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Investigation of the effects of embedded third molar to the second molar through CBCT and panoramic radiography

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ABSTRACT

Aims: The aim of this study is to evaluate the correlation between these two methods by comparatively examining the caries, external root resorption, and periodontal bone destruction caused by impacted third molars on adjacent teeth by comparing panoramic and CBCT images.

Methods: In this study, all the OPG and CBCT images of 388 impacted third molars belonging to 205 patients were evaluated. While impacted third molars were differentiated according to Pell & Gregory and Archer and Kruger classification criteria, distal caries, marginal bone loss, and external root resorption in the second molar were examined by panoramic and CBCT.

Results: 388 impacted teeth were evaluated in 205 patients, and the rate of distal caries was 27.5% in panoramic radiographs and 31% in CBCT ($p<0.05$). External root resorption formation in second molars observed in CBCT was not observed in 18.8% of panoramic radiographs ($p<0.05$). Marginal bone loss was observed 9.8% more in CBCT than in panoramic x-rays ($p<0.05$). All three pathologies were observed at the highest rate in the Class 2 position, while distal caries was observed at the highest rate in position B. In the examinations performed for the lower and upper jaws, the rate of all three pathologies was found to be higher in the CBCT evaluation than in the panoramic radiography.

Conclusion: CBCT; Although it is disadvantageous in terms of radiation dose and cost, it has been found to be more effective than panoramic x-ray in the detection of distal caries, marginal bone loss, and external root resorption pathologies. It is thought that this situation can be considered as a criterion in terms of profit-loss analysis when the examination is requested, thus preventing pathologies from being overlooked.

Keywords: Impacted molar tooth, distal caries, external root resorption, marginal bone loss, CBCT, panoramic radiography

INTRODUCTION

Impacted teeth are teeth that are completely or partially covered by mucosa and bone for more than two years after a physiologic eruption. In the permanent dentition, mandibular third molars are most commonly impacted, followed by maxillary third molars. Impacted third molars may cause caries lesions and resorption in adjacent teeth, periodontal disease, marginal bone loss on the root surface of adjacent teeth, and cysts or tumors.[1,2] Caries and resorption caused by impacted third molars in second molars sometimes require removal of the third molar and restoration of its defect. Early detection and evaluation of the caries risk of second molars associated with second molars can help in the prevention of distal caries in second molars.[3]

Panoramic radiography is the most commonly used imaging technique for the evaluation of impacted teeth and related lesions. However, it may not be sufficient in most cases. CBCT can detect periodontal diseases, caries, and root resorption at the initial stage.[4]

The aim of this study was to examine these pathologies comparatively with panoramic and CBCT and to evaluate the correlation between the two methods. In addition, this study aimed to examine the prevalence of distal caries, external root resorption, and marginal bone loss, the classification of impacted third molars, and the effects of these groups on pathologies in adjacent second molars.

METHODS

The ethics committee approval required for the study, which was conducted at Dicle University Faculty of Dentistry, Department of Restorative Dental Treatment, was evaluated at the Dicle University Faculty of Dentistry Ethics Committee meeting dated 28.04.2021, numbered 4, and the decision was taken with the meeting decision with protocol number 2021/27. This study was produced from the specialty thesis titled "Investigation Of The Effects Of Embedded Third

Molar To The Second Molar Through CBCT And Panoramic Radiography" prepared by Hazal Kısa, a dental specialty student in Dentistry, and supervised by Assoc. Prof. Dr. Elif Pınar Bakır. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Acquisition of the Images Included in The Study

The images used in the study were obtained from the archived OPG and CBCT images of male and female patients who applied to Dicle University Faculty of Dentistry, The Department of Oral and Maxillofacial Radiology for reasons such as trauma, impacted teeth, lesion treatment, and orthodontic treatment.

Study Inclusion Criteria

Archival images were evaluated for compliance with some criteria. The main criteria for our study were the presence of OPG and CBCT images of patients aged 16 years and older and that these images were taken on the same day, the presence of fully or partially impacted third molars, and the presence of a second molar in one or more adjacent areas. Third molars with incomplete root tip closure, images with generalized bone destruction, and images with restorations or large cavitations distal to the second molars were excluded. Images of patients with intraosseous pathologies originating from third molars or trauma patients were excluded. In addition, images that could not be examined properly due to artifacts or positioning errors due to dense materials such as brackets, metal pins, or mini-screws were excluded.

In our study, all OPG and CBCT images of 388 impacted third molars in 205 patients were evaluated by the first observer with 3 years of experience. In addition to the Pell & Gregory classification, the impacted third molars were classified according to the criteria of the Archer & Kruger classification, and the effects on the second molar were analyzed. The presence of distal caries and external bone resorption was examined on both OPG and CBCT images, and bone destruction in the distal region of the second molar was measured. The images in the group of randomly selected patients were then independently evaluated by a second observer with 21 years of experience. The data analyzed by both observers was entered into data forms separately for OPG and CBCT.

Technical Specifications of the CBCT and Panoramic Device Used and Conditions For Evaluating Images

CBCT images obtained with a three-dimensional cone beam computed tomography device (i-CAT®, Model 17-19, Imaging Sciences International, Hatfield, Pa., USA) were analyzed with the i-CAT imaging program of the same company.

Panoramic radiographs were obtained using a digital panoramic radiography device called the Midmark Vantage (Midmark, Ohio, USA). Images were acquired in standard acquisition mode (66 kV, 6 mA, 16 s). The evaluation was performed under appropriate lighting, and the images were analyzed using the Metasoft PACS program (Metasoft Bilgisayar Bilgi İşlem Hizmetleri San. Tic. Ltd. Şti. Eskişehir, Turkey) and a 15.5-inch Sony VAIO monitor with 1920x1200 pixels.

Embeddedness Classification of Third Molars

In our study, panoramic and tomographic images of 388 impacted third molars of 205 patients with bone or gingival retention and failure to reach occlusion were analyzed. The angle of the longitudinal axis with the occlusal plane, its position relative to the occlusal level of the neighboring tooth, and, for mandibular teeth, its position with the anterior edge of the ramus were taken into account when classifying the teeth.

Third molars were classified as impacted according to their functional position in the occlusal plane.

Examination of Panoramic Radiography

According to the Winter classification, teeth with an occlusal plane angle of 10° to -10° with the vertical axis of the tooth were classified as vertical, 10° to 80° as mesioangular, -10° to -80° as distoangular, and 80° to 100° as distoangular. In addition, teeth with a superposed apex and crown that could not be identified on the panoramic image were classified as buccoangular and lingoangular by tomographic evaluation.

According to the Pell-Gregory classification, the occlusal plane of the third molar was classified as position A if it reached the occlusal plane of the adjacent second molar, position B if it was between the occlusal and cervical levels of the second molar, and position C if it was below the cervical level.

Figure 1. Panoramic view of impacted tooth. Examination of CBCT image;

In the Pell-Gregory classification, an examination of mandibular impacted third molars is based on the relationship with the anterior edge of the ramus. In this classification, if the distance between the distal border of the second molar tooth and the anterior edge of the ramus is wider than the mesiodistal dimension of the third molar tooth, it is called Class I; if it is narrower, it is called Class II; and if the entire third molar tooth is embedded in the ramus, it is called Class III.

After the classification was completed, the contact surfaces of the impacted third molars and the adjacent second molars were examined using the magnification feature in the panoramic imaging program. Radiolucency and loss of lamina dura, clearly seen in the root of the second molar, were considered external root resorption. The level of resorption at the distal root of the second molar was divided into two groups: "absent" and "present". Disruption of enamel continuity in the crown region of the second molar or the presence of radiolucency reaching the dentin was evaluated in favor of distal caries. The presence of caries in the distal second molar was classified as "absent" or "present".

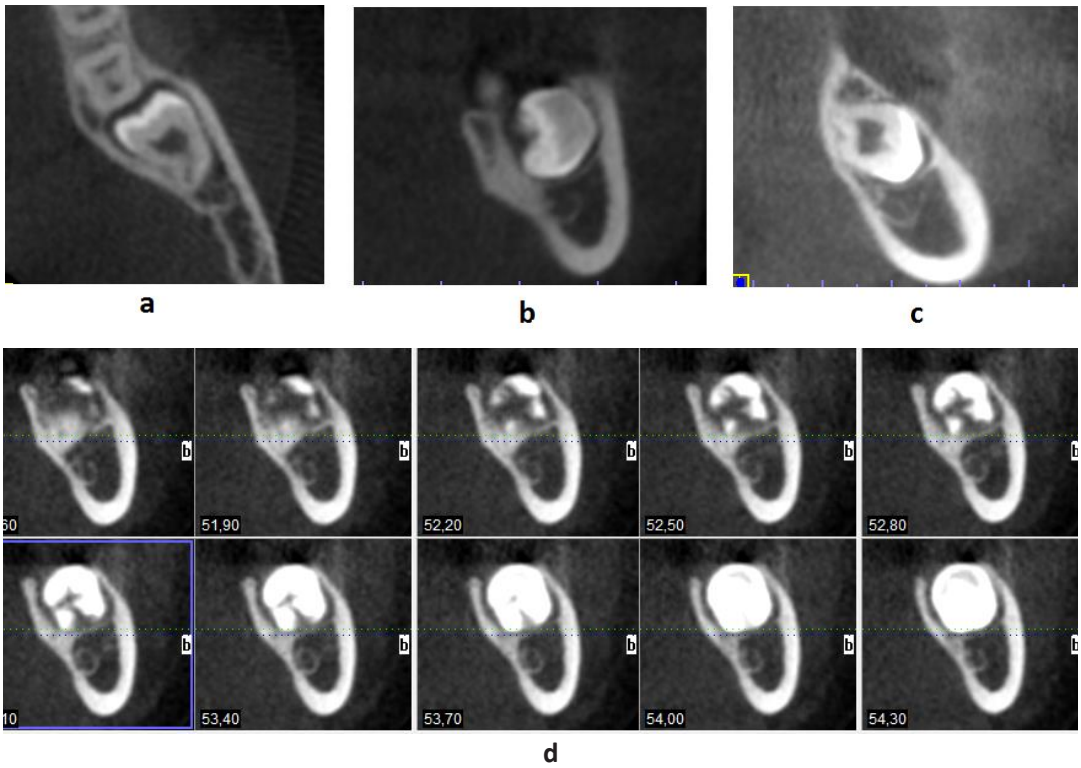


Figure 2. CBCT cross-sectional images of impacted maxillary third molar; a: coronal section, b: sagittal section, c: axial section, d: view in vertical sections.

