CASE REPORT

The Effect of Maxilla Impacted Canine Positions on Root Resorption of Adjacent Teeth Using Cone-Beam Computed Tomography Imaging

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ABSTRACT

Objective. To determine the effect of the impacted position of the maxillary canine on the root resorption of the adjacent incisor using Cone-beam Computed Tomography (CBCT) imaging.

Methods. This was an analytic quantitative study. The research sample determined CBCT images of treatment patients at the Orthodontic Specialist Policlinic in Dental Hospital of Airlangga University over a three-year period and secondary data taken from Pramita Laboratory. CBCT photos that met the inclusion criteria, including mesially impacted canine or close to central or lateral incisors with completely formed anatomy were then analyzed. Multiple linear regression was used to determine x-axis, y-axis, z-axis position of the impacted canine on the severity of root resorption of the adjacent incisor, and the effect of impacted canines on all axes simultaneously on the severity of root resorption of the adjacent incisors.

Results. The position of the impacted canine in the x-axis and z-axis planes had a significant influence on the root resorption of the adjacent incisor. Meanwhile, impacted canine from the y-axis plane showed non-significant influence on the root resorption.

Conclusion. The position of the impacted canine when viewed in all planes of the tooth axis has a significant effect on the severity of root resorption of the adjacent incisor.

Keywords: canine impaction, root resorption, cone-beam computed tomography, CBCT

INTRODUCTION

Impaction is the inhibition or termination of the normal process of the tooth. There are various terminology in the literature to define impaction including delayed eruption, primary retention, buried tooth, impacted tooth, etc. A canine is considered impacted if it is disturbed after complete root development or the contralateral tooth has erupted for at least 6 months with complete root form.[1] In general, the canines play an important role in establishing functional occlusion and serve as the foundation of an esthetic smile.[2] In addition to the third molars, the maxillary canines are the teeth most frequently impacted.[3] The etiology of impacted canines remains unclear and appears to be multifactorial. Predisposing local factors such as congenital missing lateral incisors, supernumerary teeth, odontomas, and other conditions that interfere with canine eruption, have been implicated. Genetic factors are also possible in some cases.[4] In Indonesia, a study shows there is 2.7% prevalence of canine impaction and 57.9% of cases found in age group of 15–24 years.[5]

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An impacted canine can cause several complications such as shortening of the arch length, migration of adjacent teeth, esthetic implications, cyst formation, or canine ankylosis.[6] In addition, one of the most severe complications is root resorption of adjacent teeth. As a result, it will affect the resistance of adjacent teeth in the oral cavity. Therefore, early detection and prevention will reduce the need for canine exposure and simplify orthodontic treatment.

Root resorption is a common complication of orthodontic treatment. Severe root resorption (>3mm) has been reported to occur with a frequency of 10-20%.[7] Extreme root resorption (>1/3 of the original root length) is very rare and modified treatment should be taken to prevent this complication. In addition, resorption can be difficult to diagnose by conventional methods, especially if the canines are located overlapping palatally or buccally against the incisor roots.[8]

Severe root resorption is characterized by loss of more than one third of root length. This condition can interfere with the success of orthodontic treatment, reduce tooth length and tooth capacity to withstand masticatory forces, and limit their use as anchor teeth in prosthetic rehabilitation.[6] In one study it has been shown that root resorption of the upper incisors during the first 6-9 months of treatment with fixed orthodontic appliances poses a high risk for continued resorption during subsequent treatments.[9]

Maxillary incisor root resorption is a phenomenon that can occur in patients with impacted canines, and can be at risk of developing severe root resorption. Although, severe incisor root resorption associated with impacted maxillary canines is rare, when it occurs it threatens the long-term prognosis of the resorbed tooth.[10] Early diagnosis and analysis of root resorption as a result of impacted canines is essential to salvage the resorption of teeth and to assist in planning appropriate treatment.

