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ORIGINAL ARTICLE

The prevalence of root resorption in maxillary incisors adjacent to impacted canines and the influence of canine orthodontic traction on this resorption after treatment

Navid Ranjbar[1], Parisa Ranjbarian[2*], Majid Heydarpour[3], Hasan Maslahati[4]

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Abstract

Background: Root resorption of maxillary incisors caused by impacted canines is fairly common. However, its detection depends on the imaging method used. This study assessed the prevalence of root resorption in maxillary incisors adjacent to impacted canines and investigate orthodontic canines' alignment on this resorption after treatment.

Materials and methods: This retrospective observational analytical study examined 31 impacted canines requiring traction treatment. The classification of canine impactions was based on the system proposed by Ericson and Kurol using Cone-Beam Computed Tomography. The study analyzed root resorption in the central and lateral incisors adjacent to the impacted canines, as observed in the final panoramic after treatment. Data were analyzed in SPSS version 26, with binomial and Fisher's exact tests, (α=0.05).

Results: 29% of impacted canines were located buccally and 71% palatally. The complexity of treatment of studied teeth was reported low in 54.8% and high in 45.2% of cases. No significant difference was seen in pre-treatment root resorption between buccally and palatally positioned canines (p = 0.145). Similarly, post-treatment root resorption rates in maxillary central and lateral incisors were comparable between low and high-complexity canine impaction groups, with no statistically significant difference. (p = 0.573 and p = 0.412 respectively). Overall, the prevalence of root resorption was consistent across groups and conditions.

Conclusion: Impacted canines are associated with root resorption of adjacent teeth. Although central and lateral incisors show similar resorption prevalence, orthodontic traction increases resorption more in central than in lateral incisors.

Keywords: Cone-Beam Computed Tomography, Impacted Tooth, Orthodontic treatment

Introduction

Root resorption is a condition that occurs on both internal and external surfaces of the root due to the loss of dental hard tissue (1). External root resorption (ERR) is classified into two types: acute and chronic. Acute resorption occurs due to injuries that cause tooth luxation and trauma, such as intrusion, extrusion, and avulsion. In contrast, chronic resorption results from continuous damage to the periodontal ligament area. This can be caused by factors such as orthodontic movements, traumatic occlusion, pressures on the periodontal ligament by cysts and pathological lesions, as well as the eruption of impacted teeth (1).

Corresponding author: Parisa Ranjbarian

Department of Endodontics, Faculty of Dentistry, Isf.C., Islamic Azad University, Isfahan, Iran
Email: p.ranjbarian@iau.ac.ir

[1] Faculty of dentistry, Isf.C, Islamic Azad University, Isfahan, Iran
[2]Department of Endodontics, Faculty of Dentistry, Isf.C, Islamic Azad University, Isfahan, Iran
[3]Department of Orthodontics, Boston University Henry M. Goldman School of Dental Medicine, Boston, USA
[4]Department of Endodontics, Faculty of Dentistry, Isf.C., Islamic Azad University, Isfahan, Iran

The location of impaction (palatal, buccal, bicortical) can be considered a significant risk factor for root resorption (2,3). Additionally, genetics can play a role in the individual responses each patient gives to orthodontic forces during mechanical orthodontic treatments (4,5). Maxillary canines are the most commonly impacted teeth, following third molars (6). The prevalence of maxillary canine impaction is between 0.9% and 3% (7). The site of the impaction may vary among studies, but the majority agree that it typically occurs in the palatal region (8-9).

The exact cause of this abnormality has not yet been determined. Genetics and underlying local factors such as congenital absence of lateral incisors, supernumerary teeth, odontoma, and factors that can block the path of canine eruption can be considered as risk factors (10,11). Early detection of impacted canines helps in improving the prognosis of orthodontic treatment because early therapeutic interventions reduce the complications of this impaction. Some of the most important complications include Migration of the teeth adjacent to the impacted tooth, loss of dental arch length, infections, root resorption, necrosis of the adjacent incisors, ankylosis, and pain caused by unerupted canines (12,13).

In the majority of cases, canine impaction is asymptomatic, making the clinical diagnosis difficult. This delayed diagnosis often leads to challenges and complications in orthodontic treatment of these cases. Root resorption of maxillary incisors caused by impacted canines is a relatively common phenomenon, but the diagnosis of this complication can be different based on the type of imaging technique. It has been observed that root resorption caused by maxillary canines affects the lateral incisors more than the central incisors. However, with the introduction of computed tomography (CT) and cone-beam computed tomography (CBCT) imaging devices, researchers started to have different opinions in this regard (14).

