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Comparison of dental volumetric tomography and panoramic radiography in assessing the relationship between impacted mandibular teeth and surrounding structures

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Abstract

Aim: In the field of dentistry, panoramic radiography (PR) and dental volumetric tomography (DVT) play a crucial role in assessing the position of impacted teeth and their relationship with neighboring anatomical structures. The objective of this study was to investigate the association between impacted mandibular teeth and adjacent dental structures, as well as the surrounding anatomical formations, using both PR and DVT imaging techniques.

Methodology: In this retrospective study, we examined DVT and PR images of a total of 150 patients who sought treatment at Dicle University Faculty of Dentistry between 2015 and 2021. The main objective was to assess the prevalence of impacted teeth, specifically in the mandible region, and to analyze their location, as well as their association with neighboring teeth and surrounding anatomical structures, utilizing both PR and DVT imaging modalities. The collected data were analyzed using the licensed IBM SPSS 21 software package.

Results: The study included a total of 150 patients, comprising 70 women and 80 men, in whom 206 impacted teeth were detected in the radiographs. Among these, the most common classifications were impacted lower-third molars (ILTM), with a vertical orientation accounting for 41.04%, class B with a rate of 50.87%, and class II with 68.79% prevalence. The inferior alveolar canal (IAC) was found to be positioned inferiorly in 71.68% of cases, with no bone septum observed between the IAC and ILTM root in 50.87% of cases. In 23.7% of cases, the ILTM root was in contact with the lingual cortical bone, while lingual bone perforation was observed in 8.67% of cases. Significant statistical differences were found between the DVT and PR images concerning the position of the IAC and its relationship with the lingual bone, as well as the examination of distal caries and external root resorption (ERR) in the second molar tooth ($p<0.05$). Additionally, impacted canines were predominantly observed in the buccal position, six out of 14 teeth being in contact with the incisive canal. Positioned lingually, impacted premolars and supernumerary premolars were frequently observed. Second molars were commonly seen to be mesially inclined and not in contact with the IAC.

Conclusion: The alignment and positioning of teeth within the mandible are intricately linked to the nearby anatomical structures. It is crucial to regularly monitor impacted teeth using PR, and, in cases where there is a higher risk, it is recommended to augment the diagnosis with three-dimensional DVTs.

Keywords: Impacted tooth, cone-beam computed tomography, panoramic radiography, inferior alveolar canal, lingual bone, distal caries

Introduction

Regarding tooth impaction, several definitions have been proposed. These include teeth that are unable to erupt despite reaching the age of eruption, teeth that cannot properly position themselves in the dental arch, teeth that are deemed incapable of eruption based on radiological and clinical examinations, as well as teeth with complete or partial retention within the surrounding bone or soft tissues (1). The prevalence of impaction varies among different teeth, with the lower third molars having the highest impaction incidence rates (2, 3). After lower third molars, maxillary third molars, maxillary canines, and mandibular premolars are the teeth most commonly affected (2). The classification of impacted teeth serves various purposes, such as facilitating scientific communication among clinicians, providing information about surgical challenges and potential complications, and ensuring accurate recordkeeping for audit and research purposes. While multiple classification systems have been proposed for impacted teeth, the Pell and Gregory and Winter classifications are the most widely accepted for impacted lower third molars (4).

Impacted teeth, although asymptomatic in some cases, can lead to a range of complications, such as local infection, temporomandibular joint diseases, neuralgiform pain, root resorption in adjacent teeth, and cyst- or tumorlike pathologies (5). Additionally, their proximity to anatomical structures makes them capable of causing more severe issues, including bleeding, paresthesia, infection, edema, and bone fractures (6). Panoramic and periapical radiographs are commonly used for routine dental examinations. Panoramic radiography (PR) is the primary imaging technique used to evaluate impacted teeth and associated lesions. While PR provides valuable information for diagnosis, the monitoring of tooth eruption, and treatment outcomes, it may not always be sufficient (7). Cone-beam computed tomography (CBCT), also referred to as dental volumetric tomography (DVT), has the advantage of generating high-resolution three-dimensional and cross-sectional images. Compared with conventional radiography, CBCT provides more precise and accurate information (8).

The objective of this study was to conduct a comparative analysis of impacted teeth in the mandible using panoramic radiography and dental volumetric tomography, focusing specifically on their relationships with surrounding structures. Furthermore, this research also examines the prevalence of impacted teeth, the impaction status, and the classification of impacted teeth as part of its scope.

Materials and Methods

This study was approved by the local ethics committee of the Dicle University Faculty of Dentistry at a meeting held on October 27, 2021 (protocol number 2021-53.

This retrospective study included a working group of 150 patients who sought treatment at the Department of Oral and Maxillofacial Radiology at the Dicle University Faculty of Dentistry between 2015 and 2021. Both PR and CBCT were performed on these patients for a variety of reasons. Demographic data, including age and sex, were recorded for each patient. The age groups were categorized as 19–29, 30–39, 40–49, 50–59, and 60 years and older. The inclusion criteria for the patients in this study were as follows:

- PR and CBCTs had to be recent.
- The image quality of PR and CBCT had to meet the required standards.
- The apexification of the impacted teeth had to be complete.
- No intraosseous pathologies, such as cysts or tumors, were present in the pertinent regions that might hinder the examination.
- No high-density materials, such as orthodontic materials, intracanal posts, or surgical screws, were present within the evaluation area.

Evaluation of impacted lower third molar teeth

Of the 173 impacted third molar teeth identified, those with enamel-cement junctions located below the bone were categorized as semi-impacted, while teeth positioned completely below the bone level were classified as fully impacted. The impacted teeth in the right and left jaws were analyzed separately. The classification used in this study was based on the Winter (1926) classification system, which consists of mesioangular, horizontal, vertical, distoangular, and other categories. Additionally, the Pell-Gregory (1933) classification system was employed to categorize the impacted teeth as Class I, Class II, or Class III, depending on their relationship with the ramus's anterior border. They were classified into Class A, B, or C based on their relationship with the occlusal plane of the adjacent teeth.

Following the classifications, PR was evaluated based on the presence or absence of radiolucency at the root tip and interruption of the white line of the inferior alveolar canal (IAC), according to the Rood and Shehab criteria. Indicators such as mandibular canal diversion, narrowing, and root dilaceration were not assessed due to their infrequent occurrence in the examined radiographs (Fig. 1).

The vertical relationship between the IAC and inferior dental (ILTM) roots was assessed using CBCT and categorized into one of four distinct classes: buccal, lingual, inferior, and interradicular. The contact status of the inferior alveolar canal with the tooth roots was classified as either present or absent. Similarly, the relationship of the IAC with the lingual cortical bone was analyzed and divided into three classes: absent contact, present contact, and perforated lingual bone (Figs. 1-2). The potential effects of the ILTM on external root resorption (ERR) and the development of distal caries in the adjacent second molar were examined using both CBCT and PR. The presence or absence of these conditions was documented and recorded (Figs. 3-4).