Conventional two-dimensional radiographs are usually used to view impacted canines. One of them, panoramic radiography is often taken to see the general picture, initial diagnosis, canine localization, prediction of tooth eruption, treatment plan, and assessment of treatment outcome. However, the diagnostic information obtained from panoramic radiographs is limited because it has many weaknesses, such as distortion, magnification, artifacts, image blur, or superimposition.[11] Although panoramic radiographs are the standard diagnostic tool in orthodontics, the risk of misinterpretation when reading panoramic radiographs is high. Thus, panoramic radiography is not the only method in detecting canine impaction and root resorption, especially on the palatal or buccal aspect.[12] Therefore, other radiographic techniques are needed to determine the exact position of the impacted canine and determine the resorption of the lateral incisor.

In this case, due to the good contrast of dental tissue and proper three-dimensional imaging, some authors use cone-beam computed tomography (CBCT) to evaluate canine impaction and lateral incisor resorption. This machine uses radiation in the form of cones to collect information on the maxillofacial region with high spatial resolution. In addition, CBCT can reduce costs and significantly reduce radiation dose.[12,13]

One of the advantages of CBCT is that it provides an undistorted three-dimensional image with excellent resolution, allowing visualization of shape anatomy and original size. So that the researcher can see the position canine impaction in the fields of the x-axis, y-axis, and z-axis, and can analyze root resorption of the inconsistent tooth affected by the canine impaction on all side of the root of the tooth. This study was conducted to determine the effect of the impacted position of the maxillary canine on the root resorption of the adjacent incisor using CBCT imaging.

METHODS

Study Design

This study used a quantitative, descriptive and correlational approach in examining whether there was an influence between the position of the impacted canine on the level of root resorption of the adjacent tooth.

Ethical Considerations

The protocol was approved by the institutional ethics committee with ethical clearance number 182/HRECC. FODM/IV/2021.

Study Population

The study population was determined using CBCT radiographic data of patients at the Orthodontic Specialist Clinic RSGM Airlangga University and secondary data was taken from Pramita Laboratory.

Inclusion criteria

1. Patients who come to the Orthodontic Specialist Clinic RSGM Universitas Airlangga for the period 2018–2020
2. Patients with unilateral/bilateral impacted maxillary permanent canines
3. The patient has never had orthodontic treatment / is currently under orthodontic treatment but has not had canine surgery
4. Patients with a complete canine anatomy based on CBCT radiograph (the crown and roots are fully formed)
5. Patients with impacted canines that tend to be mesial or close to the central and lateral incisors
6. Patients over 13 years old, male or female

Exclusion Criteria

1. The patient has had orthodontic treatment and canine impaction surgery
2. Patients who have anomalous number of teeth
3. Patients who have jaw anomalies
4. Radiographic signs of dental trauma
5. The quality of the radiographs is not good

6. There is a cyst or tumor around the impacted canine
7. The patient with the impacted canine position is far from the central and lateral incisors

Sampling

The sampling technique in this research is total sampling. Total sampling is a sampling technique where the number of samples is the same as the population. The reason for taking total sampling is because the number of population of CBCT radiograph with maxillary canine impaction is less than 50 therefore, the research sample involves the entire population. Based on the sampling technique, the sample size was 22 pair samples from CBCT radiographs (right and left region) obtained at Universitas Airlangga Hospital and Pramita Laboratory.

Image Analysis

CBCT photos that met the inclusion criteria were then analyzed using imaging analysis software (Dolphin 11.7, Dolphin Imaging & Management Solutions, Chatsworth, California). The position of the impacted canine on the CBCT photo is divided into 3 planes, namely: x-axis, y-axis, and z-axis. The measurement of the sector location of the maxillary canine tip in relation to the adjacent incisors was divided into five sectors on the CBCT radiograph. Whereas in the y-axis plane it is measured based on the height of the crown of the canine vertically which is divided into three divisions (Figure 1). The labio-palatal position of the maxillary canine impaction and maxillary incisor resorption were assessed on CBCT radiographs classified as labial, mid-alveolar, or palatal. The contact of the impacted canine with the incisor and the presence of root resorption of the lateral incisor were viewed axially and transactionally and assessed from 4 categories (Ericson and Kurol 2000), namely:

1. No resorption – intact root surfaces, except for loss of cementum
2. Mild resorption – up to half of the dentine thickness to the pulp
3. Moderate resorption – half way to the pulp or more; the pulp is covered with dentine
4. Severe resorption – the pulp is exposed[12]

Furthermore, the position of the impacted canine on the CBCT photo of the 3 x-axis, y-axis, and z-axis planes was analyzed as well as the possibility of root resorption of the maxillary incisor on the CBCT radiograph (Figures 1 and 2).

