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Root resorption of adjacent teeth due to maxillary impacted canines – comparative analysis of the findings on cone beam computed tomography and panoramic imaging

Resorpcija korenova susednih zuba izazvana impaktiranim maksilarnim očnjacima – uporedna analiza nalaza na snimku kompjuterizovane tomografije konusnog zraka i panoramskom snimku

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Abstract

Background/Aim. A frequently reported phenomenon associated with impacted maxillary canines is root resorption (RR) of the adjacent teeth. The reported incidence of RR also depends on the radiographic imaging method used. The aim of the study was to evaluate the correlation between two radiographic methods: panoramic imaging (orthopantomogram – OPT) and cone beam computed tomography (CBCT), in diagnosing contact between the impacted canine with the adjacent teeth and the existence of their resorption. **Methods.** The study included 64 subjects aged 12 to 33 years, with 80 impacted maxillary canines not orthodontically treated previously. Positions of impacted maxillary canines and possible RR of adjacent teeth were firstly estimated on the OPT and then on the CBCT**. Results.** The estimated prevalence of RR of permanent teeth was significantly different concerning the estimation of OPT and CBCT imaging. RR of the adjacent teeth was found in 25% of the OPT but in 66.25% of the CBCT. The lateral incisor was the tooth most commonly affected by RR. It is especially important to emphasize that premolar resorption was not detected at all using OPT. **Conclusion.** There was a highly significant difference between OPT and CBCT analysis concerning the relationship between the impacted canine and adjacent teeth and their possible resorptions. CBCT is a more accurate and precise examination method compared to OPT for determining the localization of impacted teeth and the possible presence of RR in the adjacent teeth.

Key words:
cone-beam computed tomography; cuspid; radiography, panoramic; root resorption; tooth, impacted.

Apstrakt

Uvod/Cilj. Česta pojava koja se javlja kao posledica impaktiranih maksilarnih očnjaka jeste resorpcija korenova (RK) susednih zuba. Učestalost otkrivenih RK zavisi i od korišćene radiografske metode. Cilj rada bio je da se uporedi pouzdanost dve radiografske metode: panoramskog snimka (*orthopantomogram* – OPT) i kompjuterizovane tomografije konusnog zraka (*cone beam computed tomography* – CBCT) u dijagnostici kontakta impaktiranog očnjaka i susednih zuba, kao i postojanja resorpcije njihovih korenova. **Metode.** U studiju su bila uključena 64 ispitanika, starosti od 12 do 33 godina, sa 80 impaktiranih maksilarnih očnjaka, koji prethodno nisu bili ortodontski tretirani. Položaj impaktiranih maksilarnih očnjaka i moguća RK susednih zuba ispitivani su najpre na OPT snimku, a potom na CBCT snimku. **Rezultati.** Procenjena učestalost RK susednih zuba bila je statistički značajno različita na OPT i CBCT snimku. Utvrđeno je 25% resorpcija na OPT, a 66,25% na CBCT snimcima. RK su bile najučestalije na lateralnim sekutićima. Posebno je važno istaći da ni jedna resorpcija na premolarima nije otkrivena na OPT-u. **Zaključak.** Postoji statistički značajna razlika u nalazu RK susednih zuba izazvanom impaktiranim maksilarnim očnjakom utvrđena analizom OPT i CBCT snimaka. CBCT je tačnija i preciznija metoda ispitivanja u poređenju sa OPT u određivanju položaja impaktiranog zuba i eventualnog prisustva RK susednih zuba.

Ključne reči:
kompjuterizovana tomografija konusnog zraka; očnjaci; ortopantomografija; zub, koren, resorpcija; zub, impakcija.

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Introduction

Impaction of maxillary canines is a frequently encountered clinical problem, the treatment of which usually requires an interdisciplinary approach. The maxillary canines are commonly impacted teeth, second only to third molars, with a prevalence of approximately 1–3% [1, 2]. The most frequently reported complication associated with the occurrence of impacted maxillary canines is root resorption (RR) of the adjacent teeth.

RR is an asymptomatic phenomenon defined as a progressive loss of cementum and dentine. Its diagnosis is essentially radiographic. Panoramic radiography is the most frequently used diagnostic imaging method in the treatment planning of impacted maxillary canines. However, often panoramic radiography does not provide enough information in treatment planning for safely performing orthodontic treatment of impacted canines. For RR associated with impacted teeth, cone beam computed tomography (CBCT) –scans provide substantially superior visualization of roots than routine radiographs by eliminating artifacts resulting from the superimposition of structures and depicting the 3D root structure from all possible directions [3, 4].