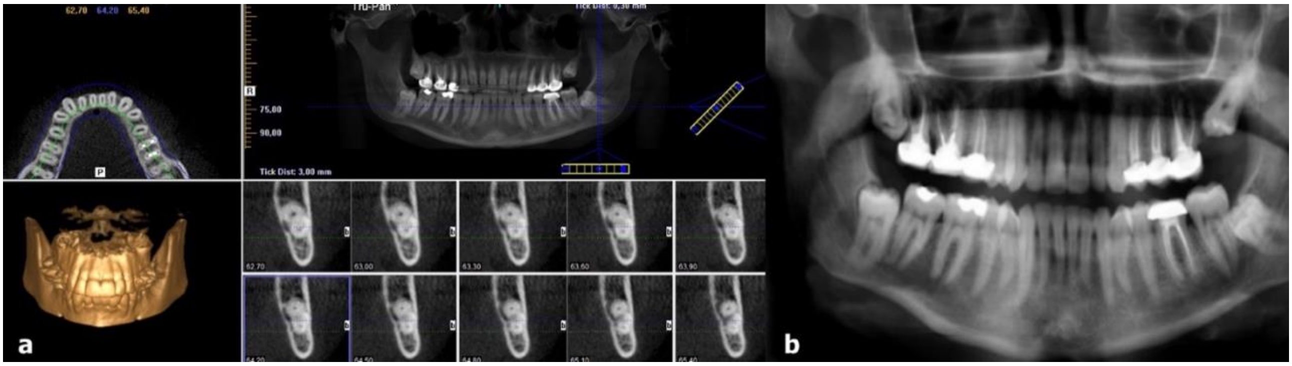

Figure 1. Cone-beam computed tomography (CBCT) and PR images of tooth no. 38. (a) The inferior alveolar canal (IAC) is lingually positioned and in contact with the inferior dental (ILTM root); (b) PR shows no white line interruption and no radiolucency at the root tip.

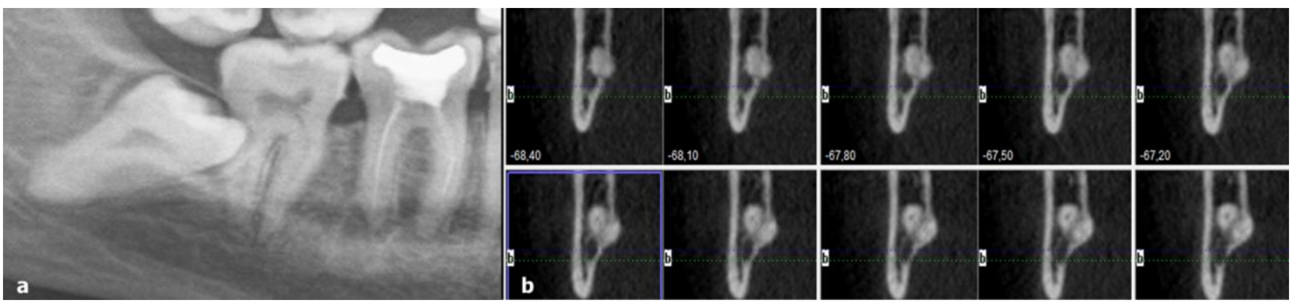

Figure 2. Relationship of ILTM root no. 48 with the lingual cortical bone. (a) PR images of tooth no. 48 (there is an interruption in the white line of the IAC), (b) Cross-sectional images of tooth no. 48 on CBCT (lingual bone perforation).

Evaluation of impacted lower second molar teeth

The second molars were classified as impacted when they were either partially or completely positioned below the line drawn to the occlusal plane on the radiographs. The parameters assessed and documented included: the location of impacted second molars (right or left), whether the impaction was unilateral or bilateral, the extent of impaction (complete or partial), the relationship between the IAC and the second molar roots (classified into four different classes—buccal, lingual, inferior, and interradicular), the contact status of the inferior alveolar canal with the tooth roots (whether present or absent), the presence of adjacent impacted third molars, the presence of resorption in the adjacent tooth, and the relationship of the tooth root with the lingual bone. In addition, the depth and angle classifications used to evaluate the position of the third molars were employed to assess the position of the second molars.

Evaluation of impacted mandibular canines

Radiographic analysis was conducted to assess various parameters associated with impacted mandibular canines. The factors analyzed included the location of the impacted tooth, that is, its right-left orientation and whether it was unilateral or bilateral. Additionally, the position of the impacted tooth was evaluated and classified as mesioangular, vertical, horizontal, or distoangular. The location of the tooth was noted as either labial/buccal, central, or lingual. If transmigration was observed, its type was determined using the Mupparapu classification. The presence or absence of a persistent canine in the relevant area was recorded, along with the presence or absence of dilaceration in the buried canine root. The impact on neighboring teeth, including any resorption caused, was documented. Furthermore, the relationship with neighboring anatomical formations, such as the mental foramen, lingual foramen, and incisive canal, was assessed for their presence or absence. Finally, the relationship with the adjacent buccal and lingual bone was examined, noting whether there was contact, no contact, or bone perforation (Figure 6).

Types of transmigration:

Type 1: The transmigrated canine exhibits a mesial angulation either on the labial or lingual aspect of the lower anterior teeth, with the crown crossing the midline.

Type 2: The transmigrated canine is horizontally aligned with the roots of the lower anterior teeth.

Type 3: The transmigrated canine displays the inclination either mesially or distally at the level of the contralateral canine.

Type 4: The canine is positioned horizontally, aligning with the roots of the contralateral premolars.

Type 5: The transmigrated canine is positioned vertically and located centrally (Fig. 5).

Evaluation of impacted mandibular premolar and supernumerary teeth

The following radiographic variables were assessed when analyzing impacted mandibular premolars and supernumerary teeth:

- Location of the impacted tooth (right-left and unilateral-bilateral)
- Position of the tooth (mesioangular, vertical, horizontal, or distoangular)
- Tooth location (buccal, central, or lingual)
- Whether the tooth is fully or partially impacted
- Whether it causes resorption in neighboring teeth (present or absent)
- Whether it is associated with the mental foramen with neighboring anatomical formations (present or absent)
- Relationship with the neighboring buccal and lingual bone (contact, no contact, or bone perforation; Fig. 7)

Statistical Analysis

Analyses were performed using the SPSS software (IBM SPSS Statistics version 21.0, IBM Inc., Armonk, NY, USA).

Chi-square analysis was used to examine the relationships between groups of nominal variables. In 2×2 contingency tables, Fisher's Exact Test was used when the expected cell counts were insufficient. For RxC tables, Pearson's chi-square analysis was performed using the Monte Carlo simulation method. (Because more than 20% of the expected cell counts were less than 5, the chi-square analysis was conducted using the Monte Carlo simulation method). A significance level of 0.05 was used for the interpretation of results; a p-value <0.05 was considered to indicate a statistically significant association, whereas a p-value >0.05 indicated no statistically significant association.

Statistical analysis was not performed for impacted canine, premolar, supernumerary, and second molar teeth due to the low number of observations, and the distribution of these groups was evaluated as percentages only.