Statistical Analysis

The data that has been obtained will be further analyzed using multiple linear regression analysis using SPSS 21 software to answer the following research hypotheses:

The data that has been obtained will be further analyzed using multiple linear regression analysis using SPSS 21 software to prove the research hypothesis that has been determined as follows:

1. The x-axis position of the impacted canine exerts an effect on the severity of root resorption of the adjacent incisor.
2. The y-axis position of the impacted canine exerts an effect on the severity of root resorption of the adjacent incisor.
3. The z-axis position of the impacted canine exerts an effect on the severity of root resorption of the adjacent incisor.
4. All axes' positions of the impacted canine simultaneously exert an effect on the severity of root resorption of the adjacent incisors.

RESULTS

A total of 32 impacted maxillary canines was included in the analysis. Twenty (20) samples of impacted maxillary canine showed central incisive root resorption; 12 showed lateral incisive resorption. There were 2 patients with central incisive experiencing mild root resorption, and 2

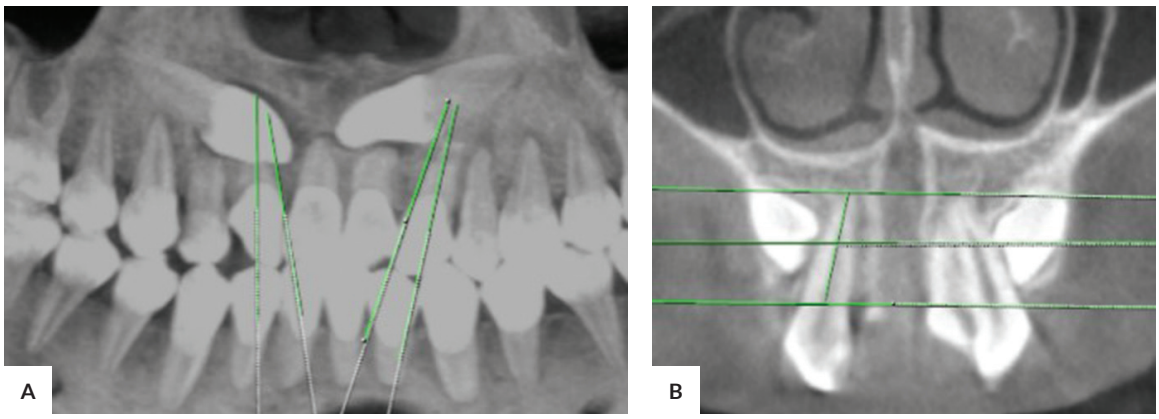

Figure 1. (A) The measurement of the sector location of the maxillary canine tip in relation to the adjacent incisors. **(B)** The y-axis plane is measured based on the height of the crown of the canine vertically.

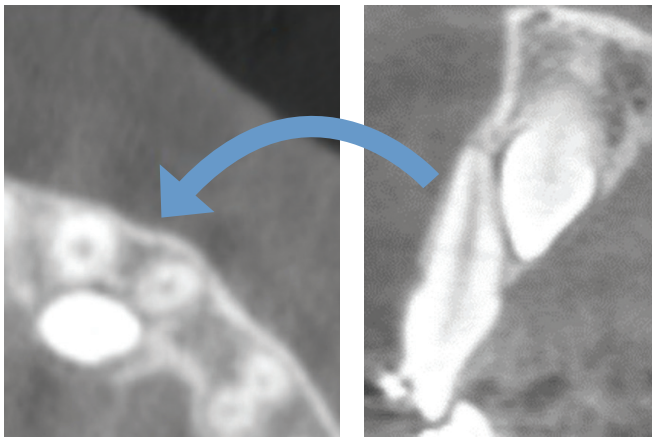

Figure 2. The labio-palatal position of the maxillary canine impaction and maxillary incisor resorption were assessed on CBCT.

lateral incisive and 4 central incisive experiencing moderate root resorption.

Table 1 shows that the position of the x-axis, y-axis and z-axis in the case of impacted canines may represent the severity of root resorption of the adjacent incisors by 45.7%. While the remaining 54.3%, represented by other variables not examined in this study.