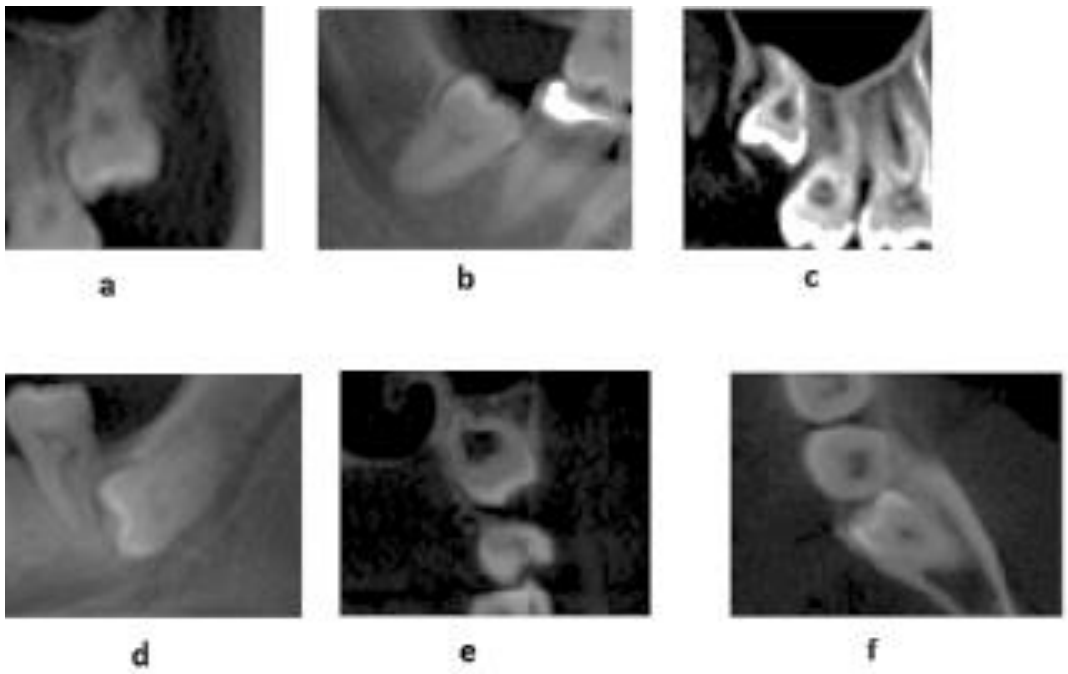


Figure 3. a: vertical **b:** mesioangular **c:** distoangular **d:** horizontal **e:** buccoangular **f:** lingoangular

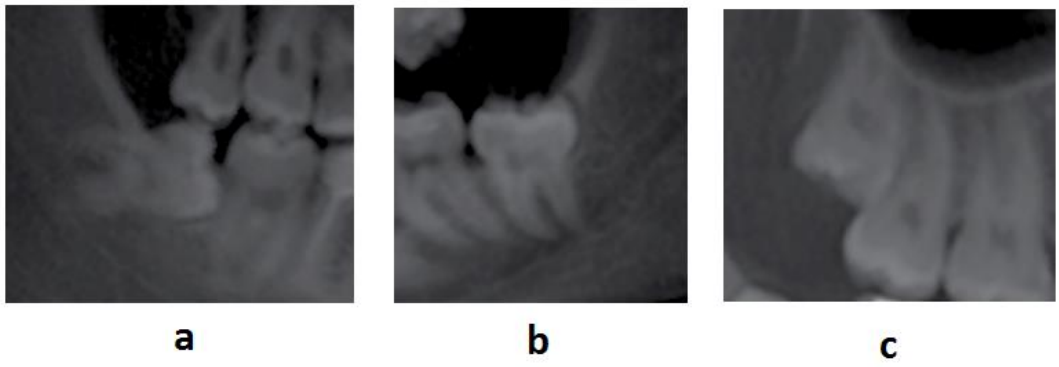


Figure 4. a: Position a, b: Position b, c: Position c

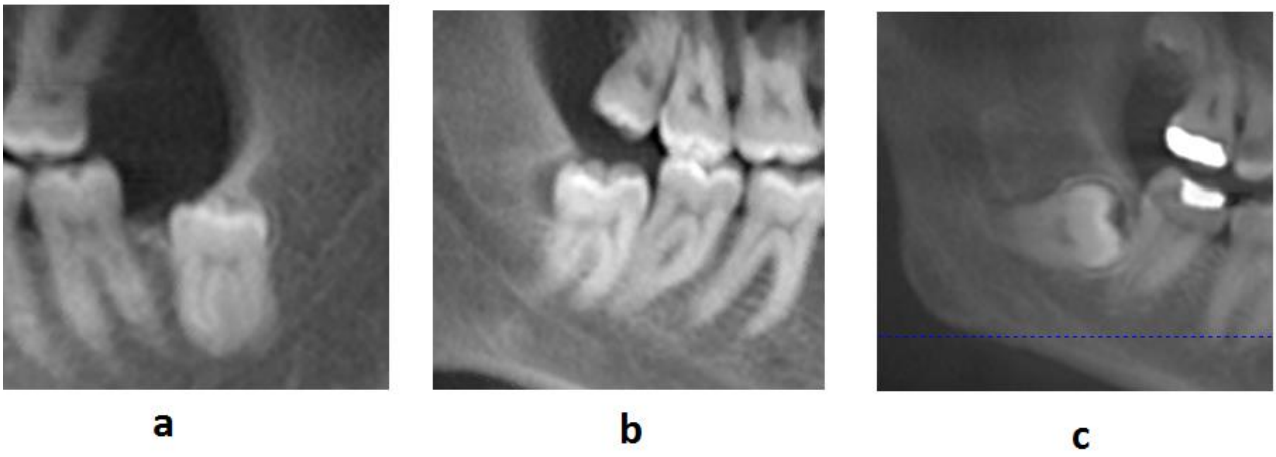


Figure 5. a: Class I **b:** Class II **c:** Class III

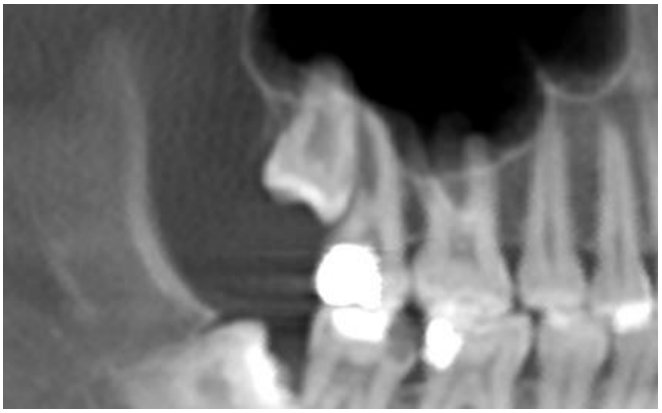


Figure 6. External root resorption (panoramic radiographic image)

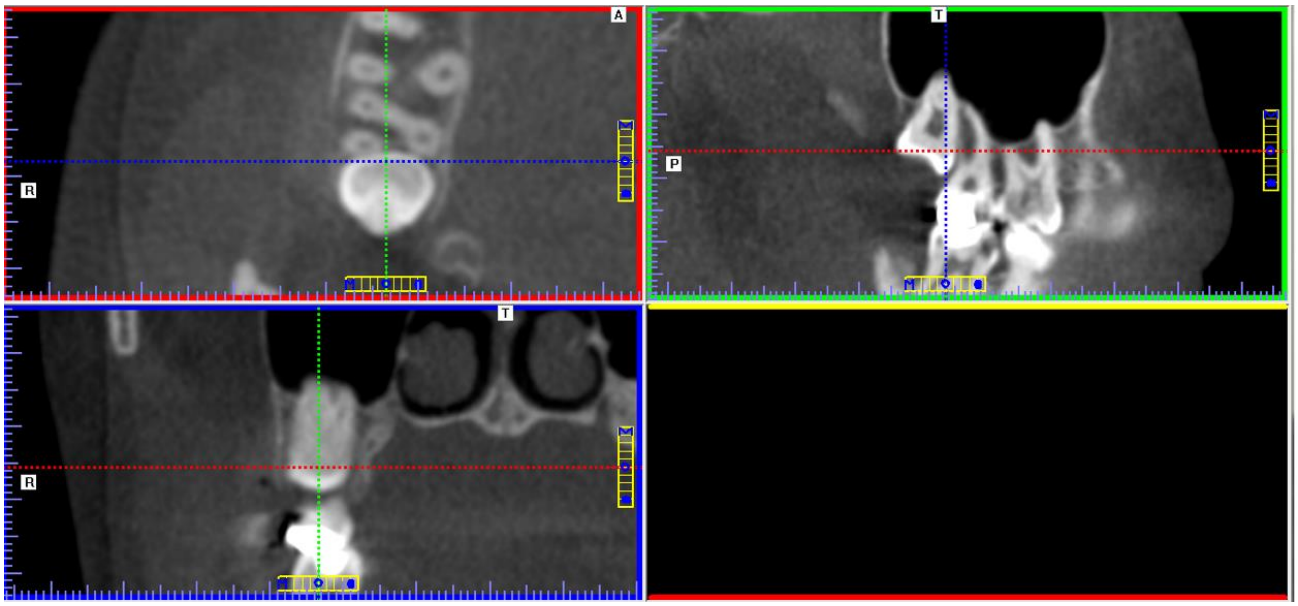


Figure 7. Examination of external root resorption on CBCT image (coronal, sagittal and axial sections)