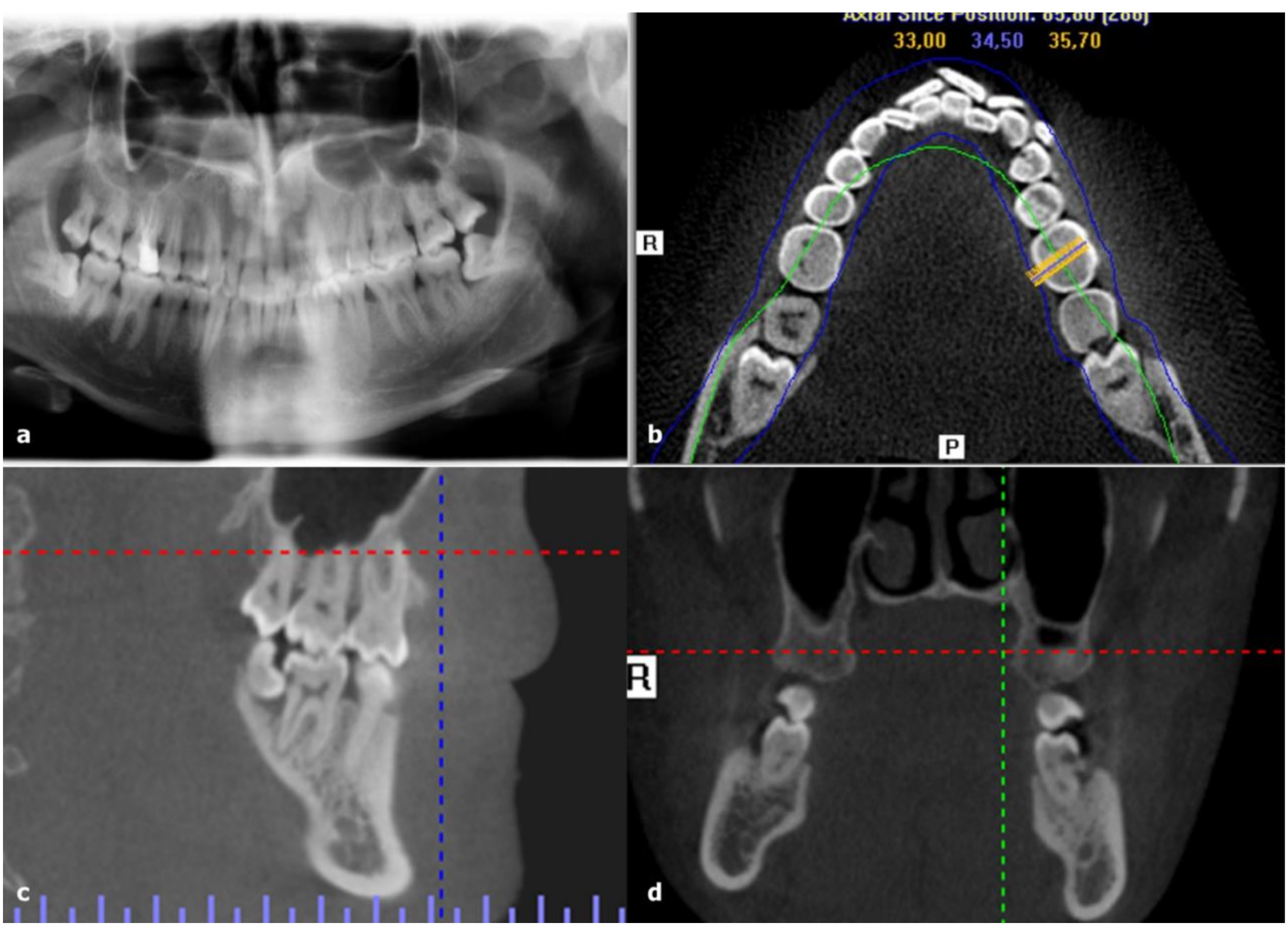

Figure 3. PR and CBCT images of the distal caries in tooth no. 38. (a) PR image of the distal caries in tooth no. 38, (b) axial section, (c) sagittal section, and (d) coronal section.

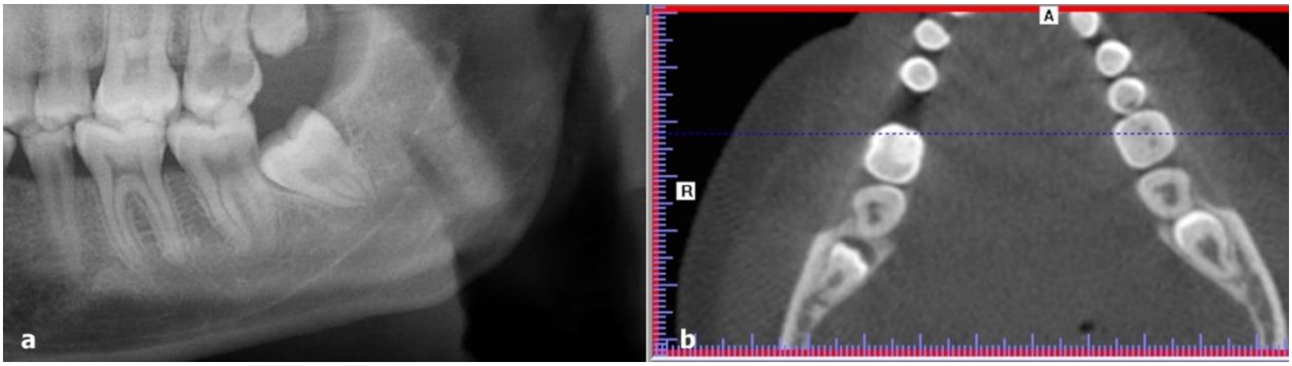

Figure 4. (a) Panoramic view of distal caries on tooth no. 38, (b) CBCT view of tooth no. 38; no distal caries were observed.

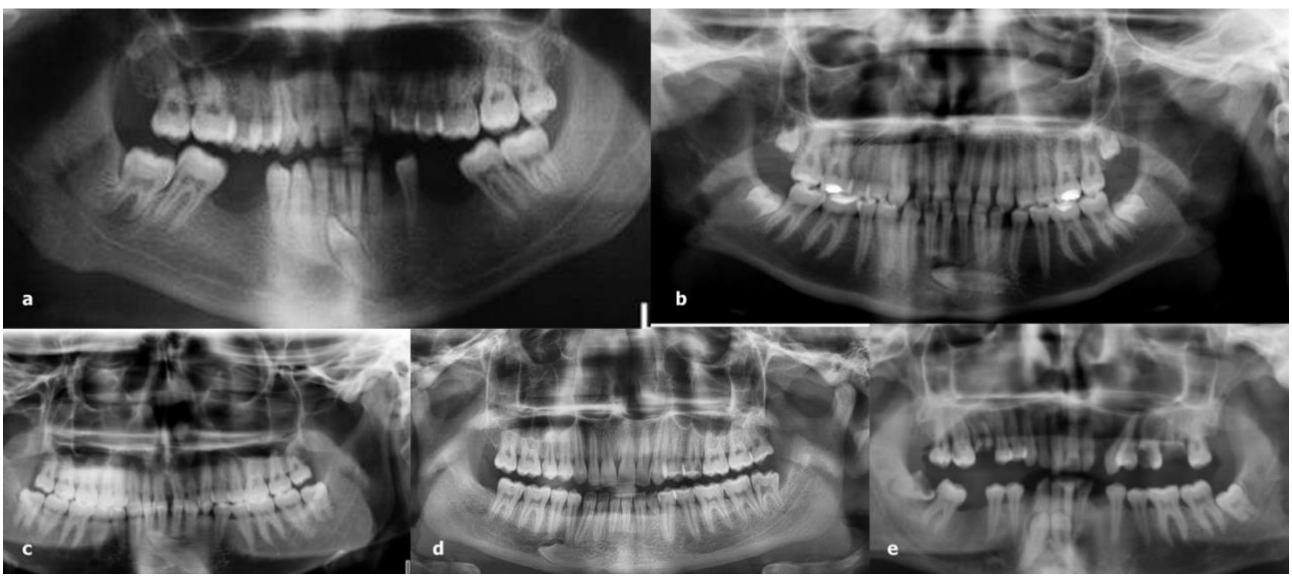

Figure 5. Transmigrant canines. (a) Type 1, (b) Type 2, (c) Type 3, (d) Type 4, (e) Type 5