The ANOVA table was used to test the simultaneous hypothesis stated above (Table 2). The criteria for testing the hypothesis is that if the significance value is < 0.000 then the proposed hypothesis is accepted, or in other words, there is a significant effect of the position of the impacted canine on the severity of root resorption of the adjacent incisor. Furthermore, it can be seen that the probability magnitude (Sig.) is 0.001 < 0.05. The more severe the impaction rate on all axes, the more severe the root resorption of the adjacent incisor.

Table 3 explained that the regression equation will be compiled using the beta value in the Standardized Coefficients, because the scale of measurement and the units specified in obtaining the data have been standardized beforehand. ANOVA analysis was used to see the relation of impaction position and severity of resorption. Based on Table 3, it is concluded that there is positive significant relation between impaction position and resorption level. The regression equation in this study is as follows.

$$y = \alpha + \beta 1 \times 1 + \beta 2 \times 2 + \beta 3 \times 3 + e$$

$$y = 0.713 \times 1 + 0.334 \times 3$$

Table 1. Research data

Variable			Z-axis position			Gender		Root Resorption Level				
									Resorption			
X	Y	Z	a	l	p	M	F	No Resorption	Central Incisive		Lateral Incisive	
									Mild	Moderate	Mild	Moderate
1	1	2	0	0	1	0	1	1	0	0	0	0
1	2	2	0	0	3	0	3	2	0	0	1	0
1	2	3	4	0	0	2	2	3	0	0	1	0
1	3	2	0	0	1	1	0	1	0	0	0	0
1	3	3	2	0	0	0	2	1	0	0	1	0
2	1	3	1	0	0	1	0	0	0	0	1	0
2	2	2	0	0	2	1	1	1	0	0	1	0
2	2	3	2	0	0	1	1	0	0	0	2	0
2	3	2	0	0	1	0	1	0	0	0	1	0
2	3	3	1	0	0	0	1	0	0	0	1	0
3	1	2	0	0	1	0	1	0	0	0	1	0
3	3	2	0	1	1	0	2	1	0	0	1	0
3	3	3	1	0	0	0	1	0	0	0	0	1
4	1	2	0	0	2	0	2	2	0	0	0	0
4	2	1	0	0	1	0	1	0	0	0	1	0
4	2	2	0	0	4	0	4	0	1	2	0	1
4	2	3	2	0	0	0	2	0	0	2	0	0
4	3	2	0	0	1	0	1	0	1	0	0	0
Subtotal			13	1	18	6	26	12	2	4	12	2
%			41%	3%	56%	19%	81%	38%	6%	13%	38%	6%
Total										32		

Information: X: x-axis planes, Y: y-axis planes, Z: z-axis planes, mid-alveolus, l: labial, p: palatal, M: male, F: female

Table 2. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.676[a]	0.457	0.399	0.57194

[a] *Dependent Variable: r*

Table 3. ANOVA test[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.716	3	2.572	7.863	0.001[b]
	Residual	9.159	28	0.327		
	Total	16.875	31			

[a] *Dependent Variable: r*
[b] *Predictors: (Constant), z, y, x*

Table 4. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.652	0.669		-2.467	0.020
	x	0.415	0.087	0.713	4.747	0.000
	y	0.192	0.158	0.171	1.214	0.235
	z	0.445	0.200	0.334	2.229	0.034

[a] *Dependent Variable: r*
[b] *Predictors: (Constant), z, y, x*

Furthermore, the coefficient table is used further to test the partial hypothesis that has been proposed previously (Table 4). The criteria for testing the hypothesis is that if the significance value is < 0.000 then the proposed hypothesis is accepted, or in other words, there is a significant effect of the position of the impacted canine on the severity of root resorption of the adjacent incisor. The results of hypothesis testing are as follows:

1. Under normal conditions, or in other words the performance of the x-axis and z-axis positions is 0, then the performance of the root resorption severity of the adjacent incisor is 0.
2. For every 1 point increase in the performance osf the x-axis position on the impacted canine, the performance of the root resorption of the adjacent incisor root will increase by 0.713.
3. For every 1 point increase in the performance of the z-axis position on the impacted canine, the performance of the root resorption of the adjacent incisor root will increase by 0.334.