The reported incidence of RR also depends on the radiographic imaging method used. Conventional periapical radiography appeared as an inaccurate method for diagnosing RR.

The first study on the prevalence of incisor RR due to displaced or impacted canines was examined by the standard two-dimensional intraoral X-ray techniques in 1987. The canine impaction was found to cause RR on maxillary incisors in 12% of cases [5]. After 12 years, the same problem was examined in a study using the computed tomography scan, and the number of found cases increased to 48% [6]. When the combination of panoramic views and lateral cephalographs is used, RR may be overlooked in 50% of cases [7–9]. Today, it is quite clear that CBCT is an important stage in making diagnoses of impacted canines and treatment planning. This three-dimensional (3D) technique can provide overlap-free sagittal, axial, and coronal images for the dental structure in question. According to recent literature, by analyzing CBCT images, up to 70% of impacted maxillary canines cause RR of at least one adjacent tooth [10–12]. Previous studies have shown that diagnostic accuracy significantly increased with the use of 3D visualization than with panoramic views and cephalographs [13].

For generalized RR or that associated with impacted teeth, CBCT scans provide more sensitive and accurate information than periapical or panoramic radiographs. Thus, detection of slight to moderate pretreatment RR by CBCT, that may go undetected by panoramic imaging, could lead to modifications in borderline cases to reduce the duration of treatment and magnitude of tooth movement to mitigate additional RR; therefore, it can have an impact on treatment planning [14, 15].

As a result of impacted canines, RR seems to be a rapid, progressive process that almost always ceases once the impacted canine has been removed from the affected root area. Lateral incisors with RR may not exhibit clinical symptoms and may show good long-term healing and prognosis after canine extraction [16, 17].

The aim of the study was to correlate two radiography methods – panoramic imaging (orthopantomogram – OPT) and CBCT, in evaluating the relationship of maxillary impacted canine and adjacent teeth and diagnosing the existence of their RR.

Methods

The study included patients referred for consultation and treatment of maxillary impacted canine to the Department of Orthodontics at the Faculty of Medicine, University of Priština in Kosovska Mitrovica, between 2015 and 2019. This study included 64 subjects aged 12 to 33 years, with 80 impacted maxillary canines without previous orthodontic treatment. A standard examination by an orthodontist was performed in all subjects, and the absence of one or both maxillary permanent canines or the persistence of deciduous canines was determined. To confirm the clinical findings, subjects were referred for OPT imaging because of ectopic eruption of one or both maxillary canines. After clinical and radiographic examinations, those canines that did not erupt were defined as impacted canines in this study. We defined any case as maxillary canine impaction if the root formation was 2/3 complete or if the other side of the maxillary canine had erupted completely. Patients presenting cysts related to studied impacted canines, as well as patients with supernumerary teeth or missing lateral incisors or premolars, were excluded from further analysis. The study was carried out by analyzing a CBCT of the maxilla two months after OPT analysis, performed in order to plan upcoming orthodontic treatment. Informed written consent was obtained from all the subjects.

For every impacted canine, the following parameters were recorded: type of impaction (unilateral, bilateral); the labio-palatal position of the impacted canines (buccal, palatal, or mid alveolar); RR of the adjacent tooth. If the RR was suspected, resorption was graded for each tooth separately, based on the system suggested by Ericson and Kurol [6], into 4 categories: no resorption (intact root surface, the cementum layer may have been lost), slight resorption (resorption up to half of the dentine thickness), moderate resorption (resorption of the dentine midway to the pulp or more, the pulp lining being unbroken), and severe resorption (resorption reaches the pulp); The localization of RR (the cervical, middle, or apical third of root) was also recorded.

First, the given parameters were measured on the OPT. After panoramic radiography analysis, CBCT was performed in order to diagnose, plan, and prevent complications during future orthodontic treatment.

Descriptive statistics were used to describe the basic features of the study data and methods for evaluating the agreement between CBCT and OPT measurements. Statistical results were tested at a level of statistical significance (*alpha* level) of 0.05 (*kappa* coefficient [18]).

Results

In this study, a total of 64 participants with OPT images and CBCT scans were included, and 80 impacted canines were analyzed retrospectively. The mean age of subjects was 16.3 ± 4.3 years. Of the 64 included patients, 23 (35.9%) were male, so there was a statistically significant difference concerning patients' gender ($p < 0.001$).

