant relationship ($p < 0.001$) between OPG signs and CBCT findings.

The results regarding the distance between the mandibular third molars and the inferior alveolar canal showed two distinct groups based on the CBCT measurements. The first group, classified as having a “safe distance” (≥ 2 mm), included 46 cases (40.7%; fig. 5). In this group, we found that the distribution of OPG radiographic signs was as follows: 6 cases (5.3%) showed a deflection of the root, 38 cases (33.6%) presented with root darkening, and only 2 cases (1.8%) revealed an interruption of the white line.

The second group, classified as “high risk” (< 2 mm), consists of 67 cases (59.3%), showing a closer relation of the MTM roots to the which would be associated with increased risk of nerve injury during surgical tooth extraction. In this group, we found that deflection of the root was

Table 1. Radiographic signs from panoramic imaging

Sign	Number of cases	
	abs.	%
Root deflection	60	53.1
Root darkening	43	38.1
Interruption of the white line	10	8.8

Table 2. CBCT findings and positions relative to inferior alveolar canal

Position	Number of cases	
	abs.	%
Buccal	56	49.6
Lingua	36	31.9
Inferior	21	18.5

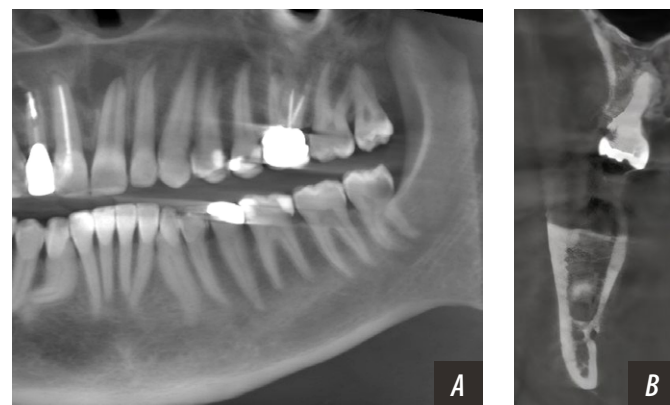


Fig. 2. Root deflection in panoramic radiography (A). Transaxial section in the cone beam computer tomography shows IDC inferior to root apex with direct contact of the mesial root of the MTM (B)

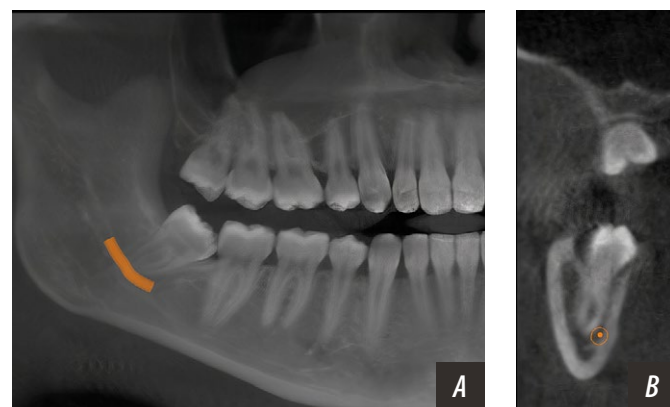


Fig. 3. Root darkening in the panoramic radiography (A). Transaxial section in the cone beam computer tomography shows IDC in lingual position to root apex with direct contact with the distal root of MTM (B)



Fig. 4. Interruption of the white line in panoramic radiography (A). Transaxial section in the CBCT shows IDC inferior to root apex of the mandibular third molar with direct contact (B)

Table 3. Inferior alveolar canal relationship to the mandibular third molars root in the CBCT in contrast to OPG relations

Radiographic sign	Number of cases (n=113)		Buccally position		Lingually position		Inferiorly position	
	abs.	%	abs.	%	abs.	%	abs.	%
Root deflection	60	53.1	29	25.7	5	4.4	26	23.0
Root darkening	43	38.1	26	23.0	10	8.8	7	6.2
Interruption of the white line of the canal	10	8.8	1	0.9	6	5.3	3	2.6

the most frequent radiographic sign, presented in 54 cases (47.8%). Root darkening was seen in 5 cases (4.4%), and interruption of the white line was identified in 8 cases (7.1%).

Most cases with a high risk of nerve damage, indicated by a distance of less than 2 mm between the MTM and the IAC, were associated with deflection of the root as the primary OPG radiographic sign. On the other hand, cases with root darkening were more frequently associated with a safe distance of ≥ 2 mm, which may suggest a less critical spatial relationship. Interestingly, interruption of the white line, though the least common radiographic sign, showed a higher percentage of cases falling into the high-risk group than the safe distance group.

Regarding OPG signs and the distance risk observed in the CBCT, Table 4 shows that root deflection represents the highest risk among other OPG findings. In contrast, root darkening seems the safest OPG finding. This was based on the 2 mm distance between the canal and the MTM root. The χ^2 test did not show a significant relationship between the patient's age and IAC distance to the MTM ($p=0.858$). Overall OPG findings regarding the risk of IDC injury due to distance less than 2 mm showed 59% sensitivity and 56% specificity. On the other hand, root deflection showed 90% sensitivity and 54% specificity.