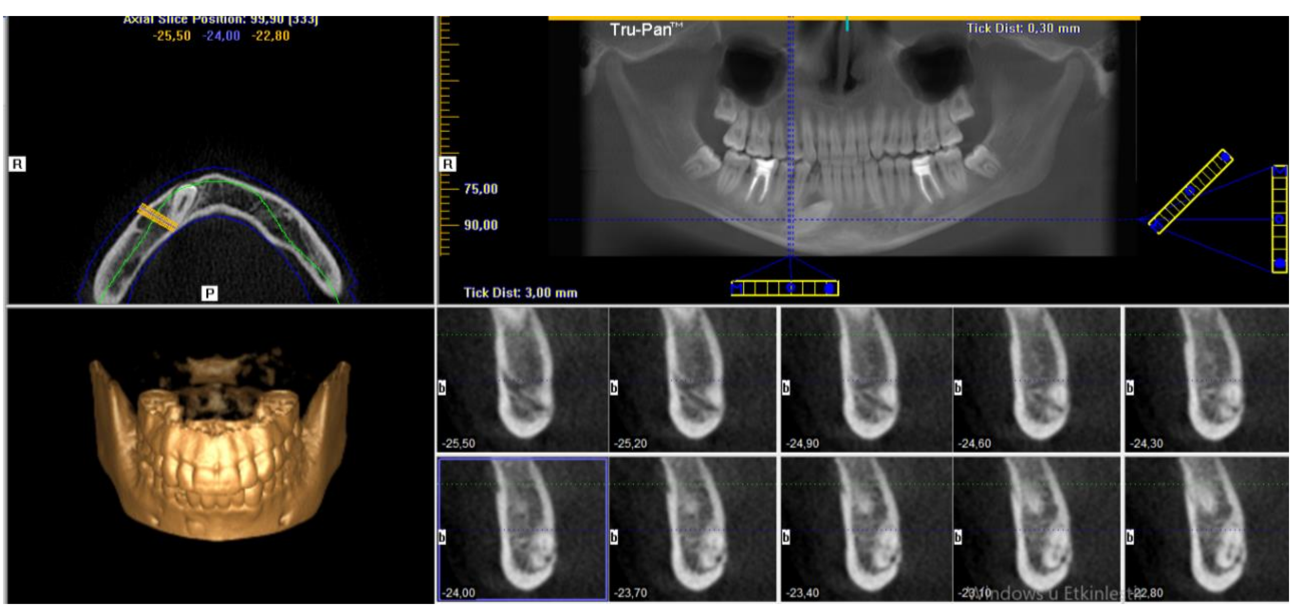

Figure 6. CBCT image of impacted tooth no. 43 (contact with the incisive canal; tooth root in contact with the lingual bone).

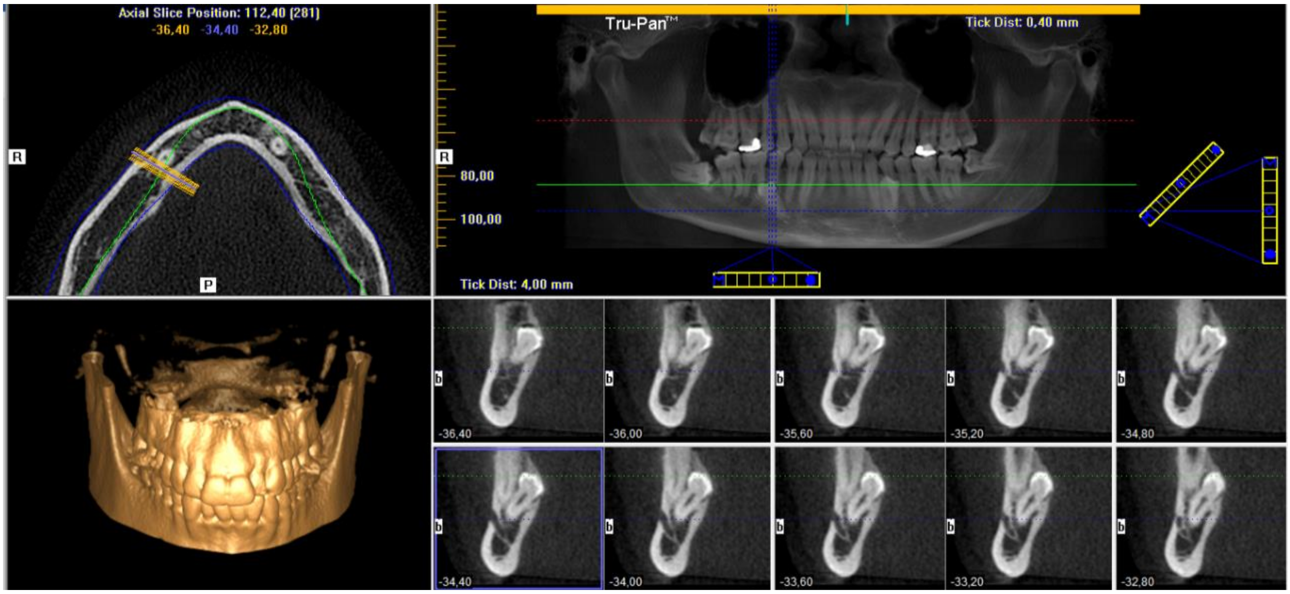

Figure 7. CBCT view of a supernumerary premolar (no contact with the mental foramen).

Results

In the study group, a total of 206 impacted teeth were observed in 150 patients. Among these, 173 (84%) were identified as ILTMs, 14 (6.8%) as mandibular canines, 8 (3.9%) as premolars, 6 (2.9%) as supernumerary premolars, and 5 (2.4%) as mandibular second molars.

Among 120 patients with impacted maxillary canines (ILTMs), 173 teeth were identified. Of the patients, 52.5% were male and 47.5% were female. In terms of the patients' age distribution, 61.67% were between 19 and 29 years old, 20% were between 30 and 39 years old, 10% were between 40 and 49 years old, 5.83% were between 50 and 59 years old, and 2.5% were 60 years or older (Table 1).

Table 1. Distribution of demographic information for patients with ILTMs

Sex	N (%)
Male	63 (52.5%)
Female	57 (47.5%)
Total	120 (100%)
Age group	
Age 19-29	74 (61.67%)
Age 30-39	24 (20%)
Age 40-49	12 (10%)
Age 50-59	7 (5.83%)
60 years and older	3 (2.5%)
Total	120 (100%)

Data are expressed as n%.

In this study, the distribution of teeth in the right and left regions was found to be 50.29% and 49.71%, respectively. Additionally, 64.74% of teeth were partially impacted, and 35.26% were fully impacted. When analyzed according to the Winter classification, the most common ILTM position was vertical (41.04%). The additional positions included horizontal (19.08%), distoangular (4.62%), mesioangular (32.95%), and other positions (2.31%). When the ILTMs were analyzed according to the Pell-Gregory classification based on the anterior border of the ramus, 68.79% were classified as class II, 28.9% as class III, and 2.31% as class I, respectively. When the Pell-Gregory classification was used based on the occlusal plane, 50.87% were classified as class B, 41.62% as class C, and 7.51% as class A, respectively.

In evaluating the vertical relationship between ILTMs and the inferior alveolar canal (IAC) using CBCT, the IAC was observed to be positioned inferiorly in 71.68% of cases. The IAC was located buccally in 12.72% of ILTMs, lingually in 13.29%, and in the interradicular position in 2.31%. In 49.13% of the ILTMs, there was no contact between the tooth root and the IAC, whereas 50.87% exhibited contact. In addition, the relationship between the ILTM root and the lingual bone was assessed using CBCT. In 67.63% of cases, no relationship between the ILTM root and the lingual bone was observed. In 23.7% of cases, there was contact between the root and the lingual bone, and 8.67% of cases exhibited perforation of the lingual bone.

In this study, 64.16% of the teeth did not exhibit radiolucency at the root tip on periapical radiographs (PR), while 35.84% did show this radiolucency. When analyzing the interruption in the white line of the inferior alveolar canal (IAC), it was observed that 60.12% of cases did not show any interruption in the white line. However, 39.88% of the cases exhibited disruption of canal continuity (Table 2).