Unilateral impaction was present in 48 (75%) patients, and 16 (25%) patients presented with bilateral impaction. The analyses of the three-dimensional location revealed that most of the impacted canines were located in the palatal position – 58 (72.5%), 19 (23.75%) were located in the buccal position, and only 3 canines (2.75%) were in the middle of the alveolar process.

In our study, we found 20 (25%) RRs on OPT images – 14 (17.5%) on the lateral incisors, 6 (7.5%) RRs on the central incisors, and no RRs on the first premolars. However, on CBCT scans, we detected 53 (66.25% of the affected quadrants) RRs – 29 (36.25%) on the lateral incisors, 19 (23.75%) on the central incisors, and 5 (6.25%) on the first premolars (Figure 1).

The lateral incisor was the tooth most commonly affected by RR due to the presence of an impacted canine. The reported prevalence of RR of permanent teeth showed significant differences between OPT and CBCT imaging (Tables 1 and 2).

Out of detected 36.25% of RRs on the lateral incisors, the resorption was located in the apical third of the root in 12 (15%), the middle third of the root in 14 (17.5%), and the

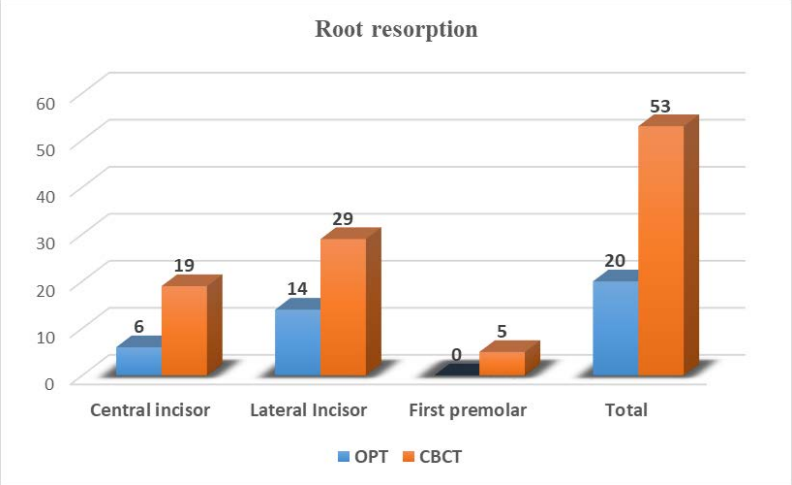

Fig. 1 – Root resorption (RR) of adjacent teeth.
OPT – orthopantomogram; CBCT – cone beam computed tomography.
k = 0.164; 95% confidence interval (CI) = 0.023–0.351 (*kappa* values: no agreement, < 0; slight, 0–0.2; fair, 0.21–0.40; moderate, 0.41–0.60; substantial, 0.61–0.80; almost perfect, 0.81–1) [18].

Table 1

Location of root resorption on lateral incisors using orthopantomogram (OPT) and cone beam computed tomography (CBCT) imaging

Parameter	CBCT				Total
	no	apical third	middle third	cervical third	
OPT					
no	46	8	9	3	66
apical third	1	3	2	0	6
middle third	3	1	3	0	7
cervical third	1	0	0	0	1
Total	51	12	14	3	80

Table 2

Severity of root resorptions on lateral incisors using orthopantomogram (OPT) and cone beam computed tomography (CBCT) imaging

Parameter	CBCT				Total
	no	slight	moderate	severe	
OPT					
no	46	9	9	2	66
slight	4	1	4	0	9
moderate	1	0	1	1	3
severe	0	1	0	1	2
Total	51	11	14	4	80

cervical third of the root in 3 (3.75 %) impacted lateral incisors; 11 (13.75%) RRs were considered slight, 14 (17.5%) moderate, and 4 (5%) severe.

This study showed differences between the two images regarding RR on lateral incisor, which was statistically significant concerning both images; a poor agreement was found between the two methods for the location of RR (κ = 0.218; 95% CI = 0.027–0.409) and its severity (κ = 0.179; 95% CI = 0.006–0.363) (Figure 2).

OPT image and CBCT very often show different findings of RRs on lateral incisors (Figure 3).

According to our results, the central maxillary incisors were affected by RR second to lateral incisors. In some cases, the impacted canine was resorbed by lateral and central incisors, together. Only one impacted canine crossed the transversal midline and it was resorbed by two central incisors. The RRs were found in 6 (7.5%) central incisors on the OPT images but in 19 (23.75%) central incisors on the CBCT scans. Results concerning RRs of central incisors are shown in Tables 3 and 4.