In addition, 3 mm below the enamel cementum level of the second molar tooth was considered normal bone level, and the results obtained from the most apical measurement of bone destruction were evaluated as marginal bone loss values.[28]

When examining the CBCT images, the external root resorption, distal caries, and bone loss were evaluated using the magnification feature in axial, coronal, and sagittal images. To measure marginal bone loss, the observers noted the measurement from 3 mm below the enamel cementum border of the second molar to the usual bone border as marginal bone destruction, as examined in the case studies.

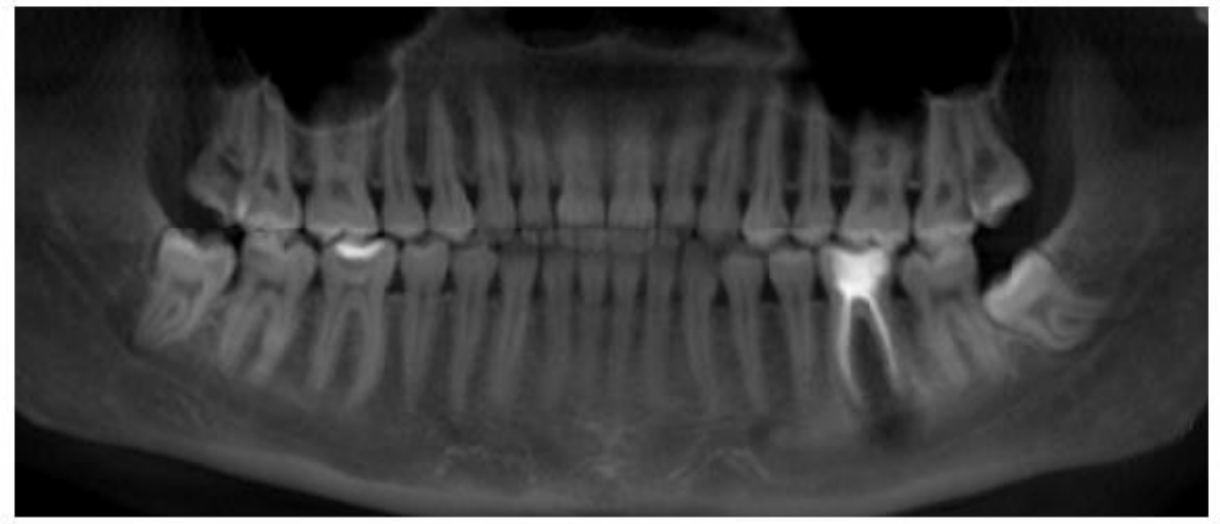


Figure 8. Presence of distal caries in tooth 47, absence of distal caries in tooth 37

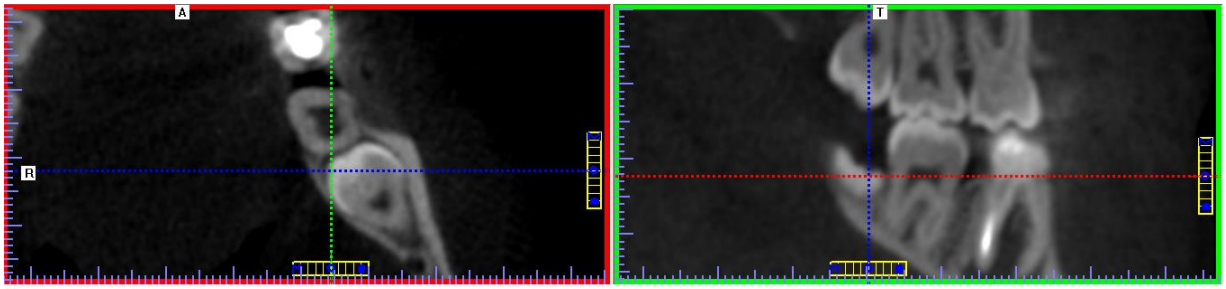


Figure 9. CBCT image of distal absence of caries in tooth 37 (axial and sagittal sections)

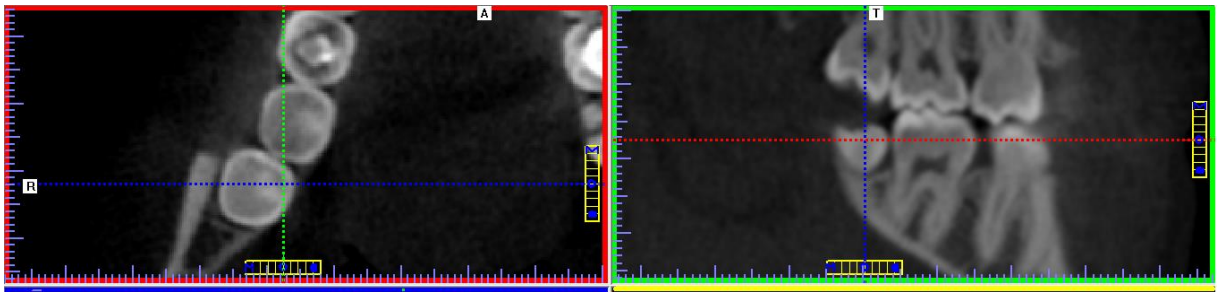


Figure 10. CBCT image of distal caries in tooth 47 (axial and sagittal sections)

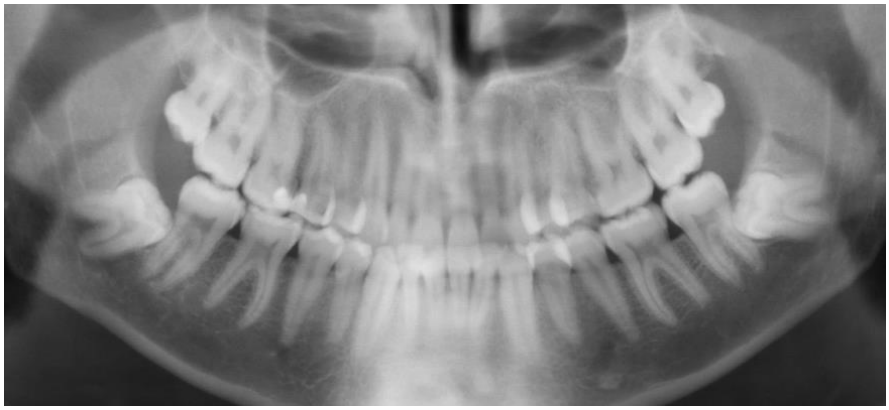


Figure 11. Panoramic image of a patient scheduled for marginal bone destruction measurement

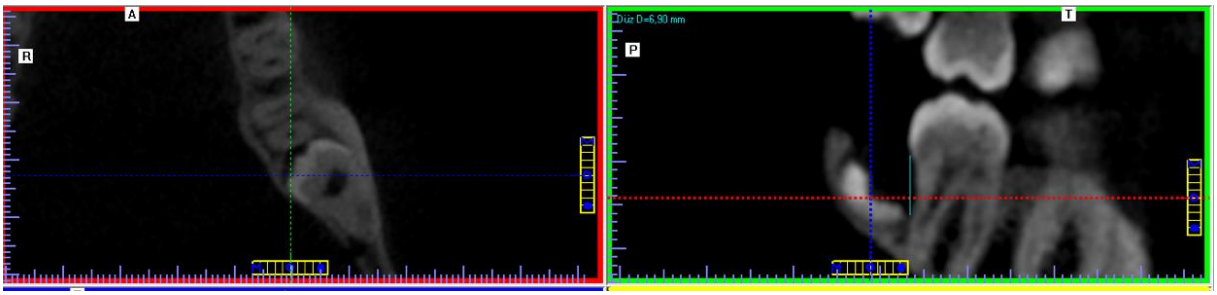


Figure 12. Measurement of 6.30 mm of marginal bone loss caused by tooth 38 on CBCT image (axial and sagittal sections)