A statistically significant correlation was found between the presence of ILTMs in contact with the IAC on CBCT and the occurrence of radiolucency at the root tip, as well as an interruption in the white line of the IAC on PR (p<0.05). Of the teeth in contact with the IAC, 56.82% exhibited radiolucency at the root tip, while 67.05% showed a break in the white line of the IAC.

A statistically significant difference (p<0.05) was found in the relationship between the ILTM root and the lingual bone on CBCT, and the occurrence of radiolucency at the root tip on PR as well as an interruption in the white line of the IAC. Radiolucency at the root tip on PR was observed in 58.54% of cases where there was contact between the tooth root and lingual bone and in 66.67% of cases with bone perforation. Additionally, 53.66% of cases with contact and 80% of cases with perforation showed an interruption in the white line of the IAC (Table 3).

Table 2. Frequency distribution table for other parameters for ILTM.

		n	%
Region	Right	87	50.29
	Left	86	49.71
	Total	173	100
According to the Winter classification	Vertical	71	4.04
	Horizontal	33	19.08
	Distoangular	8	4.62
	Mesioangular	57	32.95
	Other	4	2.31
	Total	173	100
Pell-Gregory classification, according to the anterior border of the ramus	Class I	4	2.31
	Class II	119	68.79
	Class III	50	28.9
	Total	173	100
Pell-Gregory classification, according to the occlusal plane	Class A	13	7.51
	Class B	88	50.87
	Class C	72	41.62
Vertical relationship of ILTM with IAC on CBCT	Buccal	22	12.2
	Lingual	23	13.29
	Interradicular	4	2.31
	Inferior	124	71.68
	Total	173	100
Presence of ILTM in contact with IAC on CBCT	Absent	85	49.13
	Present	88	50.87
	Total	173	100
Relationship of the ILTM root to the lingual bone on CBCT	No contact	117	67.63
	Contact	41	23.7
	Bone perforated	15	8.67
	Total	173	100
Impacted status	Half	112	64.74
	Full	61	35.26
	Total	173	100
Radiolucency at the root tip in PR	Absent	111	64.16
	Present	62	35.84
	Total	173	100
Disruption on IAC's white line in PR	Absent	104	60.12
	Present	69	39.88
	Total	173	100
Presence of distal caries and ERR caused by ILTMs in the second molar on CBCT	Absent	158	91.33
	Distal caries present	10	5.78
	ERR presents	5	2.89
	Total	173	100
Distal caries caused by ILTMs on the second molar in PR and the presence of ERR	Absent	127	73.41
	Distal caries present	20	11.56
	ERR presents	26	15.03
	Total	173	100

Table 3. The relationship between the presence of contact of ILTMs with IAC on CBCT and the parameters monitored in PR.

		Presence of ILTMs in contact with IAC on CBCT					Lingual bone relationship of the ILTM root on CBCT								
		Absent		Present		Chi-square test	Absent		Contact		Perforation		Chi-square test	Total	
		n	%	n	%	p	n	%	n	%	n	%	P	n	%
Radiolucency at the root tip in PR	Absent	73	85.88	38	43.18	0.001	89	76.07	17	41.46	5	33.33	0.001	111	64.16
	Present	12	14.12	50	56.82		28	23.93	24	58.54	10	66.67		62	35.84
	Total	85	100	88	100		117	100	41	100	15	100		173	100
Disruption on IAC's white line in PR	Absent	75	88.24	29	32.95	0.001	82	70.09	19	46.34	3	20	0.001	104	60.12
	Present	10	11.76	59	67.05		35	29.91	22	53.66	12	80		69	39.88
	Total	85	100	88	100		117	100	41	100	15	100		173	100

A statistically significant difference (p<0.05) was observed in the assessment of distal caries and ERR when comparing CBCT and PR. In 80.38% of cases where there was no presence of distal caries and ERR on CBCT, these conditions were also not observed on PR. However, more instances of distal caries and ERR were observed when evaluated using PR. Specifically, of the 20 teeth that displayed distal caries on PR, distal caries was detected on CBCT in 10 cases. Furthermore, ERR images were identified in five of the 26 teeth that exhibited ERR on PR evaluation (Table 4).

Table 4. The result of the analysis of the relationship between the presence of distal caries and ERR caused by ILTMs in the second molar tooth on CBCT, and the presence of distal caries and ERR caused by ILTMs in the second molar tooth on PR.

		Presence of distal caries and ERR in PR								Chi-square test
		Absent		Distal caries		ERR		Total		
		n	%	n	%	n	%	n	%	p
Presence of distal caries and ERR on CBCT	Absent	127	80.38	10	6.33	21	13.29	158	100	0.001
	Distal caries	0	0	10	100	0	0	10	100	
	ERR	0	0	0	0	5	100	5	100	
	Total	127	73.41	20	11.56	26	15.03	173	100	

Evaluation of impacted canine teeth

In this retrospective study, a total of 14 impacted mandibular canines were identified in 13 out of the 150 patients who were evaluated. Among these 13 patients, eight were female, and six were male. The distribution of impacted canines on the right and left sides was equal, and only one patient had bilateral impacted canines. Among the 14 impacted canines, four teeth had undergone transmigration, including one type 5, one type 2, and two type 1. A persistent deciduous canine was observed alongside an impacted canine in five teeth. Additionally, double root formation was found in two teeth, and root dilaceration was observed in one tooth. When assessing the positions of the impacted mandibular canines, the crown of seven teeth was positioned buccally with the root in a lingual position, six teeth were centrally positioned, and in one tooth, both the crown and root were oriented buccally.

Based on their angulations, six of the impacted mandibular canines were found to be in a mesioangular position, four in a vertical position, 3 in a horizontal position, and one in a distoangular position. When examining the relationship between the impacted mandibular canines and the surrounding anatomical structures, it was observed that six teeth were in contact with the incisive canal. Additionally, when evaluating the buccal and lingual cortical bones, perforation was observed in the buccal bone in six teeth, contact in the buccal bone in one tooth, and no contact was detected in seven teeth. Resorption in the adjacent teeth was observed in two teeth as determined by CBCT, and in six teeth based on PR (Table 5).

Table 5. Demographic and radiographic data of impacted canines in the mandible.

Patent No	Gender	Age	Region	Crown and root location	Transmigration Type	Angulation	Resorption of adjacent tooth on CBCT	Resorption of the adjacent tooth in PR	Mental foramen - lingual canals and relationship with the incisive canal	Apical dilaceration or root shape	Relationship with mandibular cortical bone on CBCT	Presence of persistent primary canine
1	F	25	Left	Crown buccal to root lingual (oblique)		Mesioangular	Present (in tooth no.32)	Present (in tooth no.32)	Absent	Absent	Buccal bone perforation(crown)	Absent
2	F	17	Right	Crown buccal to root lingual (oblique)	Type 2	Horizontal	Absent	Absent	Absent	Absent	Buccal bone perforation(crown)	Absent
3	F	38	Left	Central		Vertical	Absent	Absent	In contact with incisive duct	Absent	No contact	Absent
4	F	27	Right	Central		Horizontal	Absent	Absent	Absent	Absent	No contact	Absent
5	M	36	Left	Central		Mesioangular	Absent	Absent	Absent	Absent	No contact	Present
6	M	31	Right	Crown buccal to root lingual (oblique)		Vertical	Absent	Present (in tooth no.42	Absent	Absent	Buccal bone perforated (root) contact with lingual bone (root)	Absent
			Left	Crown buccal to root lingual (oblique)	Type 5	Vertical	Absent	Present (in tooth no.31 and 41	In contact with incisive duct	Absent	Buccal bone perforation(crown)	Absent
7	F	29	Right	Central		Mesioangular	Absent	Absent	In contact with incisive duct	Absent	No contact	Present
8	F	22	Right	Central		Horizontal	Absent	Absent	Absent	Double root	No contact	Present
9	F	24	Left	Root center in the crown buccal		Distoangular	Absent	Absent	In contact with incisive duct	Absent	Buccal bone perforation(crown)	Present
10	M	17	Right	Central		Vertical	Absent	Absent	Absent	Dilaceration of root	No contact	Absent
11	M	16	Left	Crown buccal to root lingual (oblique)	Type 1	Mesioangular	Absent	Present (in tooth no.31)	In contact with incisive duct	Absent	Buccal bone perforation(crown)	Absent
12	F	16	Left	Buccal	Type 1	Mesioangular	Present (in tooth no.42)	Present (in tooth no.42)	Absent	Absent	No contact	Absent
13	M	18	Right	Crown buccal to root lingual		Mesioangular	Absent	Present (in tooth no.42)	In contact with incisive duct	Double root	Buccal bone perforation(crown)	Present