Furthermore, the coefficient table is used further to test the partial hypothesis that has been proposed previously. The criteria for testing the hypothesis is that if the significance value is < 0.000 then the proposed hypothesis is accepted, or in other words, there is a significant effect of the position of the impacted canine on the severity of root resorption of the adjacent incisor. The results of hypothesis testing are as follows:

1. The results of the x-axis coefficient test show that the probability (Sig.) is 0.020 < 0.05, then the hypothesis is accepted and it can be concluded that the more severe the impaction of the canine on the x-axis, the more severe the incisor root resorption is adjacent.
2. The results of the y-axis coefficient test show that the probability (Sig.) 0.235 > 0.05, then the hypothesis is rejected and it can be concluded that the canine impaction on the y-axis has very little effect on the possibility of root resorption, or in other words others are not significant.
3. The results of the z-axis coefficient test show that the probability (Sig.) is 0.034 < 0.05, then the hypothesis is accepted and it can be concluded that the more severe the impaction of the canine on the z-axis, the more severe the incisor root resorption is adjacent (Figure 3).

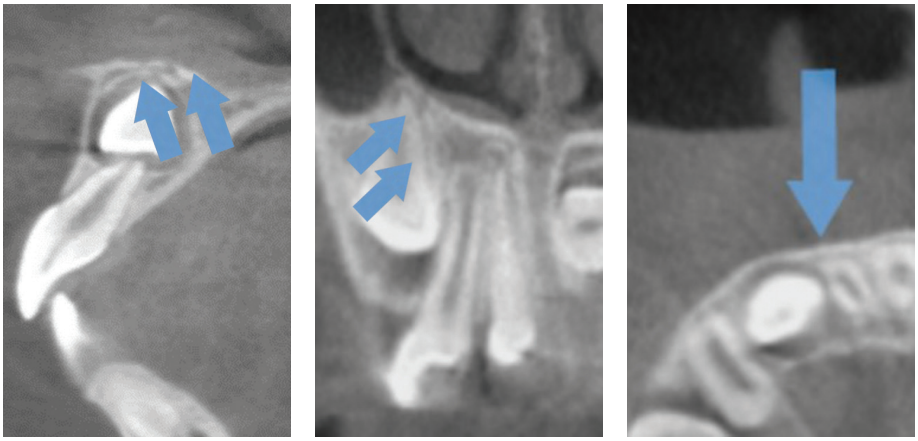

Figure 3. Incisor root resorption associated with impacted maxillary canines.

DISCUSSION

The data from this study indicated that the lateral incisors were more adjacent by root resorption than the central incisors. From the percentage of incisor types adjacent by canine impaction, as much as 44% of lateral incisors resorption more often than central incisors. Where the central incisor which experienced resorption due to canine impaction was only 19% of the entire sample. This fact was also reported in previous studies which supported theories based on the proximity of the canine to the lateral incisor rather than the central incisor.[10]

In previous studies using computed tomography (CT) or cone-beam computed tomography (CBCT) imaging, the results were not the same between different investigators. Rimes et al found 74.2% of the lateral incisors showed resorption in a total of 35 affecting the incisors. Ericson and Kurol in a CT study of 107 patients reported 80.5% lateral incisors with root resorption.

The etiologic factors underlying tooth root resorption due to eruption of adjacent teeth are still not clearly understood. Some authors stated that tooth resorption can be caused by eruption of adjacent teeth exerting physical pressure on the root surface of the tooth. This supports the results of this study which is shown in the summary model which states that the position of the x-axis, y-axis and z-axis in the case of impacted canines can represent the severity of root resorption of the adjacent incisors by 45.7%. While the remaining 54.3%, represented by other variables not examined in this study. This figure indicates that the position of the impacted canine plays a significant role in the severity of root resorption of the adjacent incisor.[10]

Pressure-induced root resorption can be observed during the eruption of the permanent teeth, especially the maxillary canines hitting the incisor roots. Osteosclerosis touching the tooth roots can also be an etiologic factor for root resorption caused by the injury phase and the stimulation phase. Stimulation is related to pathological processes that activate resorptive cells. Radiographically the surface of the adsorbed tooth is adjacent to the stimulating factor or impacted tooth.[14]

