

Maxillary incisor root resorption induced by ectopic canines *A follow-up study, 13 to 28 years posttreatment*

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ABSTRACT

Objective: To evaluate the long-term clinical and radiographic effects of maxillary incisor root resorption in cases of ectopic canines treated during the late 1970s and 1980s in Jönköping, Sweden.

Subjects and Methods: The material comprised 55 incisors in 38 subjects. The posttreatment follow-up time was 13 to 28 years. All subjects underwent intraoral radiography, 33 were referred for computed tomography or cone beam computed tomography, and 24 also underwent clinical examination. The severity of incisor root resorption was correlated with clinical characteristics. Radiographs of the resorptive lesions were documented in detail and compared with intraoral radiographs taken immediately posttreatment.

Results: Four incisors in three subjects had been lost, in part because of root resorption. Of the 36 incisors with root resorption, the lesions were unchanged in 26 teeth, improved in three teeth, and exacerbated in seven. In one case the resorption had progressed to pulpal exposure, necessitating endodontic treatment. For most of the incisors, the periodontal ligament was more clearly defined and the lamina dura showed improved trabeculation. The clinical characteristics of the incisors with resorption were not significantly different from those of sound incisors.

Conclusions: In this long-term follow-up, most cases of incisor root resorption induced by ectopic maxillary canines did not progress and teeth with root resorption showed no clinically relevant symptoms. The prognosis for long-term survival of teeth with resorbed roots is good, but in cases where extraction is indicated, lateral incisors with severe root resorption should be extracted in favor of healthy premolars. (*Angle Orthod.* 2011;81:800–806.)

KEY WORDS: Tooth impacted; Root resorption; Long-term follow-up

INTRODUCTION

After the third molars, the maxillary permanent canines are the teeth most frequently impacted. Dachi and Howell¹ reported a 0.9% incidence, Thilander and Myrberg² estimated the cumulative prevalence of canine impaction in 7- to 13-year-old children to be 2%, and Ericson and Kuroi³ reported an incidence of 1.7%.

The diagnosis, based on clinical and radiographic examination, is usually made by the general dental practitioner. For most children, clinical examination including digital palpation at the age of 9–11 suffices. However, in 7%–10% of children, supplementary radiographic assessment is necessary.⁴

In a study of 107 children with 156 ectopic maxillary canines, 50% were located to the lingual or distolingual, 18% to the distobuccal, and 21% to the buccal to the roots of the adjacent incisor.⁵ The ratio of palatal to labial impaction is uncertain, because of the difficulty in determining whether a labially impacted tooth might eventually erupt without intervention, often more superior and labial to its normal position.⁶ The etiology of canine impaction remains obscure, but several theories have been proposed. Lack of space has been suggested as a causative factor.⁷

A genetic predisposition toward palatally displaced canines has also been proposed. This is supported by the fact that other anomalies are associated with this condition, such as abnormalities of tooth form, size, or

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Accepted: March 2011. Submitted: December 2010.

Published Online: April 4, 2011

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position; congenital absence of various teeth (particularly the maxillary lateral incisors); delayed patterns of development and eruption; and transposition with the first premolar.⁸⁻¹² Retarded eruption of teeth may have multifactorial causes, either generalized or localized or a combination of both.¹³

Computed tomography (CT) is an imaging method that is superior to other radiographic methods for visualizing hard tissue.¹⁴⁻¹⁶ In recent years, digital volume tomography such as cone beam computed tomography (CBCT) has been proposed as an alternative to conventional CT in the diagnosis and treatment planning of impacted teeth.^{17,18}

An ectopic canine, if undiagnosed and untreated, will induce complex physiological and chemical processes, and the lateral incisor root may undergo resorption.^{5,19} In a study of 19 patients with 27 impacted teeth, CBCT disclosed the presence of resorption in 67% of lateral incisors, 11% of central incisors, and 4% of premolars.²⁰

A review of the associated factors indicates that it is not possible to predict when resorption will occur.²¹ There are very few follow-up studies of maxillary incisor root resorption induced by an ectopically positioned canine and of the long-term survival of the affected incisors. Severely resorbed incisors have often been extracted on the assumption that the teeth have a poor long-term prognosis.²²⁻²⁴

Becker and Chaushu²⁵ presented 11 female patients with severe apical resorption caused by impacted canines, which affected a total of seven central and 13 maxillary lateral incisors. They evaluated outcomes by measuring the crown/root ratio on periapical radiographs (or in some cases on panoramic radiographs). The follow-up period was at least 1 year and the maximum was 23 years, with a mean of 5.4 years. They concluded that the resorption process can be arrested and the affected tooth moved orthodontically without risk of further resorption.