Radiographic evaluation is essential to confirm canine impaction. Several imaging methods have been used, such as periapical, occlusal, panoramic, anteroposterior, lateral cephalometric images, and advanced techniques such as CT and CBCT. CBCT photography overcomes the limitations of two-dimensional techniques and can give more valuable results (9,15). CBCT has provided a three-dimensional view of the dental system and anatomical structures; therefore, it has facilitated studies and research compared to other methods. CBCT significantly increases the power of detecting and revealing root resorption by limiting the effect of blurring and overlapping teeth (15).

CBCT is a more reliable tool for the detection of the site and degree of resorption, compared to other common X-ray methods (16). In this study, canine impactions were classified based on the classification proposed by Ericson and Kurol (8, 16). This classification is based on the location of the cusp tip of the maxillary canine in relation to the surrounding teeth. The purpose of this study was to investigate the prevalence of root resorption of central and lateral teeth adjacent to impacted maxillary canine teeth by the CBCT method. It should be noted that no root canal treatment was performed on the studied central and lateral teeth. Also, the relationship between the complexity of orthodontic treatments for the extraction of impacted canine teeth and the prevalence of root resorption of these teeth during the treatment process was investigated.

Materials and Methods

This retrospective observational analytical study was conducted on 31 impacted canine teeth from a patient referred to a private orthodontic clinic for traction treatment. Patients were selected using convenience

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sampling based on the inclusion criteria. Ethical approval was obtained from the ethics committee of the Islamic Azad University of Isfahan (Khorasgan) under the reference number IR.IAU.KHUISF.REC. 1399.293.

Patient information, including medical history, intraoral and extraoral images, panoramic and lateral cephalometry images before and after treatment, as well as pre-treatment CBCT scans (post-treatment CBCT was not taken due to ethical considerations), were reviewed. Patients with periapical lesions, root canal treatment of maxillary incisors before treatment, history of orthodontic treatment. Prior maxillary surgery, and/or patients with other tooth impactions were excluded from the study.

Canine impactions were classified based on the classification proposed by Ericson and Kurol (Table 1), and two dentists (one endodontist and one orthodontist) examined the positions of the impacted canines along with different sections of impaction in each CBCT. The inter-rater agreement was assessed by the Kappa coefficient. An inspector did all the measurements twice over a one-month interval. The agreement between dentists was evaluated by the intraclass correlation coefficient (ICC=0.9) (CI95%, 0.81-0.97).

CBCT parameters included 4.7 mA, 89 kVp, 0.125 voxel size, and an exposure time of 15 seconds, and each section was displayed as 8x8 cm^2. CBCT scans at this point revealed the prevalence of root resorption in the central and lateral incisors before the treatment, as well as the buccal or palatal position and the degree of difficulty of the impacted canine. The canines were classified into high and low complexity groups according to the following criteria.

The impacted canines were classified into two groups based on complexity: low complexity and high complexity.

1. Low Complexity Group: Canines were classified in sections 1, 2, and 3 based on Ericson's classification.
2. High Complexity Group: This group included canines in sections 3, 4, and 5 (8, 16). Within section 3, the angle "A" was greater than 40 degrees. In this group, impactions were located in the buccal, palatal, or bicortical regions (between the buccal and palatal cortical bones) (2, 19).

Additionally, the angle B (the angle between the longitudinal axis of the lateral incisor and the canine) and the distance h (the distance from the incisal tip of the maxillary canine to the occlusal surface) were measured (8,20).

Table 1. Classification of maxillary impacted canines according to Ericson and Kurol (16)

Section	explanation
1	Cusp tip of the maxillary canine tooth between the distal part of the maxillary lateral tooth and the mesial part of the maxillary first premolar
2	Cusp tip of the maxillary canine tooth between the distal part of the maxillary lateral tooth and its longitudinal axis
3	Cusp tip of the maxillary canine tooth between the longitudinal axis of the maxillary lateral tooth and its mesial part
4	The cusp tip of the maxillary canine tooth is between the mesial part of the maxillary lateral tooth and the longitudinal axis of the maxillary central tooth
5	The cusp tip of the maxillary canine tooth is between the longitudinal axis of the maxillary central tooth and the midline between the maxillary incisors