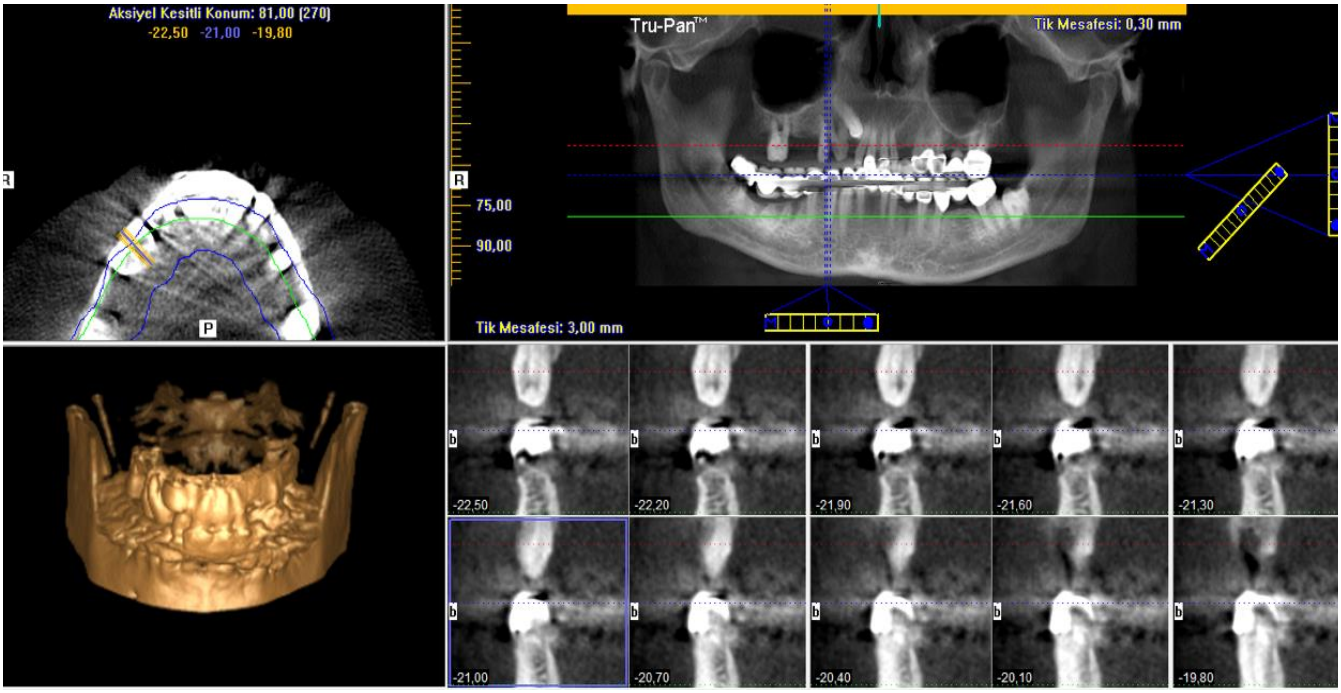


Figure 13. Metal artifact from metal restorations most commonly observed on CBCT image

RESULTS

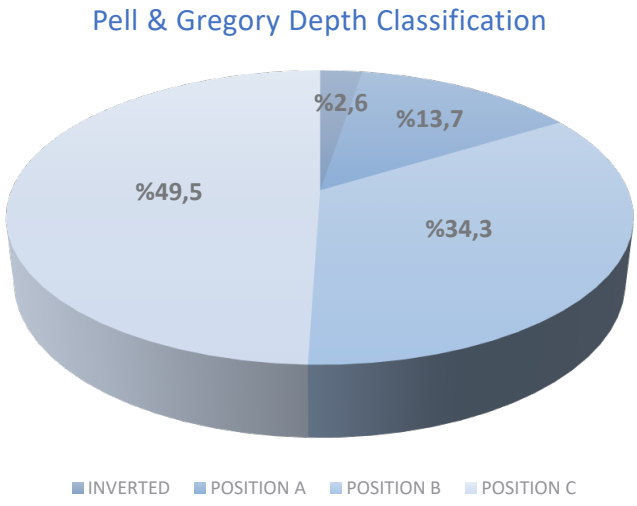
In the study, panoramic and CBCT images of 205 patients, 114 female (55.6%) and 91 male (44.4%), were evaluated (**Table 1**), 388 impacted third molars were identified (**Table 2**), and the teeth were classified in 3 different ways according to the adjacent tooth in terms of depth, according to the ramus (Pell and Gregory classification), and according to the angle made by the long axis (Winter classification).

When the gender distribution of the patients included in the study was analyzed, 55.6% were female and 44.4% were male.

When the numbers of impacted teeth were analyzed, 15.2% had tooth number 18, 20.1% had tooth number 28, 35.6% had tooth number 38, and 29.1% had tooth number 48.

When the positions of the teeth according to the occlusal distance of the adjacent teeth were examined, 2.6% were inverted, 13.7% were in position A, 34.3% were in position B, and 49.5% were in position C. When the distance of the mandibular teeth to the anterior edge of the ramus was analyzed, it was determined that the most common position was Class II with 47.7%, and the distance between the distal border of the second molar tooth and the anterior edge of the ramus was narrower than the mesiodistal distance of the third molar tooth. In addition, 28.1% of the teeth were vertical, 18% horizontal, 10.6% distoangular, 29.4% mesioangular, 7.2% buccoangular, and 4.1% lingoangular.

There was no statistically significant relationship between the genders in terms of distal caries, marginal bone loss, and external root resorption on cone beam computed tomography and panoramic radiography (p>0.05).



Graph 1: Pell & Gregory depth classification distribution of the teeth included in the study

There is a statistically significant relationship between the distal caries formation groups in the CBCT and panoramic radiography examinations, according to the Pell & Gregory classification of the distance to the anterior edge of the ramus of the teeth included in the study ($p<0.05$). In the panoramic radiography examination, it was determined that 34.7% (n=87) Class II teeth formed distal caries. In addition, distal caries was observed in 92.6% of the teeth in the Class II group. However, according to tomographic examination, 37.5% (n=94) of the impacted teeth with distal caries were in Class II, and this group was the most common. In the CBCT evaluation, 89.5% of the impacted teeth in the Class II group were found to have distal caries. The teeth in Class III also had the highest rate of caries-free teeth. In the panoramic examination, 92.1% had no caries, while in the CBCT examination, 84.2% had no caries (**Table 1**).

There was a statistically significant correlation between the presence of marginal bone loss groups in panoramic radiography and CBCT examination according to the distance to the anterior face of the ramus ($p<0.05$). If the distance between the anterior edge of the ramus and the distal border of the second molar is greater than the size of the impacted tooth (Class I), the rate of marginal bone loss (CBCT evaluation was 2.4% and panoramic evaluation was 1.2%) is low. Of the 185 impacted teeth in Class II, 74.6% in panoramic evaluation and 74.6% in CBCT evaluation caused marginal bone loss. In 38 Class III teeth, 71.1% in panoramic evaluation and 78.9% in CBCT evaluation showed marginal bone loss. There was no statistically significant correlation between the external root resorption formation groups in panoramic and CBCT image examinations according to the distance to the anterior ramus of the mandible ($p>0.05$) (**Table 1**).

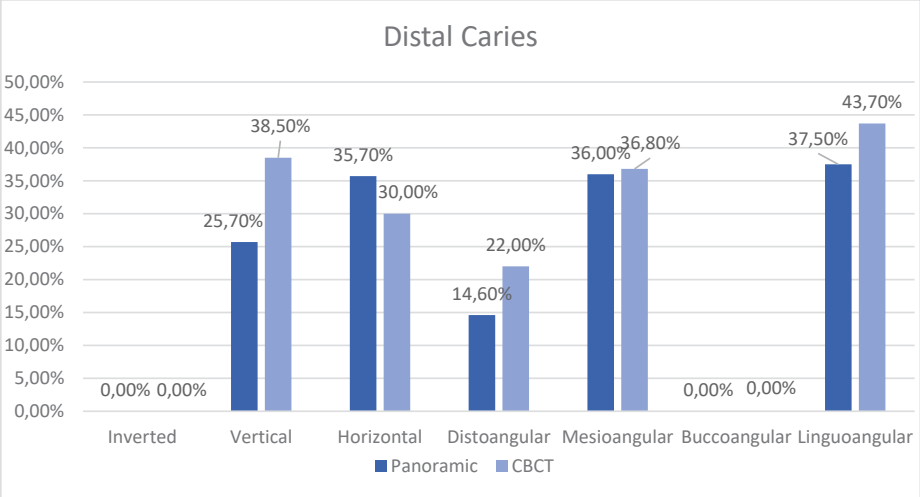
There is a statistically significant relationship between the distal caries formation groups in panoramic and CBCT examinations, according to the Pell & Gregory positions of the patients included in the study ($p<0.05$). Position B (13.4%; n=52) was the most caries-producing position in the panoramic radiography evaluation, while position B (12.4%; n=48) was the most distal caries-producing position in the CBCT evaluation. The distal caries-free rate was in favor of position C in both panoramic (41.8%) and CBCT (39%) evaluations (**Table 1**).

There was a statistically significant relationship between the external root resorption groups according to depth level ($p<0.05$). In panoramic evaluation, the incidence of external root resorption was higher in position C (24.2%) than in position A (3.4%) and position B (13.1%). In the CBCT evaluation, it was determined that position C (31.7%) showed more external root resorption than position A (4.4%) and position B (15.2%) (**Table 1**).