In this study the majority of incisor resorption was closely related to the x-axis. The impaction location in the sector where the canine angulation is mesial and closer to the midline, overlaps the incisor is strongly related to incisor root resorption. The incisor root resorption associated with impacted canines does not always resorbed vertically, but can also cause lateral resorption, for example on the palate or buccal, depending on the location of the impacted canine.[10]

This study supports the study by Schindel et al., who concluded that the more severe the impacted canine, the more likely the adjacent lateral incisor will exhibit some degree of root resorption. In his study, none of the 34 impacted canines in sectors I and II showed resorption of the adjacent lateral incisors. Of the nine canines in sector III, four impacted canines showed adjacent lateral incisors undergoing root resorption; Of the 21 canines in sector IV, 10 impacted canines showed adjacent lateral incisors undergoing root resorption. In other words, almost 50% of the chance that impacted canines will be diagnosed in sector III or IV are related to lateral incisor root resorption.[15]

The three-dimensional view of a CBCT radiograph can provide more accurate details for planning treatment of a case involving an impacted canine, including factors such as bone thickness, tooth follicle size, and stage of root development, as well as the presence of lateral incisor root resorption or the presence of root resorption central incisor. More importantly, the position of the impacted canine sector can help determine its potential for impaction. However, considering the possibility of higher levels of radiation exposure from routine use of CBCT, however, CBCT radiography should not be recommended in all cases. Sector analysis of panoramic radiographs can guide the practitioner in determining whether CBCT can be indicated when a canine has the potential for impaction.[16]

This study showed that nearly 50% cases of impact in sectors III and IV result in mild to moderate root resorption. So the current study, suggests when canine impaction is found in sector III and IV in panoramic radiography, CBCT should be considered for detect the presence of insissive root resorption and to plan treatment whether it is necessary to immediately take exposure surgical so as not to be late to resorption the incisive roots caused by canine impaction. Figure 4 showed that panoramic radiographic that demonstrated the position of the canine in the sector II and in the CBCT description do not indicate the presence of incisive root resorption (B and C). While Figure 4D shows a panoramic radiographic that demonstrated the position of the canine in sector IV and in the CBCT showing the moderate level of incisive root resorption being viewed from the sagittal and axial planes because the pulp has been involved (E and F).[17]

Radiographic evaluation is always important to detect impacted canines. Several methods have been used to achieve this: occlusal and periapical radiographs, panoramic, posteroanterior or lateral cephalometric radiographs, and more advanced techniques, such as CT and CBCT. Among diagnostic methods, CBCT overcomes the limitations of 2-dimensional (D) techniques and provides more precise results.[16,18] CBCT creates 3D visualizations of teeth and anatomical structures making the study of teeth and their relationship to surrounding structures easier. The use of CBCT significantly improves the detection of root resorption by eliminating obscuration and overlapping of other teeth. The sensitivity of CBCT compared to conventional x-rays is much higher allowing an accurate diagnosis of the location and severity of resorption.[4]