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The first panoramic radiograph was prepared before the orthodontic treatment, and the second panoramic radiograph was prepared at least one year after the active orthodontic treatment. The contours of the maxillary incisors were obtained from a panoramic radiograph and traced on acetate sheets. Although it is more appropriate to use periapical radiography in the examination of the apical root resorption of the anterior teeth, panoramic radiography was used in this study due to the unnecessary request and the lack of therapeutic need, and the unethical nature of periapical radiography. The line that connects the mesial and distal cement-enamel junction (CEJ) of the selected tooth was referred to as MD. Crown height and root length were defined as shown in Figure 1. The root length was measured as the distance from the tip of the desired root apex to the mesiodistal (MD) line, while the crown length was measured from the corresponding cusp tip to the MD line. The crown-root length ratio for the incisor was designated as X1 in the first radiograph and Y1 in the second radiograph. Changes in Y1 in relation to X1 were reported as the rate of resorption.

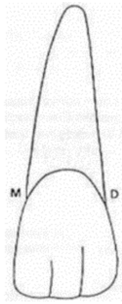

Figure 1. Crown height and root length

Results

Thirty-one impacted canines of both genders that required traction treatment were selected and evaluated based on the characteristics of the samples, including; gender, impaction direction, degree of complexity, previous central and lateral root resorption and subsequent central and lateral root resorption (Figure 2) and amount of subsequent central and lateral root resorption (Table 2).

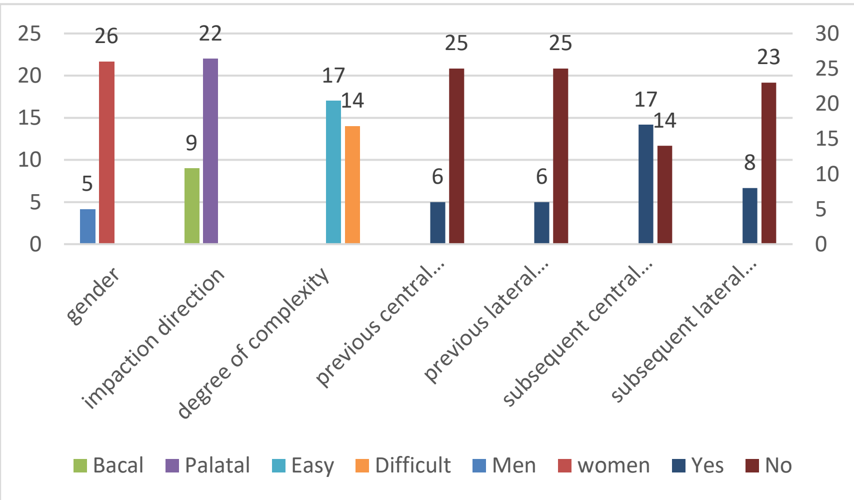

Figure 2. Frequency distribution of research variables

Table 2. Descriptive statistics of quantitative research variables

Variable	N	Min.	Max	Mean±SD
Age	31	11	30	17.23±5.76
subsequent central resorption	31	0.00	0.16	0.0255±0.0335
subsequent lateral resorption	31	0.00	0.12	0.168±0.333

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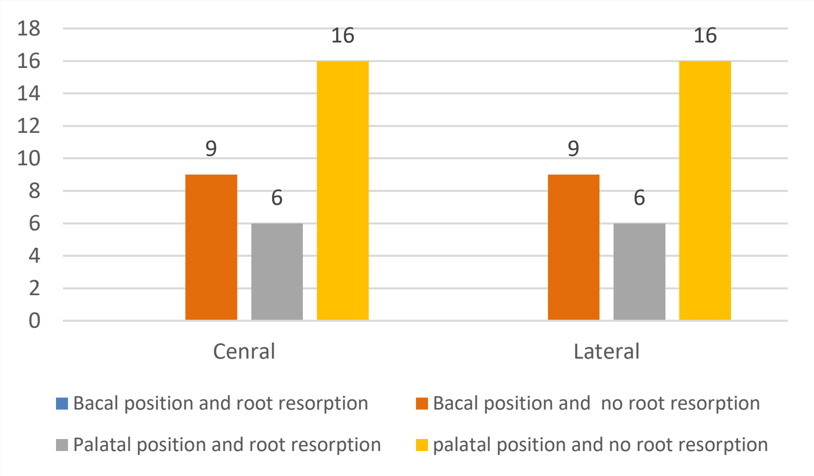

Figure 3. Comparison of the prevalence of pre- treatment root resorption in maxillary central and lateral incisors in buccally and palatally position of canine impaction

As illustrated in figure3, no resorption was observed in the central and lateral incisors in canines with buccal position, whereas resorption was detected in 6 teeth (27.7%) of palatally positioned canines, which is not statistically significant according to Fisher's exact test (95% confidence level, p=0.145). Thus, it can be concluded that the prevalence of root resorption in maxillary central and lateral incisors before treatment is similar in both the buccal and palatal areas, with no significant difference.