In this study, a total of 14 impacted teeth were identified, consisting of six supernumerary and eight premolars. Among these impacted teeth, eight were in the right region and six were in the left region. Of the 13 patients evaluated, eight were female and five were male. Among the examined teeth, three were partially impacted, and 11 were fully impacted. When assessing the position of the teeth, the majority were found to be in a lingual position, with seven teeth in this position. Additionally, one tooth was in a buccal position, four teeth were centrally positioned, and the remaining two were in an oblique position. Based on angulation, six teeth were vertically positioned, five were mesioangular, two were distoangular, and one was horizontal. No bony septum was observed between the roots and mental foramen in three examined teeth. Resorption of adjacent teeth was observed in three teeth, as determined by both CBCT and PR. When evaluating the contact between the mandibular cortical bone and tooth root, no contact was observed in half of the teeth (Table 6).

Table 6. Demographic and radiographic data of impacted premolars and supernumerary teeth in the mandible.

Patient No	Gender	Age	Region	Location	Impacted status	Relationship with the mental foramen (CBCT)	Relationship with mandibular cortical bone	Resorption of adjacent tooth on CBCT	Resorption of adjacent tooth in PR	Angulation
1	Female	31	Left	Central	Half	Absent	No contact	Absent	Absent	Vertical
2	Female	31	Left	Oblique	Full	Absent	Contact with buccal bone (root)	Absent	Absent	Mesioangular
3	Male	21	Right (supernumerary premolar)	Lingual	Full	Absent	Absent	Absent	Absent	Mesioangular
4	Female	20	Right	Oblique	Full	Present	Contact with lingual bone (root)-buccal bone perforated (crown)	Absent	Absent	Horizontal
5	Female	27	Right (supernumerary premolar)	Lingual	Full	Absent	Lingual bone perforated (crown)	Present (in tooth no. 46)	Present (in tooth no. 46)	Vertical
			Left (supernumerary premolar)	Lingual	Full	Present	Lingual bone perforated (crown)	Absent	Absent	Distoangular
6	Male	19	Right (supernumerary premolar)	Lingual	Half	Absent	Lingual perforated (root)	Absent	Absent	Vertical
7	Male	20	Left (supernumerary premolar)	Lingual	Full	Absent	Absent	Present (in tooth no. 35)	Present (in tooth no. 35)	Vertical
8	Female	22	Right	Central	Full	Absent	Absent	Absent	Absent	Vertical
9	Male	19	Left	Lingual	Half	Absent	Lingual perforated (crown)	Absent	Present (in tooth no. 33-34)	Mesioangular
10	Female	24	Left	Central	Full	Absent	Absent	Absent	Absent	Mesioangular
11	Female	16	Right	Buccal	Full	Absent	Absent	Absent	Present (in tooth no. 46)	Distoangular
12	Male	21	Right (supernumerary premolar)	Lingual	Full	Absent	Lingual contact (root)	Absent	Present (in tooth no. 44-45)	Mesioangular
13	Female	40	Right	Central	Full	Present	Absent	Present (in tooth no. 46)	Present (in tooth no. 46)	Vertical

The table below provides clinical and radiographic data concerning impacted mandibular second molars. Of the 206 impacted teeth in the lower jaw, five were mandibular second molars. Three of these five teeth were located on the right side, while the remaining two were located on the left side. The gender distribution among the patients was an equal number of females and males. In terms of impaction, four of the teeth were fully impacted, while one was partially impacted. The examination of the vertical relationship between the tooth root and the inferior alveolar canal (IAC) revealed that the IAC was positioned inferiorly in four teeth and lingually in one tooth. Notably, contact between the IAC and the canal was only observed in the tooth that was positioned lingually. Regarding the relationship between the lingual cortical bone and the second molar, only one tooth caused a perforation in the lingual bone. Two teeth exhibited contact between the tooth root and the lingual bone. No CBCT evidence of resorption was found in the neighboring teeth, although resorption was observed in a single tooth using PR. As shown in Table 7, all the impacted mandibular second molars were found to have adjacent third molars, with two being abnormally positioned.

Table 7. Clinical and radiographic data of impacted second molars in the mandible.

Patient no	Region	Sex	Age	2nd molar tooth impacted status	Position and angulation of the 2nd molar tooth	The inferior alveolar canal position relative to the 2nd molars	Resorption of the 1st molar tooth on CBCT	Resorption of the 1st molar in PR	2nd molar in relation to lingual bone	3rd molar presence
1	Right	Male	18	Full	Vertical-class C	Inferior-no contact	Absent	Absent	No contact	Present
2	Left	Female	19	Full	Vertical-class C	Lingual-no contact	Absent	Absent	No contact	Present
3	Right	Male	17	Half	Mesioangular -class B	Inferior-no contact	Absent	Absent	Perforated	Present
4	Right	Female	22	Full	Mesioangular -class C	Inferior-no contact	Absent	Absent	Contact	Present (abnormal position)
5	Left	Female	22	Full	Mesioangular -class C	Inferior-no contact	Absent	Absent	Contact	Present (abnormal position)

Discussion

Impacted teeth are a frequent occurrence in dental conditions, with a reported prevalence ranging from 18 to 32 percent (9). The status and prevalence of impacted teeth can vary across different geographic locations and ethnic groups (10). Owing to these variations and the overall frequency of impacted teeth, numerous studies similar to this investigation have been conducted in various regions worldwide and at different times.

To ensure the selection of the most suitable treatment strategy for impacted teeth and to minimize any complications that may arise during or after treatment, it is crucial to thoroughly evaluate the relationship between impacted teeth and adjacent anatomical structures and their degree of impaction. Radiologic methods play a vital role in both diagnosis and treatment planning. Dentists commonly rely on panoramic radiography and CBCT as the primary radiographic techniques for visualizing impacted teeth. However, two-dimensional radiographic techniques have certain limitations, including distortion, overlapping of structures, and magnification (9, 11).

Numerous studies have documented the advantages of CBCT over traditional two-dimensional imaging techniques in the diagnosis of impacted teeth. CBCT offers superior features, including high-resolution imaging and a lower radiation dose compared to CT, which is commonly used in dentistry (9, 11-13).

This study analyzed 206 impacted teeth in 150 patients, specifically focusing on impacted teeth in the mandible. Of these, 173 were identified as ILTMs, 14 as mandibular canines, eight as premolars, six as supernumerary premolars, and five as mandibular second molars. Among all the examined impacted teeth, ILTMs were the most frequently impacted (2, 3). Following ILTMs, other commonly impacted teeth included maxillary wisdom teeth, upper canines, and mandibular premolars (2).