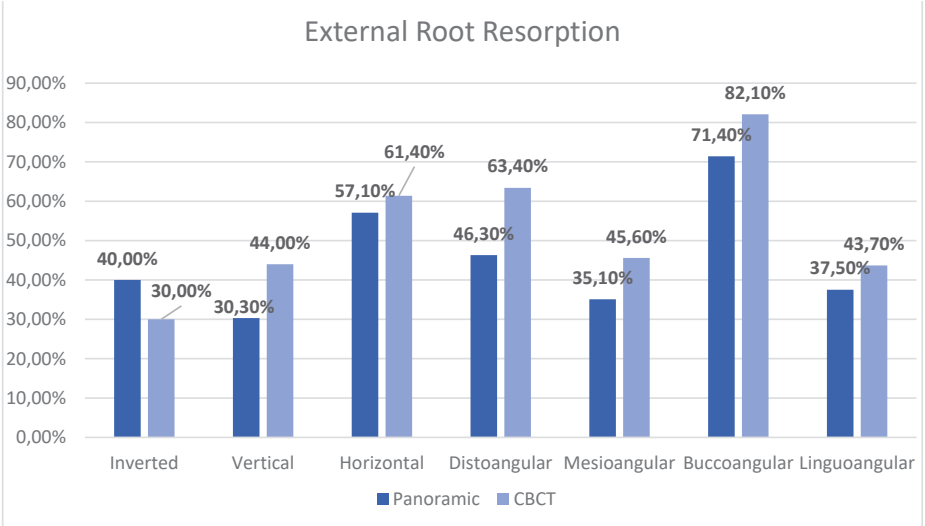
In the evaluation of CBCT and panoramic images, it was determined that there was a statistically significant difference between the rates of marginal bone loss according to the depth level ($p<0.05$). In panoramic radiographs, marginal bone loss was most frequently observed in position C with a rate of 36.1%, whereas in CBCT evaluation, the rate increased to 43.3%, with the highest rate in position C. However, the position that caused the least marginal bone loss was position A (5.2%) in the panoramic evaluation, while the result in the CBCT examination showed position A (4.9%) (**Table 1**).

Table 1. Comparison of the relationship between pathologies and positions in panoramic and CBCT results

		PANORAMIC						CBCT					
		Distal Caries		External Root Resorption		Marginal Bone Loss		Distal Caries		External Root Resorption		Marginal Bone Loss	
		Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent
		n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)
Angulation	Vertical	7.2	20.9	1.0	1.5	18.0	10.1	10.8	17.3	12.4	15.7	20.6	7.5
	Horizontal	6.4	11.6	10.3	7.7	14.7	3.4	5.4	12.6	11.1	7.0	15.7	2.3
	Mesioa.	10.6	18.8	10.3	19.1	24.2	5.2	10.8	18.6	13.4	16	26.3	3.1
	Distoa.	14.6	9	4.9	5.7	6.4	4.1	2.3	8.2	6.7	3.9	9.3	1.3
	Buccoa.	0	7.2	5.2	2.1	4.9	2.3	0	7.2	5.9	1.3	5.9	1.3
	Lingoa.	1.5	2.6	1.5	2.6	2.3	2.3	1.8	2.3	1.8	2.3	2.6	1.6
	Inverted	0	2.6	1	1.5	0.3	2.3	0	17.3	0.8	1.8	0.3	2.3
	p	0.000*		0.000*		0.000*		0.000*		0.001*		0.000*	
Depth	Position A	6.2	7.5	3.4	10.3	8.5	5.2	8.5	5.2	4.4	9.3	8.8	4.9
	Position B	13.4	20.9	13.1	21.1	26	8.2	12.4	21.9	15.2	19.2	28.4	5.9
	Position C	7.7	41.8	24.2	25.3	36.1	13.4	10.3	39.2	31.7	17.8	43.3	6.2
	Inverted	0	2.6	1.0	1.5	0.3	2.3	0	2.6	0.8	1.8	0.3	2.3
	p	0.000*		0.011*		0.000*		0.000*		0.000*		0.000*	
Ramus classification	Class I	1.6	5.6	2.4	4.8	6.0	1.2	2.0	5.2	3.2	4.0	4.8	2.4
	Class II	34.7	39	23.1	50.6	55.0	18.7	37.5	36.3	29.9	43.8	58.6	15.1
	Class III	1.2	13.9	6.8	8.4	10.8	4.4	2.4	12.7	17.3	8.0	12.0	3.2
	Inverted	4.0	0	1.6	2.4	0.4	3.6	4.0	4.0	1.2	2.8	0.4	3.6
	p	0.000*		0.441		0.000*		0.000*		0.749		0.000*	



Graph 2: Percentage graph of distal caries formation according to angulation groups



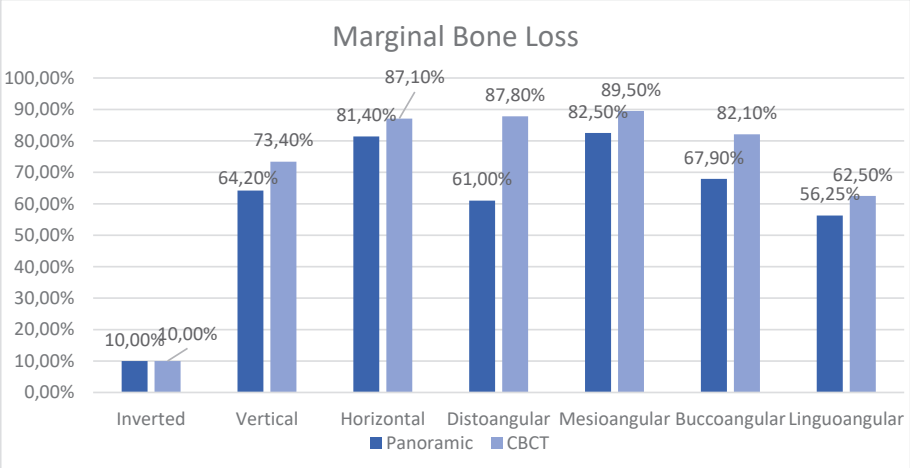
Graph 3: Percentage plot of external root resorption formation according to angulation groups

There is a statistically significant relationship between the distal caries groups in the CBCT and panoramic evaluation according to angulations ($p<0.05$). In panoramic evaluation, the most common angulations were mesioangular (10.6%), vertical (7.2%), and horizontal (6.4%). In CBCT evaluation, mesioangular and vertical (10.8%) caused the highest rate of distal caries formation, followed by horizontal (5.4%) (Table 1).

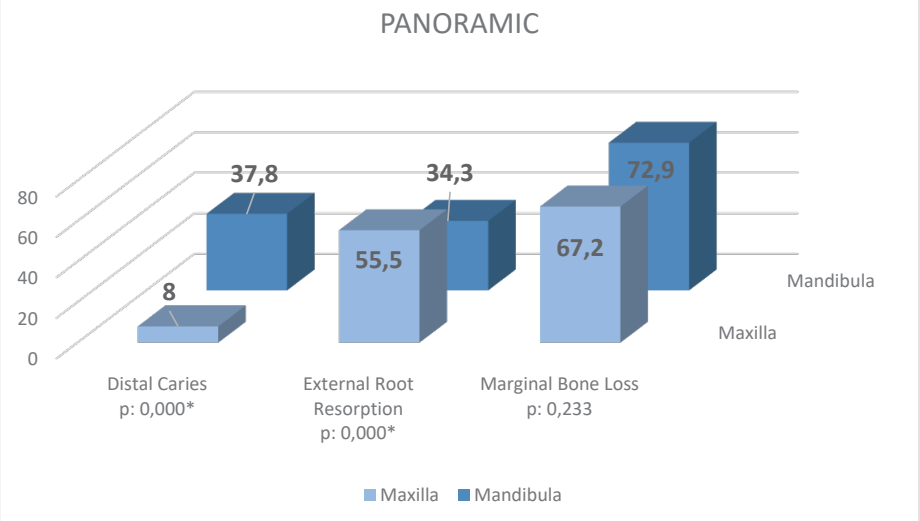
There was a statistically significant difference in external root resorption according to angulation in CBCT and panoramic examination in impacted 3rd molars (p:0.001 for CBCT and p:0.000 for panoramic; $p<0.05$). In the CBCT evaluation, the rate of external root resorption in the mesioangular position (13.4%) was higher than the vertical (12.4%) and horizontal (11.1%) positions. In panoramic evaluation, the ratio of mesioangular and horizontal (10.3%) was the same and higher than vertical (8.5%).

In impacted third molars, a statistically significant difference was found between the rates of marginal bone loss according to angulation in CBCT and panoramic evaluation (p:0.000; $p<0.05$). In the general population, it was observed that the most marginal bone loss occurred in the mesioangular position. While 24.2% bone loss was found in the mesioangular position and 18% in the vertical position in the panoramic evaluation, 26.3% for the mesioangular position and 20.6% for the vertical position in the CBCT evaluation (**Table 1**). In panoramic examination, the rate of marginal bone loss was higher in the mesioangular (82.5%), horizontal (81.4%), and buccoangular (67.9%) positions compared to the inverted (10%) position. Similarly, the rate of marginal bone loss was higher in the mesioangular (89.5%), horizontal (87.1%), and distoangular (87.8%) positions compared to the inverted (10%) and lingoangular (62.5%) positions (**Table 4**).