As illustrated in figure 4, the prevalence of post-treatment root resorption in maxillary central incisors in low and high complexity group of canine impactions respectively was 47.1% (8 teeth) and 64.3% (9 teeth), which showed no significant difference at the 95% confidence level (p=0.573) according to Fisher's exact test The prevalence of post-treatment root resorption in maxillary Lateral incisors in low and high complexity group of canine impactions respectively was 17.6% (3 teeth) and 35.7% (5 teeth), which showed no significant difference at the 95% confidence level (p=0.412) according to Fisher's exact test.

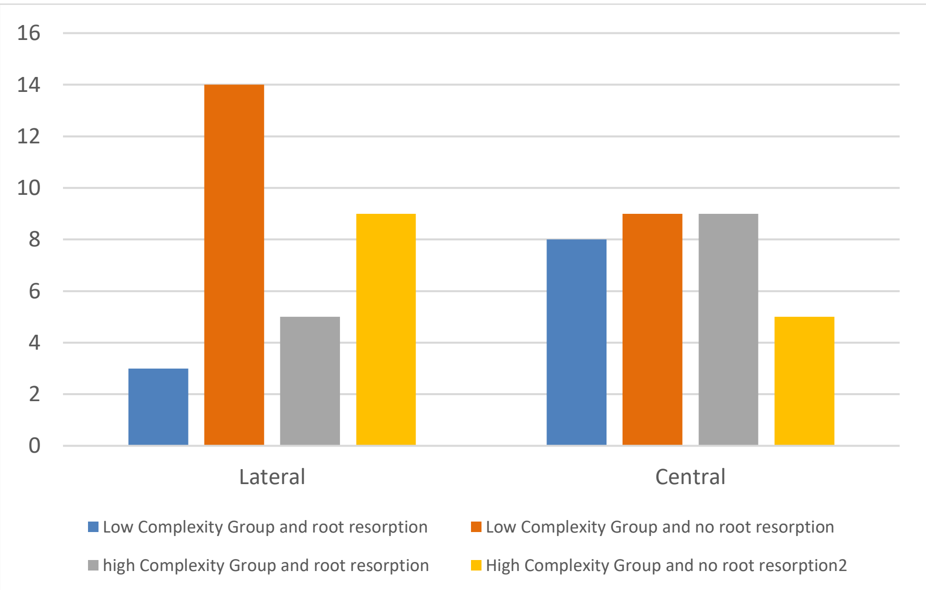

Figure 4. Comparison of the prevalence of post-treatment root resorption in maxillary central and lateral incisors in the low and high complexity groups of canine impactions

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Discussion

Impacted teeth can cause problems for the teeth and their nearby structures, including weakening of the bone in that area and external root resorption of the adjacent teeth. Therefore, timely diagnosis and treatment of this phenomenon is very important. After the third molar, the maxillary canine is the most likely to be impacted.

In the past, when advanced imaging techniques such as CBCT were not available and only periapical and panoramic radiographs were used to evaluate the jaw and teeth, the problems caused by the presence of impacted teeth, including impacted canine teeth, were diagnosed less frequently. Therefore, the prevalence of these problems was reported much less frequently. Currently, CBCT is a powerful tool used for diagnosis, three-dimensional positioning, evaluating the effects of remaining teeth in the jaw, and planning the treatment of impacted teeth.

According to the results of the present research, the prevalence of impacted canines was five times higher in females than in males, and the rate of palatal impaction was reported to be 2.5 times higher than buccal impaction. More than half of the patients had an easy canine traction treatment. After the treatment, the prevalence of root resorption of central and lateral maxillary incisors increased among the studied patients, and the highest rate of root resorption after treatment was related to central maxillary incisors.

Before treatment, root resorption was not observed in CBCTs of central and lateral incisors in buccally canine impaction, However, in cases of palatally canine impaction, the prevalence of root resorption in both central and lateral maxillary incisors was reported to be 21.3%. Although root resorption was more common in cases of palatally impacted canines, the difference was not statistically significant. This lack of significance may be due to the small sample size in the current study.