Most often, the resorption was located in the middle third of the root in 8 (10% of the total 23.75%) central incisors, in the apical third of the root in 5 (6.25%), and 6 (7.5%) in the cervical third of the root. Seven (8.75%) resorptions were considered slight, 9 (11.25%) moderate, and 3 (3.75%) severe.

The RR on central incisors showed a poor and very poor agreement between OPT images and CBCT scans (Figure 4).

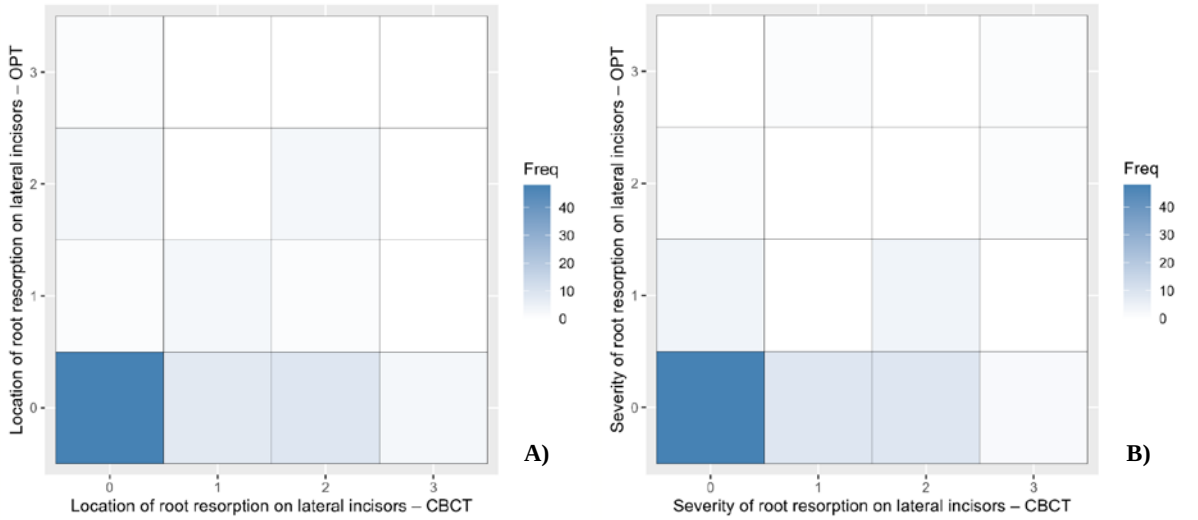

Fig. 2 – A) Agreement for the location of root resorption on lateral incisors on orthopantomogram (OPT) and cone beam computed tomography (CBCT) (κ = 0.218; 95% CI = 0.027–0.409); B) Agreement for the severity of root resorption on lateral incisors on OPT and CBCT (κ = 0.179; 95% CI = 0.006–0.363).

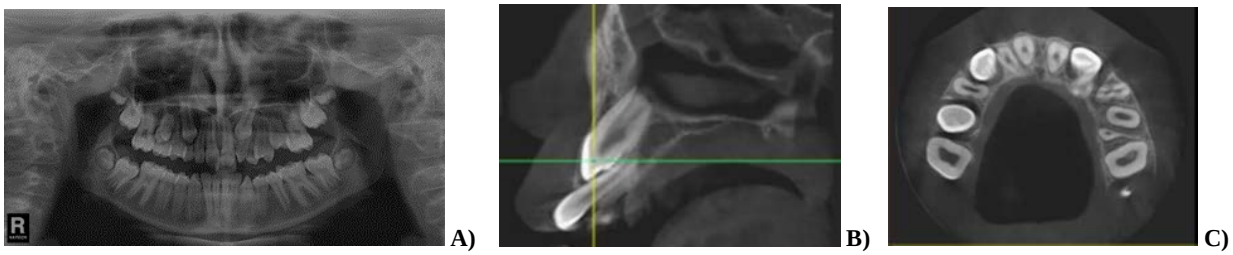

Fig. 3 – A 13-year-old patient. A) Orthopantomogram (OPT) image shows a buccal left impacted canine which overlaps with lateral incisor, with suspected moderate root resorption (RR) on lateral incisor; B) The sagittal plane on cone beam computed tomography (CBCT) scan shows RR in the apical third of the root on lateral incisor; C) Axial plane on CBCT shows slight RR.