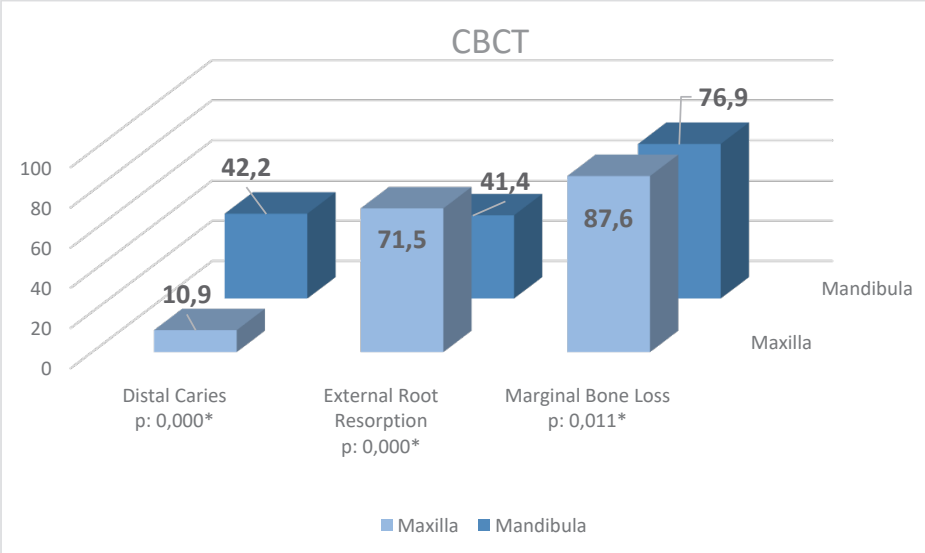
There is a statistically significant correlation between the rates of distal caries and external root resorption in CBCT and panoramic radiographs ($p<0.05$). In the maxilla and mandible, the rates for all three pathologies were lower in panoramic radiography than in CBCT. The caries incidence rate in the adjacent molars of the mandible was 37.8% in panoramic radiography and 42.2% in CBCT. Similarly, for the upper jaw, the rate of distal caries was 8% in panoramic radiography, while this rate increased to 10.9% in CBCT. Similarly, for the mandible, 34.3% of external root resorption was seen in panoramic radiography, while 41.4% was found in CBCT. While 55.5% external root resorption was detected in the adjacent tooth of the upper jaw in the panoramic examination, it was found to be 71.3% in the CBCT examination.



Graph 4: Percentage graph of marginal bone loss formation according to angulation groups



Graph 5: Panoramic evaluation of upper and lower impacted molar pathologies.



Graph 6: CBCT evaluation of upper and lower impacted molar pathologies.

There was no statistically significant difference in the rate of marginal bone loss between the jaws in the panoramic evaluation (p>0.05). However, a statistically significant difference was found between the rates of marginal bone loss in the CBCT evaluation (p: 0.011*; p<0.05), and it was concluded that 87.6% of marginal bone loss was seen in the upper jaw and 76.9% in the lower jaw.

Table 2. Comparison of CBCT and panoramic radiography for the presence of distal caries in patients

Distal Caries 0 1			Panoramic		Total
CBCT	0	n	239	28	267
		%	89.5%	10.5%	100.0%
		% Dental class	84.8%	26.4%	68.8%
		% Total	61.6%	7.2%	68.8%
	1	n	43	78	121
		%	35.5%	64.5%	100.0%
		% Dental class	15.2%	73.6%	31.2%
		% Total	11.1%	20.1%	31.2%
X2: 122.173			**p: 0.000***		

There was a statistically significant difference between the CBCT and panoramic evaluation groups for distal caries in the second molar (p<0.05). Distal caries was observed in 11.1% of the patients who did not have distal caries in the panoramic evaluation, but distal caries was observed in the CBCT evaluation. The proportion of images with distal caries in both CBCT and panoramic evaluation was 20.1%. Similarly, in 7.2% of the examinations, distal caries was observed in the panoramic evaluation but not in the CBCT evaluation.

Table 3. Comparison of CBCT and panoramic radiography for the presence of external root resorption in patients

External Root Resorption 0 1			Panoramic		Total
CBCT	0	n	153	33	186
		%	82.3%	17.7%	100.0%
		% Dental class	67.7%	20.4%	47.9%
		% Total	39.4%	8.5%	47.9%
	1	n	73	129	202
		%	36.1%	63.9%	100.0%
		% Dental class	32.3%	79.6%	52.1%
		% Total	18.8%	33.2%	52.1%
X2: 84.692			p: 0.000*		

There is a statistically significant relationship between the panoramic and CBCT evaluation groups in terms of external root resorption (p<0.05). The proportion of images in which external root resorption was not found in panoramic evaluation but was found in the CBCT evaluation was 18.8%. The proportion of images with external root resorption in both CBCT and panoramic evaluation is 33.2%. Similarly, in 8.5% of the examinations, external root resorption was observed in the panoramic evaluation but not in the CBCT evaluation.

Table 4: Comparison of CBCT and panoramic radiography for the presence of marginal bone loss in patients

Marginal Bone Loss 0 1			Panoramic		Total
CBCT	0	n	50	25	75
		%	66.7%	33.3%	100.0%
		% Dental class	44.2%	9.1%	19.3%
		% Total	12.9%	6.4%	19.3%
	1	n	63	250	313
		%	20.1%	79.9%	100.0%
		% Dental class	55.8%	90.9%	80.7%
		% Total	16.2%	64.4%	80.7%
X2: 63.483			**p: 0.000***		

There was a statistically significant correlation between the panoramic and CBCT evaluation groups in terms of marginal bone loss between the two teeth (p<0.05). 64.4% of the radiographs showed marginal bone loss in both panoramic and CBCT evaluations, while 16.2% showed marginal bone loss in CBCT images that was not observed in panoramic radiography. In 9.1% of the radiographs in which bone loss was observed on panoramic evaluation, no bone destruction was observed on CBCT evaluation.

Table 5. Statistical evaluation of marginal bone loss measurement in patients

		Mean ± Standard Deviation	Minimum	Maximum	Test Value	p
Gender	Female	3.47±2.02	0.00	10.88	2.754	0.005*
	Male	2.92±1.46	0.00	6.70		
Jaw	Maxilla	3.24±1.61	0.00	10.88	0.671	0.503
	Mandibula	3.11±1.84	0.00	10.03		
Dental Class	18	1.45±0.20	0.00	6.66	1.265	0.286
	28	1.70±0.20	0.40	10.88		
	38	1.69±0.16	0.00	7.38		
	48	2.01±0.21	0.00	10.03		
Position	Inverted	1.89±3.27	0.00	5.66	1.652	0.177
	Position a	3.50±2.09	1.00	10.88		
	Position b	2.96±1.71	0.00	10.03		
	Position c	3.25±1.67	0.00	9.42		
Class	Inverted 1	1.89±3.27	0.00	5.66	2.696	0.047* (1>2.3)
	Position I 2	4.35±2.59	0.00	10.03		
	Position II 3	3.00±1.61	0.00	6.72		
	Position III 4	3.25±2.28	0.00	9.42		

*p<0.05

The marginal bone loss in the adjacent tooth of the impacted third molars examined in the study was measured in mm on CBCT radiographs. While there was no statistically significant difference in bone loss measurements according to the jaw and depth classification (p>0.05), there was a statistically significant difference according to gender and ramus classification (p<0.05). It is seen that the bone loss mm values of females are higher than those of males. The bone loss mm values of Class I teeth were higher than those of Class II and Class III teeth.

DATA ANALYSIS

The data obtained in the study were analyzed using the SPSS 25.0 program. Descriptive statistical methods (number, percentage, minimum-maximum values, mean, and standard deviation) were used to evaluate the data.

The normal distribution of the data depends on the skewness and kurtosis values being between ±1.5. For the comparison of quantitative data in normally distributed data, an independent sample t test was used for the difference between two independent groups, a one-way analysis of variance was used for the difference between more than two independent groups, and a Bonferroni pairwise comparison test was used to determine which group the difference originated from. The relationship between categorical variables was investigated with the chi-square test. The significance level was accepted as 95%.

DISCUSSION

Impacted third molars are a common oral health problem that causes problems such as pain, swelling, and infection in patients and may cause pathologies such as caries, external root resorption, or bone destruction, which are often unrecognized by the individual.[5] Long-term retention of these teeth in the jaws is known to be a risk factor for related pathologies such as caries, periodontal diseases, cysts, and tumors.[6]

Discussion of the Material Method

In addition to intraoral examinations, radiologic examinations are also needed for a detailed examination of the complications caused by impacted third molars. Two-dimensional imaging modalities such as periapical, occlusal, and panoramic radiographs are the standard diagnostic imaging modalities for the evaluation of teeth and surrounding lesions.[7] Although it has a lower radiation dose compared to CBCT, it has disadvantages such as lack of buccolingual evaluation, failure to show initial lesions, superposition of surrounding tissues, magnifications, distortion of images, and perspective problems.[8,7] In the images obtained with CBCT, tissues are examined in coronal, sagittal, and axial sections without superposition.[4]

Matzen et al.[9] evaluated the pathologic findings related to mandibular third molars, resorption, and marginal bone loss in second molars comparatively on PR and CBCT images in their study with four observers. They examined variables such as angulation type, contact point with the second molar, resorption and marginal bone loss on the distal surface of the tooth, and the presence of periodontal space in the third molars.

Yeşiltepe et al.[10] examined 188 maxillaries impacted third molars in 121 patients aged 18 years and older on CBCT images. Embeddedness, angulation type, root development, follicle width, relationship with the maxillary sinus, marginal bone loss distal to the adjacent maxillary second molar, presence of caries, and level of distal root resorption were evaluated by two observers.