The prevalence of root resorption of maxillary central and lateral incisors has increased after canine traction treatment. Even though the rate of root resorption in both groups of maxillary incisors in difficult traction treatment was reported to be higher than easy one, there was no significant difference between the prevalence of resorption after treatment and the difficulty level of this treatment. The rate of prevalence and average resorption rate in central incisors was reported to be higher than in laterals.

In a study, Rimes et al. (13) have reported root resorption of 26 lateral incisors and 9 central incisors in relation to 32 misplaced canines. In two-thirds of the cases, the resorption pattern involved both the middle and apical thirds of the root. It was also stated that despite the extensive resorption of the roots, the patients reported few symptoms. In addition, in this study, the most common site of canine impaction was found in the palatal region (43.8%). In terms of the prevalence of palatal canine impaction, the present study was consistent with the study by Rimes et al (13). However, this study is not consistent with the present study in terms of the prevalence of lateral tooth resorption adjacent to the canine compared to the central teeth. This difference may be due to the type of resorption defined in the classification proposed by Ericson and Kurol, which was not investigated and compared in previous studies.

In the study performed by Cuminetti et al., they concluded that there is no difference in the root resorption of lateral maxillary incisors in relation to the location and angle of canine impaction, which is consistent with the results of the present research. They also stated that the inclination of canines in the buccal region was higher than the palatal, but it did not affect the rate of lateral root resorption (17).

Rafflenbeul et al. (18) stated that root resorption occurred in more than two-thirds of the teeth adjacent to the maxillary latent canines among 60 people. The

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results of the present research were consistent with the research conducted by Rafflenbeul et al. (18). In the present study, the rate of central and lateral root resorption of maxillary canines was reported to be equal (19.4%).

Milberg et al. (19) investigated the relationship between the position of the impacted maxillary canine and the root resorption of the maxillary central tooth and found that the pressure resulting from the labially impacted canine had led to the root resorption of the maxillary central tooth. Al-Nimri et al. investigated the complications of maxillary canine impaction on maxillary incisors. They found that the anomaly of the lateral tooth might be due to the palatal impaction of the maxillary canine (20). Based on the results of the present research as well as the results of previous studies, it can be stated that the impacted canine has a great impact on the surrounding teeth in terms of root resorption. They also found that orthodontic traction is an important factor in increasing the rate of root resorption, especially in the maxillary central incisors. As discussed in the development of occlusion, the apex of the canine is deeper and at a higher level than that of the adjacent teeth, and the apex remains fixed in its position during a normal eruption (21) where the crown moves towards the occlusal surface. Therefore, the root length will take a natural shape, but if there is an obstacle in the eruption path and the crown cannot reach the occlusal surface normally, the root will be compressed reversely and the eruption will be completed in depth.

Various studies showed that the lateral tooth adjacent to the impacted canine tooth is more likely to be affected by the impacted tooth, while other teeth are rarely affected (20-23). Liu et al. (9) showed root resorption of the central and the lateral incisors in 23.4% and 27.2% of cases, respectively. The location of the resorption can show the degree of root susceptibility, since most of the lesions occur in the apical third of the root, and the cervical third of the root is less involved, the lateral resorption is less likely to affect their root length. The results of the present study were not consistent with the study performed by Liu et al. (9) in terms of the frequency of root resorption of central and lateral incisors.

In a study by Wee Loon Ng et al. (24) involving CBCT analysis of 148 impaled canines, it was observed that cases of moderate severity were more common than those of high or slight severity. Similarly, in the present study, low complexity cases were more prevalent than high complexity ones. While lateral incisors were reported to be more prone to root resorption in the study performed by Ng, whilst in our study, central incisors were more affected (24). A similar study by Arriola-Guillén et al., which investigated the relationship between the degree of impaction complexity and root resorption in upper incisors, found no significant difference in the prevalence of root resorption between low and high complexity cases, aligning with the findings of the present study (25).

As a general conclusion, it can be stated that the impacted canine has a great impact on the root resorption of the adjacent teeth, especially the maxillary central incisors after orthodontic traction, and this rate is the same in the buccal and palatal sections. Further studies are necessary because most research has not investigated the rate of root resorption after orthodontic traction.

Conclusion

The presence of impacted canines can lead to root resorption in adjacent teeth. The prevalence of root resorption among maxillary incisors adjacent to impacted canines is similar for both central and lateral incisors. However, following orthodontic traction of the impacted canines, the rate of root resorption is

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higher in the maxillary central incisors compared to the lateral incisors.

Conflict of Interests: The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or non-financial in this article

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