Extraction of the third molars is considered the most common minor surgical procedure in maxillofacial surgery. These extractions may be necessary for several reasons, including pericoronitis, neuralgic pain, ERR, development of distal caries in adjacent teeth, periodontal damage, prosthodontic and orthodontic indications, and the presence of cystic and tumoral formations associated with these teeth (14).

In this study, ILTMs were most prevalent among individuals aged 19–29 years, comprising 61.67% of the cases. This prevalence gradually declined with advancing age and was least common in individuals aged ≥ 60 years (2.5%). In the literature review, the greatest number of impacted teeth was found in the 18–29 age group. The decrease in the incidence of impacted teeth with increasing age can be primarily attributed to the extraction of impacted teeth over time (2, 15). Kruger and Venta reported that impacted third molars undergo positional changes as individuals age. They argued that the decline in the rate of impacted teeth with age may be due to either the repositioning of asymptomatic impacted teeth over time or to patients having their impacted teeth extracted due to complications occurring at an advanced age (16, 17).

Of the 120 patients included in this study group with impacted third molars, 52.5% were male, and 47.5% were female. No significant difference was observed between the sexes in terms of the prevalence of impacted third molars. Consistent with these findings, some studies have also reported no significant difference between the sexes concerning the rate of impacted third molars (2). However, other studies have reported a higher incidence of impacted teeth in males (9, 18). Anqudi et al. and Byahatti et al. observed more impacted teeth in females, and this difference was statistically significant (19, 20).

This study found that 64.74% of the ILTMs were partially impacted and 35.26% were fully impacted. These findings align with those of Kaplan et al., who reported that out of 828 impacted third molars, 450 were partially impacted. Şekerci et al. found that 76% of mandibular third molars were partially impacted (15, 21).

An analysis of the ILTMs in this study according to the Winter classification showed that 41.04% were vertical, 32.95% were mesioangular, 19.08% were horizontal, 4.62% were distoangular, and 2.31% were categorized in the “other” category. These findings are consistent with the literature, in which ILTMs were frequently observed in the vertical position. Saruhan et al. reported a vertical position rate of 54.2%, and Şekerci et al. reported that 62.32% of teeth were positioned vertically (14, 21). However, some studies have more commonly observed the mesioangular position (5, 9, 22). Tantanapornkul et al. reported that horizontal angulation was the most common type of impaction (12).

In this study, according to Pell-Gregory’s classification with reference to the occlusal plane for tooth position, 50.87% were classified as class B, 41.62% as class C, and 7.51% as class A. Bui et al. found class B to be 55.6%, class A to be 33.50%, and class C to be 10.9% (23). Salahaldin et al. also reported the highest number of class B positions in impacted lower third molars (24). Arslan et al. reported that the most common position was class C with a rate of 64.3% (25). Additionally, in this study, 68.79% of ILTMs were found to be in the class II position, which is consistent with the findings of Göksu et al., who also reported the most common class II position in their study (23, 26).

Preoperative radiographic evaluation plays a crucial role in assessing the relationship between the roots of impacted mandibular third molars and the inferior alveolar nerve canal. This assessment can help predict and potentially prevent postoperative sensory impairment (12, 27). However, two-dimensional radiographic methods may not clearly demonstrate the absence of cortical bone surrounding the IAC or accurately determine its vertical position in relation to the ILTM root (11). Patel et al. and Liye et al. have shown that CBCT is an ideal radiographic method for assessing the position of the IAC owing to its high resolution and ability to provide three-dimensional images (11, 28). In this study, when evaluating the relationship between ILTMs and the mandibular canal, it was found that the IAC was most frequently positioned inferior to the third molar root, at a rate of 71.68%. These findings are consistent with those of other studies (9, 12, 25). However, some studies have reported the mandibular canal was located more lingually (29, 30). Furthermore, in this study, the bone septum between the impacted tooth and the mandibular canal was not visible in 50.87% of the cases. Başaran et al. reported a similar rate of 52% (9). H. Ghaeminia et al. examined the relationship between the mandibular canal and ILTM roots using both PR and CBCT images and found that 88% of the teeth had contact with the mandibular canal (30), and Çelikel et al. reported a rate of 71% for this relationship (25).

The socket of the lower third molar is situated in the lingual process of the mandible, where the lingual bone plate is thinner than the buccal plate. In cases where the lingual bone is very thin, the roots of the third molar can cause perforation of the lingual cortical bone. This serious complication can lead to direct contact with the submandibular lingual nerve, potentially affecting its function (31, 32). To minimize such complications and overcome the limitations of panoramic radiography, CBCT is recommended as a more advantageous imaging modality. Several studies have suggested that certain markers observed on panoramic radiographs can be indicative of the anatomical relationship between the

IAC and the roots of third molars. Radiolucency at the root tip and interruption of the white line of the IAC may indicate a close relationship between the canal and the root (29, 33). However, other studies have shown that white line interruption and darkening of the root do not significantly correlate with the presence of corticalization (11). In this study, a significant correlation was found between the radiographic indicators observed on panoramic radiographs (white line interruption and root darkening) and the contact between the IAC and the tooth root. Similar findings have been reported in other studies, suggesting that these radiographic indicators may indicate lingual cortical bone perforation (31, 33). In this study, the relationship between these indicators on panoramic radiographs and lingual cortical bone was found to be significant ($p<0.05$).

Radiolucency at the root tip and white line interruption were also observed more frequently in teeth with perforations in and/or contact with the lingual bone. There was a significant difference between the indicators in the PR and contact status with the lingual bone ($p<0.05$). Tantanapornkul et al. reported that radiolucency at the root tip does not necessarily indicate a relationship between the tooth root and the canal, but rather perforation caused by the roots in the lingual cortical bone (31). Ülker et al. found that 19.3% of cases with lost canal continuity exhibited lingual cortical bone perforation while only 2.08% of cases with radiolucency at the root tip showed lingual cortical bone perforation (29). Moreover, Patel et al. reported that the white line interruption on radiographs was most commonly associated with thinning or perforation of the lingual cortical bone (11). In this particular study, 8.67% of ILTMs were found to have perforated the lingual cortical bone while 23.7% were found to be in contact with the cortical bone.

The angular position and location of ILTMs are closely related to the pathological problems they may cause in the adjacent second molars. Advanced imaging techniques, such as CBCT, provide a more detailed and precise view of this anatomical relationship (22). In this study, when the presence of distal caries and ERR caused by ILTMs in the second molar was analyzed using CBCT, distal caries was detected in 5.78% of the teeth, and ERR was found in 2.89%. However, when analyzed using PR, distal caries was detected in 11.56% of the teeth, and ERR was seen in 15.03%. Xiang et al. reported a distal caries formation rate of 37.6% in the mandibular second molars of ILTM teeth using PR (34). Aslan et al. found caries formation on the distal surface of second molars to be 20.7% and ERR prevalence to be 5% in their study using CBCT (22). In this study, a statistically significant difference ($p<0.05$) between CBCT and PR was observed in the evaluation of the presence of distal caries and ERR. More distal caries and ERR were detected in the evaluation performed with PR. Of the 20 teeth with distal caries detected using PR, distal caries was confirmed in 10 of them using CBCT. Similarly, out of the 26 ERRs detected with PR, 5 showed ERRs using CBCT. Other studies that utilized both imaging techniques also found varying rates of distal caries, with Qenning et al. reporting a rate of 4.3% and Geduk et al. reporting a rate of 1.14% (35, 36). One key factor contributing to the difference in findings between CBCT and PR is the absence of superimposition in CBCT images, allowing for better visualization of structures on different planes (37). It is believed that the discrepancies in the results across studies are influenced by various factors, such as study design, methodology, and patient population.

The normal positioning of maxillary and mandibular canines within the dental arch is crucial for both aesthetic and functional reasons. It has been reported that the incidence of impacted canines is 20 times higher in the maxilla compared to the mandible, making it a rare anomaly for the mandibular canine to remain impacted (8, 38).