Table 3

Location of root resorption on central incisors using orthopantomogram (OPT) and cone beam computed tomography (CBCT) imaging

Parameter	CBCT				Total
	no	apical third	middle third	cervical third	
OPT					
no	57	4	8	5	74
apical third	2	1	0	0	3
middle third	2	0	0	0	2
cervical third	0	0	0	1	1
Total	61	5	8	6	80

Slight RRs on adjacent teeth are most commonly omitted on OPT (Figure 5).

It is especially important to emphasize that premolar resorption was not detected using OPT images, but after CBCT analysis, we found 5 (6.25%) resorptions of the first premolars – 2 were moderate resorptions in the middle third of the root, and 3 were slight resorptions in the apical third of the root. These resorptions were found with palatal impacted canine with distal inclination, and in the second case, the cause is the transposition of the buccal impacted canine and the first premolar.

Discussion

The comparative analysis of our study confirmed that CBCT provides more precise information in diagnostic analysis, especially for planning orthodontic and surgical procedures where complications can be expected due to the close relationship of maxillary impacted canine and adjacent teeth.

Over the years, clinicians have searched for clues that may indicate a high risk for incisor RR associated with impacted maxillary canines. CBCT enables determining the exact distance of adjacent teeth; such a relationship is almost

Table 4

Severity of root resorption on central incisors using orthopantomogram (OPT) and cone beam computed tomography (CBCT) imaging

Parameter	CBCT				Total
	no	slight	moderate	severe	
OPT					
no	57	6	8	3	74
slight	1	1	1	0	3
moderate	2	0	0	0	2
severe	1	0	0	0	1
Total	61	7	9	3	80

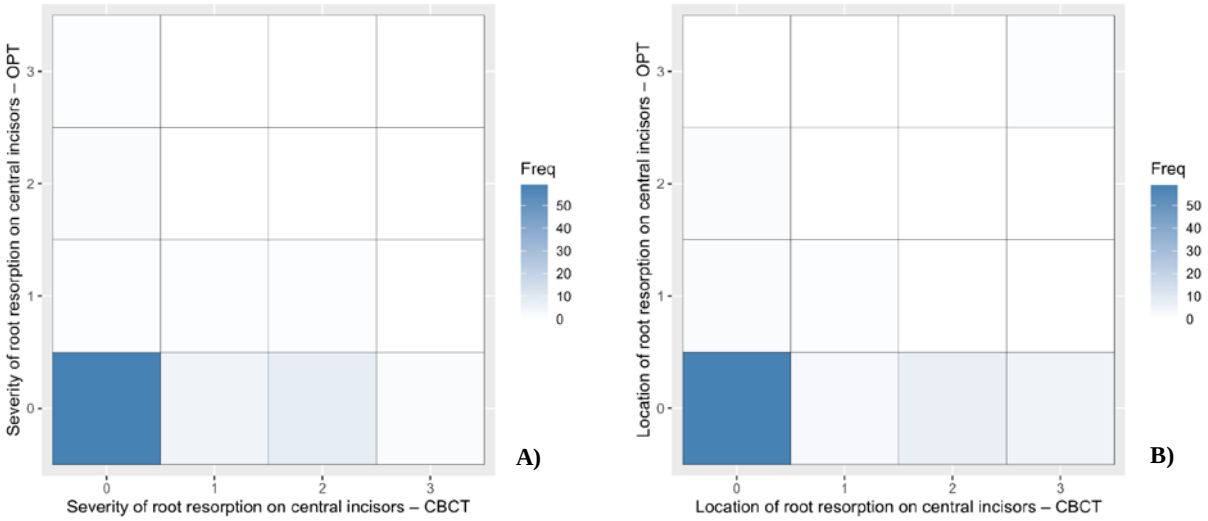

Fig. 4 – A) Agreement for the location of root resorption (RR) on central incisors on orthopantomogram (OPT) and CBCT (κ = 0.109; 95% CI = 0.102–0.320); B) Agreement for the severity of RR on central incisors on OPT and CBCT (κ = 0.016; 95% CI = 0.118–0.149).