Kang et al.[3] classified five hundred mandibular third molars without root resorption, large cavities, and cystic lesions in CBCT images of 469 patients according to their degree of impactedness and angulation and retrospectively analyzed findings such as the presence of distal caries in the second molars, the cementoenamel junction distance between the second and third molars, and the presence of pericoronitis in the third molars according to age and gender.

Our study is similar to the studies of Matzen et al.[9] and Yeşiltepe et al.[10] in terms of the images used and the parameters analyzed. One of the differences of our study is that Matzen et al.[9] additionally examined the increased periodontal space in the third molar in their evaluation of panoramic and CBCT images. In addition to these parameters, we also examined the presence of distal caries. The differences in our study are that both maxillary and mandibular teeth were evaluated, and the relationship of maxillary teeth to the sinus was not evaluated. However, we classified the impacted teeth in our study in the same way as Kang et al.[3]

Discussion of Radiographic Evaluations

a. Evaluation of the relationship with the anterior edge of the ramus

Patel et al.[11] compared panoramic radiography and CBCT findings for the relationship between impacted mandibular third molar root and inferior alveolar nerve canal and found a prevalence of 51% Class I, 36.5% Class II, and 11.5% Class III impacted third molars.

Garcia et al.[12] found a prevalence of 32% in Class I, 28% in Class II, and 39% in Class III in their study, in which they examined 166 teeth to evaluate the difficulty of surgical extraction according to the Pell & Gregory classification.

Göksu et al.[13] reported that 46.2% were in Class II, 27.1% in Class III, and 26.7% in Class I positions in their study.

In our study, we observed the mandibular third molars more or less in Class II (73.7%), Class III, and Class I positions, respectively. Although studies on the evaluation of impacted mandibular third molars according to ramus distance have reported different results, the majority of them show that the mandibular third molars are usually impacted in Class II and Class III positions. In our study, it was observed that the lower impacted third molar was frequently found in Class II and Class III positions. These results, which are consistent with the literature, support the idea that space limitation is highly associated with impacted teeth. The Class I position was found to be the least common position, with a rate of 7.2%.

b. Evaluation of the type of angulation

Jung and Cho[16] evaluated CBCT data and found that the most common angulation type of maxillary third molars was vertical (59.0%), followed by buccoangular (18.2%) and mesioangular (13.2%).

Göksu et al.[13] retrospectively analyzed the positions of impacted mandibular third molars from a demographic point of view on panoramic X-ray images and reported that vertical angulation was the most common according to the Winter classification.

Patel et al.[11] reported the most common angulation type as vertical in their study, in which they compared panoramic and CBCT findings for the relationship between the root and inferior alveolar nerve canal of impacted third molars.

Peker et al.[14] reported that the most common angulation type was mesioangular in their study, in which they examined the relationship with the inferior alveolar canal in the preoperative examination of mandibular impacted third molars using panoramic X-rays and CBCT.

Syed et al.[4] reported that the most common angulation type was mesioangular (60.4%) and then horizontal (24.4%) in their study, in which they examined 979 panoramic radiographs from Saudi people and found that 39% of impacted third molars caused distal caries in the second molars.

It is difficult to compare studies on impacted third molars due to different classification systems (according to angulation, degree of impactedness, and ramus). In most of the studies, classifications were made with two-dimensional imaging. However, in our study, the images were evaluated with both two- and three-dimensional graphics, and it was found that the most common angulation type was mesioangular, followed by vertical and horizontal types, respectively. The least common angulation type, lingoangular position, was seen in 4.1% of the teeth.

In our study, in agreement with Peker et al.[14] and in contrast to Jung and Cho[16] and Göksu et al.[13], the most common angulation type was the mesioangular type. These proportional differences in the literature are thought to be due to the study method and the genetic differences of the patient group included in the study. In addition, in our study, the presence of distal caries (panoramic 10.8%; CBCT 10.6%) was found most frequently in the teeth in the mesioangular angulation, in accordance with the study of Syed et al.

c. Evaluation of the depth relationship according to the occlusal table

When the literature is examined, Hugoson and Kugelberg[17], who investigated the classification of impacted teeth according to the adjacent second molar, reported that position A was more common in the lower jaw, while Quek et al.[18] reported that position B was common in 85% of impacted teeth in the lower jaw. Yuasa et al.[19] found similar results, with a rate of 42.1% for position B and 29.6% for position C. In the teeth included in our study, position C was observed most frequently, with a rate of 49.5% according to the Archer classification, followed by position B with 34.3% and position A with 13.7%. We attribute the high rate of position C in our study, which is different from the literature, to the fact that the studies were conducted with individuals belonging to different races and that genetic differences were determinative for these reasons.

d. Evaluation of caries distal to the second molar

Dental caries is one of the most common problems seen in panoramic radiographs of second molars adjacent to third molars.[3] Distal surface caries in the second molar is considered a late complication of eruption or impacted third molars.[20] Caries caused by impacted third molars in second molars sometimes require the removal of the third molar and restoration of the caries defect. Furthermore, in some cases where caries lesions are too large to be restored, the involved second molars are extracted, resulting in a significant loss of masticatory function. Early detection and evaluation of the caries' risk associated with second molars may help in the prevention of distal caries in second molars.[3]

Özeç et al.[21] reported that the prevalence of distal second molar caries associated with partially or completely impacted third molars ranged from 20% to 47% in their study based on panoramic X-rays. McArdle et al.[22] reported a 15% incidence of distal caries in their study, in which they calculated the costs associated with distal caries of second molars associated with impacted mandibular third molars with a mesioangular angle. Kang et al.[3], using cone beam computed tomography to diagnose caries, found that the rate of an affected caries on the distal surface of the adjacent mandibular second molars caused by mandibular third molars was as high as 52%.

Xiang et al.[23] analyzed distal caries on the distal surface of the distal surface of the mandibular second molars induced by impacted mandibular third molars using panoramic X-rays and found that the prevalence of distal caries was 37.6% and the caries rate in position B was higher than in position A. In our study, the prevalence of distal caries in position B was 13.4% on panoramic radiography and 12.4% on CBCT.

Ye et al.[24] reported the presence of distal caries in mandibular second molars with a prevalence of 18.75% in a study conducted to evaluate the relationship between impacted mandibular third molars and pathologies caused by impacted third molars. 72.22% of the mandibularly impacted third molars were observed in position A, 20.83% in position B, and 6.94% in position C. They also reported that the frequency of distal caries in mandibular second molars was highest in mesioangular impacted teeth in position A. We detected distal caries most frequently in position B, with a rate of 13.4% in panoramic and 12.4% in CBCT. The results of our study are consistent with those of Xiang et al.[23], but not with those of Ye et al.[24]

AlHobail et al.[25] analyzed panoramic and bitewing radiographic images for the presence of caries on the distal surface of second molars associated with third molars in Saudi patients and found a prevalence of 48.6%. They identified mesioangular angulation as a risk factor for distal caries. They also reported distoangular impaction as a protective factor for dental caries.

In our study, distal caries due to impacted third molars were detected in 27.3% of panoramic radiographs and 31.7% of CBCT. This result is generally compatible with the results reported in the literature.[3,21-25] This proportional difference between the studies may be due to the number of patients/teeth, oral hygiene status/adherence to the selected population, and inclusion criteria.

In our study, distal caries was found to be 8% panoramic and 10.9% CBCT in the maxilla, while it was 37.8% panoramic and 42.2% CBCT in the mandible, and a significant difference was found between the jaws in terms of caries incidence rates. In this study, the incidence of caries may have been different in the CBCT assessment, possibly because some surface caries was not easily identified on panoramic radiographs. This suggests that CBCT has greater sensitivity and accuracy than panoramic and intraoral radiographs in the diagnosis of caries adjacent to the distal aspect of the second molar.

In routine treatment procedures, panoramic radiography is preferred to CBCT due to reservations about cost, equipment, and radiation dose. However, in prosthodontic, orthodontic, and surgical treatments and periodontal procedures where the second molars are to be retained in the mouth (use as an abutment for prosthodontic restorations and orthodontic treatments, restoration of lost occlusion, fixation in cases of trauma, support in cases where there are many missing teeth in the anterior region, splinting, etc.), the retention of the second molars gains value. In cases where prognosis is important, it is absolutely necessary to keep the second molars in the mouth. In terms of its superiority in detecting initial pathologies, CBCT can be used by the physician in such cases, considering the profit-loss ratio.

In our study, CBCT evaluation found that mesioangular impacted third molars caused distal caries with a rate of 36.8% in the mesioangular, 30% in the horizontal, and 38.5% in the vertical. These rates were found to be 36% in the mesioangular, 35.7% in the horizontal, and 25.7% in the vertical in the panoramic evaluation. Our study is consistent with the studies of Ye et al.[24], AlHobail et al.[25], and McArdle et al.[22]

The highest caries rate (37.5%) in the neighboring second molars in CBCT images occurred in the third molar Class II position. This may be due to the fact that the impacted third molar creates a gap with the adjacent second molar, which leads to a higher food accumulation effect that is not conducive to cleaning and caries formation on the surface of the nearest second molar.