Table 4. Relation of OPG signs to the distance between mandibular third molars & IAV

OPG radiographic signs	Distance ≤ 2 mm		Distance ≥ 2 mm	
	abs.	%	abs.	%
Interruption of the white line of canal	8	7.1	2	1.8
Root darkening	5	4.4	38	33.6
Deflection of the root	54	47.8	6	5.3

DISCUSSION

Our study shows a higher proportion of symptomatic impacted mandibular third molars in females than males. This is in line with a recent systematic review reporting that females have a slightly higher likelihood of impacted third molars, which may reflect a greater tendency among women to seek dental care and undergo prophylactic extractions [18]. As far as age is concerned, the current study's results consistent with earlier research in that they fall within the commonly known age range where lower third molar issues are more noticeable. Adeola et al. (2023), for example, discovered that 73.1% of patients with impacted mandibular third molars were between the ages of 20 and 29. [19].

The dental panoramic radiograph (OPG) is commonly used as a standard diagnostic tool for the initial evaluation of the mandibular third molar (IAV) and its anatomical relationship with the IAC [20, 21]. The study data showed that only 3 OPG criteria were noticed, most of which were

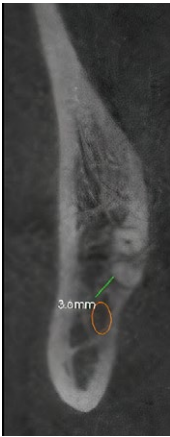


Fig. 5. The transaxial section in CBCT shows IDC in the inferior buccal position to the root apex without contact, a distance of 3.6 mm

root deflection and darkening. The seven panoramic signs established by Rood and Shehab do not always support the possibility of injury to the inferior alveolar nerve as later on reported by Palma-Carrio et. al [22].

We found that root deflection is the most frequently observed radiographic sign, which indicates a close relationship between the MTM roots and the IAC. This observation is consistent with findings by Monaco et al. (2004), who identified root deflection as a significant risk factor for nerve injury during MTM extraction [20]. While root darkening was the second most common sign. Sedaghatfar et al. (2005) reported that root darkening strongly correlates with potential IAC involvement [23]. However, interruption of the white line of the canal was observed in 8.85% of cases, which

is the least frequent sign in our study. This contrasts with higher incidences reported by Nakagawa et al. (57.5%) [10] and Umar et al. (68%) [24], though it closely matches Nakamori et al. (9.4%) [8].

In the current study, the canal's position was predominantly buccal, followed by inferior and lingual. These findings are consistent with those reported by Safaee et al. (2016), who also observed a similar predominance of the buccal course of the inferior alveolar canal in their CBCT study [25].

These findings highlight the critical advantage of CBCT in high-risk cases, where panoramic imaging alone may not accurately show the relationship between MTMs and the IAC. The advantage is that CBCT has a three-dimensional capacity with better visualization of root morphology and IAC positioning; this considerably lowers the possibility of nerve damage during extraction. This finding is supported by Matzen et al. (2013), who highlight CBCT's diagnostic accuracy in cases with high-risk radiographic signs [26].

OPG and CBCT results showed a strong association in our study, especially when root deflection and darkening were present. When OPG images are not clear, CBCT offers spatial clarity. For example, CBCT explained how root deflection relates to the IAC regarding proximity and spatial orientation, but OPG recognized it as a high-risk indicator. These findings align with Tofangchiha et al. (2021) who demonstrated significantly higher diagnostic accuracy by using CBCT to confirm proximity indicators initially identified on OPG [27].

The results of the current study demonstrated a clinical implication that highlights the crucial role of CBCT in preoperative planning for MTM extraction, especially in cases with high-risk panoramic signs. The ability of CBCT to evaluate root position relative to the IAC reduces the risk of postoperative complications like nerve injuries or par-anesthesia. If the cases show low-risk panoramic signs, then OPG could be used as an initial imaging tool. However, CBCT would be a more accurate imaging diagnostic tool for high-risk cases.

The relationship between the mandibular third molar and the inferior alveolar canal is important in determining

the danger of nerve damage after surgical extraction. It is crucial to assess this relationship accurately by using CBCT, which determines the distance between MTMs and the IAC, classifying the risk levels based on proximity. Because a closer distance is associated with a higher chance of nerve involvement, the mandibular third molar's proximity to the canal greatly increases the risk of inferior alveolar nerve injury [28].

Another important factor is the positional relationship between the MTM and IAC. When the position is vertical, which means that MTM is profoundly impacted or inferiorly located, it is more likely to cause nerve damage. Mesio-angular and horizontal impactions have been associated with increased surgical difficulty and a higher probability of contact with the inferior alveolar canal. Cone-beam computed tomography (CBCT) offers a more accurate three-dimensional evaluation of the spatial relationship between the mandibular third molar and the canal compared to conventional panoramic radiography [29].

The relatively small sample size and variability in interpreting panoramic radiograph images might be considered limitations to our study. In addition, the relatively small

sample size and the single-center design may limit the generalizability of the findings to broader populations. Another limitation is the absence of long-term clinical follow-up to assess postoperative outcomes and the risk of nerve injury. More studies are needed to validate these findings further and assess the cost-effectiveness of routine CBCT use. A new advancement in CBCT technology may improve its accurate diagnostic ability, resulting in better surgical outcomes for MTM extractions.

CONCLUSION

Despite that OPG findings can predict the nature of the relationship between IAC and MTM, it is not useful in assessing the distance. However, it can be suggested that root deflection in the OPG radiograph might carry more nerve injury risk than other OPG radiographic findings. This is based on the fact that distance of ≤ 2 mm between the MTM and the IAC would increase the risk of nerve injury.

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