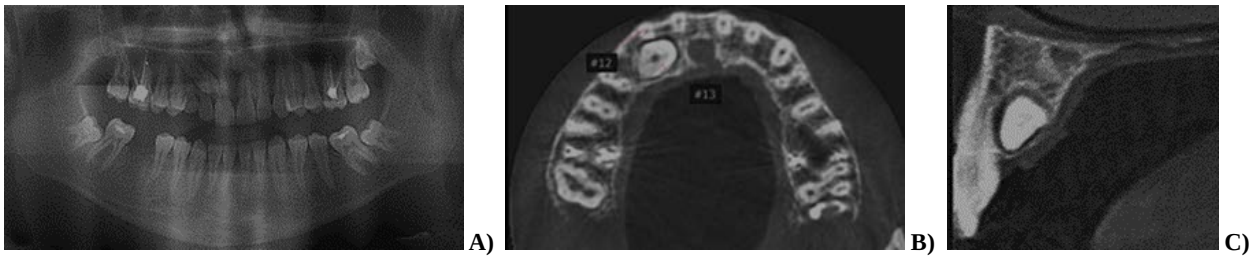

Fig. 5 – A 16-year-old patient. A) Orthopantomogram (OPT) image shows a palatally right impacted maxillary canine and no root resorption (RR) on adjacent teeth; B) Axial plane on cone beam computed tomography (CBCT) scan shows slight RR on central incisor; C) Sagittal plane shows resorption in the middle of the root.

impossible to assess accurately on OPT. Any distance of an impacted canine less than 1 mm implies contact with the adjacent tooth; in many instances, that contact also causes RR of the adjacent teeth [19, 20].

In our study, we found RRs in 25% of OPT images (17.5% on the lateral incisors, 7.5% on the central incisors, and no resorptions on the first premolars). However, on the CBCT scans, we detected much more cases (66.25%) with RR. Our findings confirmed that not every resorption of the permanent root was detected on panoramic imaging. RR may be overlooked in many cases on the OPT, such as first premolars and many resorptions on incisors. There was poor agreement between CBCT and OPT in assessing the resorption of permanent adjacent teeth.

Botticelli et al. [21] found only 5.6% of RRs on incisors using OPT, but 15.6% of RRs on CBCT. As a result of a sophisticated future and improved "cone-beam" method, images of impacted maxillary canines detect RRs even in 66.7% of lateral and 11.1% of central incisors [22]. With the same sample of the impacted canines as ours, Rafflenbeul et al. [23] actually found two-thirds of resorptions in untreated patients, while in our country, this result is higher than 65% of resorptions.

In our study, as well as in many other, maxillary lateral incisors were found to be the most affected teeth, followed by maxillary central incisors. We found similar results in other publications as well [9, 19, 24]; however, other studies showed different results concerning first premolars – the first premolars were more often resorbed than the central incisors [23, 25].

There is disagreement in the perception of the location of RR of compatibility in the results of the OPT and CBCT regarding the severity of RR and its localization. Other authors also found similar results [13, 14, 25–27]. This enhanced information, derived from the CBCT scans relative to the OPT images, may be critical in changing treatment plans. Although such treatment decisions appear to be a logical clinical outcome with the use of CBCT, the effects of the superior information derived from CBCT images may influence treatment decisions.

Of all adjacent teeth examined, resorption was most present in the middle and apical thirds of the root. Severe resorption has been presented the least, but slight and moderate resorptions have been similarly presented. Regarding the localization and severity of incisor RR, we found similar results in other publications [10, 19, 23–28].

Thereby, diagnosed resorption usually does not change prior to orthodontic treatment but significantly affects the treatment plan in terms of determining the direction of orthodontic traction. Otherwise, resorption existing on the adjacent teeth may become worse by displacing the impacted canine. This predominance is confirmed by all studies, excluding patients with past or ongoing orthodontic treatment. Early diagnosis and treatment are imperative [27, 29-31]. The prevalence of moderate and severe resorptions tends to be higher in most other studies, perhaps because in cases of past or ongoing orthodontic treatment, poor control of the relationship between the canine and the adjacent roots could have worsened already present RRs at a lesser extent.

Our further research will be focused on monitoring diagnosed resorptions during orthodontic treatment and expansion of impacted maxillary canines – whether and how they will change.

Conclusion

The diagnosis of the presence of RR was significantly different between the OPT images and the CBCT scans. Accordingly, 25% of RRs were found on OPT images but 66.25% on CBCT scans. There was a highly significant difference between OPT and CBCT in analyzing the relationship between the impacted canine and adjacent teeth and their resorption. These results showed that OPT and CBCT images of impacted maxillary canines could produce different diagnoses and treatment plans.

Conflict of interest

The authors declare no conflict of interest.

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