There is a lack of comparative panoramic and CBCT studies investigating distal caries associated with third molars in the literature. Our study aims to shed light on this gap in the literature. In the 388 teeth examined in this study, distal caries was observed in 78 teeth in common on CBCT and panoramic X-rays. While distal caries was observed in a total of 121 teeth in the CBCT evaluation, it was determined in 106 teeth in the panoramic evaluation. The reason for the 28 teeth (7.2%) with distal caries on panoramic X-rays but not on CBCT was thought to be cervical burnout or the optical illusion effect, which is among the panoramic image errors. In addition, the rate of teeth with distal caries on CBCT was 31.2%, while this rate was 11.1% on panoramic. This suggests that approximately two out of three caries cannot be observed on panoramic X-rays and that the physician may miss two out of every three caries. Further studies are needed to obtain more detailed information on this subject.

e. Evaluation of marginal bone defect on the distal surface of second molars

Bağış et al.[26], in their study comparing intraoral radiography and CBCT in the detection of periodontal defects, reported that CBCT achieved the highest sensitivity and diagnostic success in the detection of many periodontal pathologies. They also reported that this success was higher in posterior teeth than in anterior teeth.

Matzen et al.[27] measured the marginal bone loss on the distal surface of the mandibular second molars associated with impacted third molars on CBCT images and reported a marginal bone loss rate of approximately 49%. They identified mesioangular and horizontally positioned mandibular third molars as risk factors. They also reported the agreement between panoramic and CBCT as 66-85% for marginal bone loss and 54-74% for external root resorption.

Dias et al.[28] compared marginal bone loss in second molars due to impacted mandibular third molars between panoramic images and CBCT and found an incidence of 62.9% in panoramic images and 80% in CBCT images. Approximately 29% of the teeth with no bone loss on panoramic images showed bone loss on CBCT scans. In general, they reported that panoramic X-rays underestimate the severity of bone destruction compared to CBCT.

Hermann et al.[29] found the incidence of marginal bone loss in the distal part of maxillary second molars to be 84.9% on CBCT scans and 81.6% on panoramic scans in a comparative study of upper jaw teeth using panoramic and CBCT images. They found that although some of the resorption seen on CBCT was not seen on panoramic X-rays, it could be seen to a large extent.

Moreira-Souza et al.[30], in a review of 539 articles, reported that the prevalence of marginal bone loss ranged from 21.9% to 62.9% on panoramic and 21.6% to 80% on CBCT. They reported that the consistency between panoramic and CBCT ranged between 66% and 85%.

This study is consistent with the studies of Dias et al., Hermann et al., and Moreira-Souza et al. The incidence of marginal bone loss was 80.7% on CBCT and 64.4% on panoramic X-ray. In addition, it was determined that teeth in the mesioangular position caused 82.5% marginal bone loss in panoramic and 89.5% in CBCT. In horizontal angulation, 81.4% marginal bone loss was observed in panoramic and 87.1% in CBCT. This result confirms mesioangular and horizontal angulation as risk factors.

In our study, it was observed that the greater the depth of the impacted tooth in the mandible, the more marginal bone loss was observed. In panoramic evaluation, the incidence of bone destruction was 8.5% in position A, 26% in position B, and 36.1% in position C. In the CBCT evaluation, the incidence of bone destruction was 8.8% in position A, 28.4% in position B, and 43.3% in position C.

It seems reasonable to evaluate marginal bone loss by CBCT, as it is more reliable in making the diagnosis. Therefore, CBCT is indicated when a treatment decision is to be made for second molar resorption.

f. Evaluation of external root resorption in second molars

When the impacted teeth are close to the roots of the neighboring teeth, they may initiate the process of external root resorption through mechanical and chemical stimuli on the neighboring tooth root.

In their study, Yamaoka et al.[31] reported that external root resorption due to third molars was more common in males and associated this with the effect of sex hormones. In our study, no significant difference was found between external root resorption and gender.

Tunç et al.[32] reported a higher incidence of external root resorption in CBCT studies compared to studies using panoramic radiography. Since CBCT provides multi-planar reconstruction images, external root resorption of the second molars caused by the third molars can be evaluated more accurately than two-dimensional imaging techniques.

Vaz de Souza et al.[33] compared CBCT and periapical radiographs in the detection of external root resorption in mandibular teeth and found that CBCT was significantly better in the detection of external root resorption. In our study comparing panoramic and CBCT images, we found that the frequency of external root resorption was higher on CBCT (52.1%) than on panoramic radiographs (33.2%). In 10.3% of patients who did not have external root resorption on panoramic radiographs, we observed external root resorption on CBCT images. In the presence of mesioangularly impacted mandibular third molars, the incidence of external root resorption in the second molars was 35.1% on panoramic and 45.6% on CBCT. In addition, the incidence of external root resorption in teeth in position C was 24.2% on panoramic and 31.7% on CBCT. The fact that the contact area between the second and third molars is wider in this type of angulation

and depth leads to more transmission of mechanical pressure to the tooth roots due to eruption movement that may cause resorption.

Li et al.[32] found the prevalence of external root resorption to be 32.6% in the maxilla and 52.9% in the mandible in a retrospective study of CBCT images. Mesioangular and position C third molars were identified as risk factors. In our study, the prevalence was 55.5% for maxilla and 34.3% for mandible on panoramic, and 71.5% for maxilla and 41.4% for mandible on CBCT. These proportional differences in the literature are thought to be due to differences in the study method and the patient group included in the study.

Wang et al.[34] evaluated the incidence of external root resorption in second molars with mesioangular and horizontally impacted mandibular third molars using CBCT images from patients in China and reported that patients with 29.8% impacted in position A had the highest incidence of external root resorption in second molars, followed by position C (24.5%) and B (16.1%). Similarly, a gradual increase in the incidence of external root resorption was observed from position A to C in both CBCT and panoramic evaluation. In our study, in accordance with the literature, mandibularly impacted third molars in position C had a higher incidence of external root resorption than those in positions A and B (34-35). This may be due to the fact that the point of contact with the neighboring tooth as a result of the eruption movement coincides with the root surface of the second molar tooth and induces external root resorption.

In our study, it was also found that the incidence of external root resorption was higher in the maxilla (71.5%) than in the mandible (41.4%) on CBCT and in the maxilla (55.5%) than in the mandible (34.3%) on panoramic. Similar results were reported by Oenning et al.[36], Li et al.[35], and Tunç et al.[32] who reported that 33.6% of impacted 3rd molars caused external root resorption, and this rate was 22% and 11.6% in the maxilla and mandible, respectively.

Caries, external root resorption, and marginal bone destruction in the distal part of the second molars are among the complications associated with impacted third molars, and it has been reported that CBCT is a more detailed method than two-dimensional imaging for detecting such complications before intervention in impacted third molars.[9,10,29,30] Although there are publications on CBCT, comparative studies of three-dimensional and two-dimensional imaging techniques in diagnosis are lacking in the literature.[29,30] In this study, the relationship between second molars and impacted third molars was demonstrated on CBCT and panoramic X-rays.

Detection and evaluation of pathologies such as external root resorption, marginal bone loss, and caries are difficult on panoramic X-rays due to the superposition of anatomical structures and adjacent teeth. In a study by Hermann et al.[29], it was reported that the detection of external root resorption was not possible with panoramic compared to CBCT, while the detection of marginal bone loss was partially possible. In addition, it has been demonstrated in the literature that 2D imaging methods such as panoramic, periapical, and bitewing are not as successful as CBCT in detecting caries lesions in the distal part of the second molar.[21,37]

Three-dimensional information is usually required to evaluate root resorption and root surface morphology, especially in the early stages.[38] While external root resorption was detected on CBCT in 202 second molar teeth adjacent to 388 impacted third molars, no resorption was detected on a panoramic radiograph in 73 of these teeth, and no resorption was seen on CBCT in 33 of 162 teeth with external root resorption on a panoramic radiograph. The two imaging methods showed a common finding of external root resorption in only 129 teeth (33.2%). Similarly, the presence of external root resorption in both imaging techniques was consistent with the studies of Alqerban et al.[39] (4.9%) and Oenning et al.[36] (4.3%). The underlying reason for this result is thought to be the fact that CBCT provides three-dimensional images, and that superposition is not seen in films viewed in the axial and sagittal planes.

CONCLUSION

CBCT is a more reliable method than panoramic radiography in the evaluation of distal caries, marginal bone loss, and external root resorption pathologies. Impacted third molars close to occlusion but not reached (position B) were identified as a risk factor for distal caries. Physicians should inform individuals about this area, which is risky in terms of soft tissue retention and food accumulation in terms of oral hygiene.

The prognosis of asymptomatic third molars located in the bone may be underestimated by clinicians. However, in our study, it was determined to be a risk factor for external root resorption and marginal bone loss. Therefore, prophylactic extraction may be considered. Class 2 position was determined as a risk factor for all three pathologies (distal caries, external root resorption, and marginal bone loss). In third molars that are close to eruption, the physician should carefully examine the second molar and adjacent structures.

External root resorption is most commonly observed in the horizontal and mesioangular positions, while marginal bone loss is most commonly observed in the mesioangular position. Therefore, the patient should continue to be followed up for external root resorption and marginal bone loss in teeth that continue to erupt and are close to the second molars.

ETHICAL DECLARATIONS

Ethics Committee Approval: The ethics committee approval required for the study, which was conducted at Dicle University Faculty of Dentistry, Department of Restorative Dental Treatment, was evaluated at the Dicle University Faculty of Dentistry Ethics Committee meeting dated 28.04.2021, numbered 4, and the decision was taken with the meeting decision with protocol number 2021/27.

Informed Consent: All patients signed and free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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