However, transmigration tends to occur more frequently in the mandible, unlike the situation described. The lower anterior teeth are observed to have a smaller distance from the base of the nose, making transmigration less common in the maxilla. This can be attributed to the presence of the roots of the upper incisors, which act as an obstacle for eruption, along with the middle palatal suture, which serves as a barrier (39, 40). The exact factors contributing to transmigration are not fully understood, but it is widely accepted that it involves abnormal displacement or deviation of the tooth bud. Although transmigrating teeth do not cause symptoms often, they carry significant clinical importance. The [insert type of teeth here] teeth are crucial for the dental arch, and migration can lead to functional and aesthetic deficiencies, as well as damage to the surrounding structures during the transmigration process (41).

In this retrospective study, 57.14% of the animals with mandibular impacted canine teeth were female, while 42.86% were male. Jain et al. (42) reported a similar finding, with a rate of 71.42% for females. Aydın et al8 found that 24 out of 42 patients were female. In our study, two out of four patients with transmigration were female, and the remaining two were male. Most of the studies reported a higher occurrence of transmigration in females compared to males (39, 41, 43). However, Görmez et al. (41) found that transmigration was more common in male patients. Some studies have shown that sex does not significantly influence the occurrence of transmigrating teeth (44).

Upon evaluation of the position of the impacted canine teeth, it was observed that the crown was predominantly in the buccal position, followed by the lingual and central positions. Similar findings were reported by Aydın et al. (8), who found that the crowns were mostly located buccally. Bertl et al. (45) reported a distribution of 55.3% labial, 36.2% central, and 8.5% lingual placement of embedded canine teeth in the mandible. Qadeer et al. (46) found that 70% of mandibular impacted teeth were labially located. Güller et al. (47) reported that the crowns of impacted mandibular teeth were mostly positioned buccally, accounting for 76.8% of cases.

Upon examining the region where impacted mandibular teeth were located, we found an equal distribution between the right and left sides. Aydın et al. (8) also observed a balanced distribution, with half of the 54 impacted mandibular teeth being located on the right side and the other half on the left side. Şentürk et al39 found that 8 out of 13 impacted teeth were on the left side, while five were on the right side. However, Görmez et al. (41) reported a higher prevalence of impacted mandibular teeth on the right side, with 31 cases on the right side compared to 28 cases on the left side.

Dalessandri et al. reported burial rates of mandibular canines to range between 0.92% and 5.1%, with the incidence of cases with transmigration ranging from 0.1% to 0.31% (48). The occurrence of transmigration in mandibular canines varies between 0.33% and 0.46% (49, 50). It is worth noting that the majority of transmigration cases reported in the literature are classified as Type 1, while Type 5 is the least frequently observed (51). In the present study, out of 14 impacted mandibular canines, 4 were found to be transmigrated, with 2 cases falling under Type 1, and one each falling under Type 5 and Type 2. Mupparapu classified Type 1 as the most common type of transmigration, with a prevalence of 45.6% in his study on the classification of mandibular canines showing transmigration (52). However, contrasting these findings, Görmez et al. reported an equal distribution between Type 1 and Type 2 transmigration, while Aktan et al. observed a higher prevalence of Type 2 appearance at 47% in their study (41, 44).

The mandibular incisive canal, through which the incisive nerve passes, is situated mesial to the mental foramen and exhibits a smaller diameter and less corticalization in comparison to the mandibular canal. The incisive canal's reduced corticalization and traversal through intramedullary spaces present challenges in its detection using conventional radiography (53). Our research revealed that the incisive canal was detected in contact with impacted canines in 6 of 14 cases using CBCT. Karabaş et al. reported a 62.12% incidence of incisive canal contact in impacted mandibular canines (54). The presence of an incisive canal in the mental interforaminal region, typically regarded as a safe area, poses notable risks during surgical procedures, including sensory disturbances, edema, hematoma, insufficient osseointegration of implants, and changes in pulp sensitivity. In light of this, the implementation of CBCT is crucial in reducing postoperative complications and ensuring the success of surgical interventions (53, 54).

Impacted mandibular second permanent molars are exceedingly rare (55). The prevalence of impacted second molars has been reported to range between 0.03% and 1.36% in various studies (56). In this study, we examined patients who underwent both CBCT and PR simultaneously, revealing that out of the 206 impacted teeth, five were impacted second molars. The distribution of patients according to sex showed an equal number of females and males, with two cases each. However, previous studies have reported different ratios. Müftüoğlu et al. calculated the ratio of female to male patients as 1.25 (57), while Fatih et al. found a female-to-male ratio of 1:1.2 favoring males, albeit without any significant superiority (56). In this study, it was observed that mandibular impacted second molars were unilateral in three patients, while bilateral impacted teeth were found in only one patient. Of the five impacted teeth, three were located in the mesioangular position and two were in the vertical position. These findings are consistent with those of previous studies that have also indicated a higher prevalence of mesioangular and unilateral impacted teeth (56, 57). Şentürk et al. and Bereket et al. also discovered that the vertical position of teeth was more frequently observed in their respective studies(56,58). In our study, when the vertical relationship between the root of the impacted second molar and the IAC was evaluated, the results were similar to those found for ILTMs. Among the four teeth examined using CBCT, the IAC was positioned inferiorly in four, lingually in one, and in contact with the canal in only one. Regarding the relationship between the second molar and the lingual bone, two teeth were in contact with the bone, and the root of one tooth perforated the lingual cortical bone.

When impacted third and second molars are asymptomatic, periodic radiographic follow-up of these teeth is generally recommended, especially if no pathological condition is observed. This recommendation is made to avoid potential complications that may arise from tooth extraction, such as mandibular nerve damage, lingual nerve injury, bone perforation, and migration of fractured tooth roots into the submandibular lumen (56, 58).

Of the 206 teeth examined in this study, eight were premolars and six were supernumerary premolars. Previous studies have also explored the prevalence of impacted lower premolars, and it has been found that after third molars and maxillary canines, mandibular premolars are the most commonly impacted teeth (2). In general, the incidence of supernumerary teeth in the population can vary between 0.1% and 3.8% (59). Furthermore, it has been noted in the literature that the incidence of supernumerary teeth is higher in males compared to females (60). In this study, three out of four patients with supernumerary teeth were found to be male. Supernumerary premolars are typically observed to be fully impacted in a lingual position. Similarly, in alignment with the existing literature, all supernumerary teeth identified in this study were situated lingually, had normal morphology, and were fully impacted. Çıtır et al. previously reported in their study that mandibular supernumerary premolars closely resemble premolars with typical size and morphology (61). Additionally, Şişman et al. reported that all nine supernumerary premolars documented in their study were fully impacted (62).

Conclusion

1. Radiographic examinations have an important place in the examination of the position of impacted teeth, the surrounding anatomical structures of impacted teeth, and the relationship between impacted teeth and neighboring teeth. Two-dimensional radiographic methods are routinely used to evaluate impacted teeth. For accurate diagnosis and uncomplicated treatment, more reliable examinations that provide three-dimensional images, such as CBCT and CT, should be used in high-risk cases.
2. The classification of impacted teeth using various classification systems, evaluation of the relationship with surrounding structures, and treatment in light of this information are important to avoid unnecessary surgical procedures and postoperative complications.
3. Early diagnosis and treatment of these impacted teeth are necessary because they threaten normal occlusion, may cause possible pathologies, and may cause problems during treatment. This will be useful for dentists to raise patients' awareness of periodic controls.

Disclosures

Ethical Approval: Ethics committee approval was received for this study from the Scientific Ethics Committee of Dicle University, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2021-53.

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