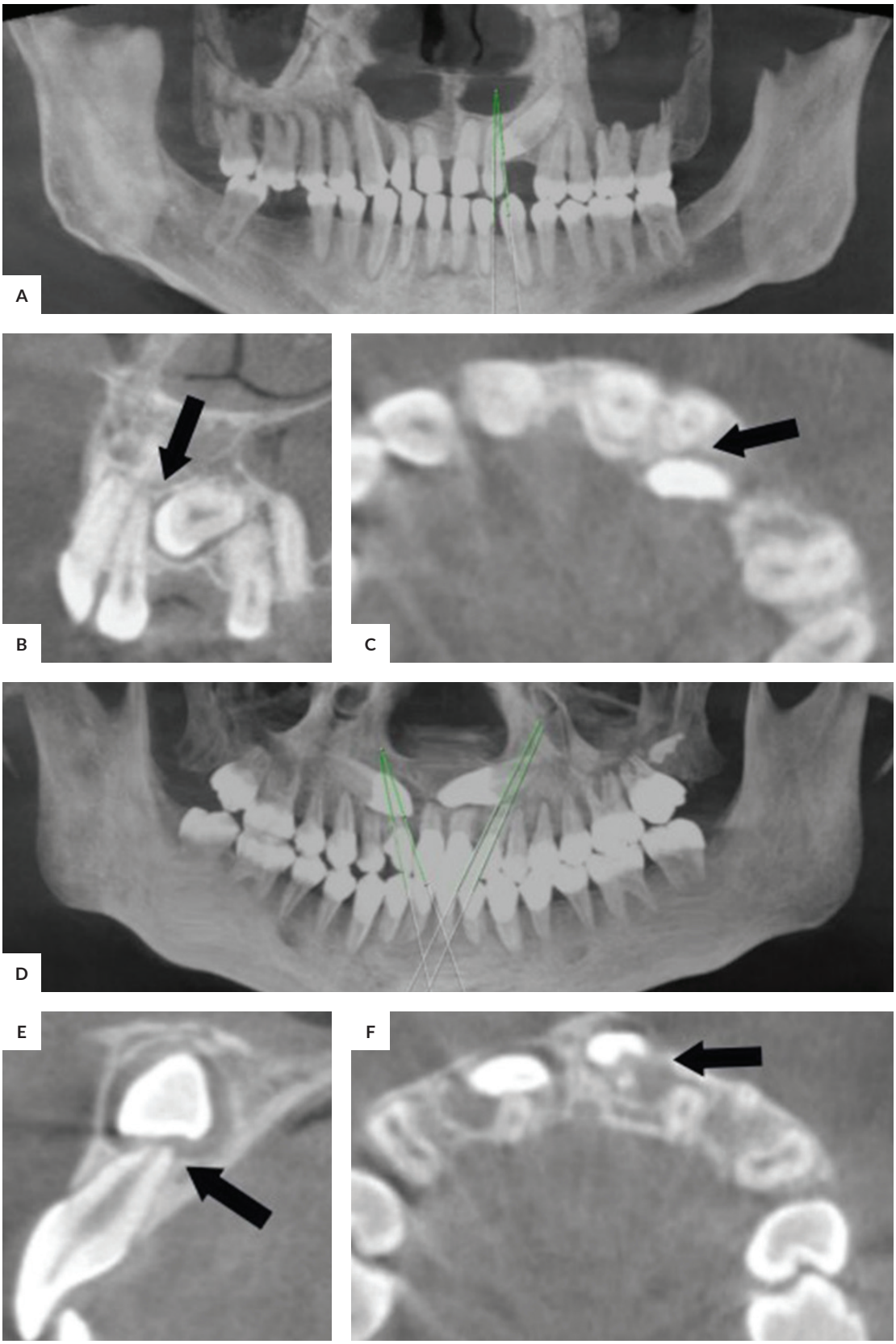

Figure 4. Overview of the position of the canine in the sector as seen from panoramic photos **(A, D)** and detecting root resorption in CBCT photos of the sagittal and axial planes **(B, C, E, F)**.

CONCLUSION

In general, the results of this study indicate that there is a significant effect of the position of the impacted canine when viewed in all planes of the tooth axis on the severity of root resorption of the adjacent incisor. In other words, the more severe the impaction rate on all axes, the more severe the root resorption of the adjacent incisor. However, if we look at each axis plane, it shows that the position of the impacted canine in the x-axis and z-axis planes has a significant influence on the root resorption of the adjacent incisor. Meanwhile, if the position of the impacted canine viewed from the y-axis plane shows a very small effect on the possibility of root resorption, or in other words it is not significant.

Almost 50% of impaction cases were in sectors III and IV resulted in mild to moderate root resorption. Hence, when impacted canines are found in sectors III and IV on panoramic radiographs, CBCT should be performed to detect the presence of incisive root resorption and to plan the treatment, whether it is necessary to take immediate exposure measures so that not late in resorption of incisor roots caused by impacted canines

Further research is needed to determine the severity of incisor root resorption as seen from the classification of impacted canines. And, further research that examines the effect of incisor root resorption related to the age ratio.

Statement of Authorship

Both authors contributed in the conceptualization of work, acquisition and analysis of data, drafting and revising and approved the final version submitted.

Author Disclosure

Both authors declared no conflicts of interest.

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