In another follow-up study, 27 children underwent pretreatment evaluation by intraoral radiographs and CT.²⁶ The children (7 boys and 20 girls) had root resorption on 24 lateral and eight central incisors. Severe resorption, either to or through the pulp, was diagnosed in 11 teeth. No resorbed incisors had been lost during the 2- to 10-year follow-up period.

Before the introduction of CT, patients with ectopically positioned maxillary canines were treated without any means of ascertaining the presence of buccal or palatal resorption on the adjacent incisor roots. It is now recognized that in almost 50% of cases, ectopically positioned canines induce resorption on the adjacent incisor roots. It can therefore be surmised that a number of these treated patients would exhibit root resorption.

The purpose of the present study was to evaluate the long-term status of maxillary incisors in patients treated for ectopic retained maxillary canines during the late 1970s and 1980s in Jönköping, Sweden. At that time, the practice of pretreatment CT was very limited.

SUBJECTS AND METHODS

Subjects

The study was approved by the Research Ethics Committee, Faculty of Health Sciences, Linköping University, Linköping, Sweden. The subjects comprised patients referred for consultation and treatment of ectopically positioned maxillary canines during the late 1970s and 1980s. Inclusion criteria were resorption detectable on radiographs or a high probability of existing resorption as indicated by the ectopic position of the maxillary canine. The patients included in the study had started treatment with fixed orthodontic appliances between 1976 and 1989, and radiographs taken at the conclusion of orthodontic treatment were accessible. A further inclusion criterion was that orthodontic treatment should have been completed at least 10 years ago.

Fifty-two patients were identified from the archives. Three had moved abroad and could not be contacted; therefore, 49 were offered a follow-up examination. Eleven of these did not participate in the study; nine had moved to other cities, one was pregnant, and one expressed concerns about undergoing CT examination. Thus the study subjects comprised 38 individuals (18 men and 20 women), all with a history of severely ectopic maxillary canines.

The mean age of the subjects at the start of treatment was 13.3 years (SD 3.15). Treatment comprised surgical exposure of the canine and elastic traction in combination with fixed orthodontic appliances. The mean treatment time was 2.3 years (SD 1.16). Treatment was completed between 1978 and 1993 (mean, 1983). At follow-up, the mean age of the subjects was 36.3 years (SD 8.38).

Methods

Digital intraoral radiographs were taken. Each incisor was captured in two different projections. All radiographs were compared to the radiographs taken pretreatment and immediately posttreatment. Thirty-three subjects, with 49 incisors of interest, were referred for contiguous transverse CT scans or CBCT.

The resorptive lesions were characterized with respect to position: buccal/distobuccal, palatal/distopalatal, distal, or apical. Also noted was the location of the lesion on the root: cervical third, middle third, apical

Table 1. Locations of Incisors in the Different Groups at Follow-up

Location	No	Uncertain	Resorption	Extraction	Total
	Resorption	Resorption			
Lateral	4	4	21	3	32
Central	5	2	15	1	23
Σ	9	6	36	4	55

third, or at the apex. The severity of the resorptive lesions was graded as slight, moderate, or severe on the basis of both intraoral radiographs and CT. The location of each resorbed area was determined in three planes. Signs of apical root resorption were registered with index scores from 0 to 4 as described by Levander and Malmgren.²⁷

The severity of mesial, distal, buccal, or lingual resorptions was recorded on a scale of 1 to 4, as described by Ericson and Kurol.²⁸ A score of 1 indicates no resorption, with intact root surfaces, except for loss of cementum; 2, slight resorption, up to half the thickness of the dentin; 3, moderate resorption, ie, halfway to the pulp or more, with the pulp remaining covered with dentin; and 4, severe resorption, with the pulp exposed.

In addition, a clinical examination was performed on 24 of the subjects. Vitality, pocket depth, palpation, percussion, apical tenderness, mobility, discoloration, and position of every incisor were documented.

RESULTS

The distribution of the 55 incisors (32 lateral and 23 central incisors) in the 38 subjects is presented in Table 1. The results of the follow-up radiographic and CT examinations are shown in Table 2. Twelve subjects had resorption on two or more incisors.

Resorption was detected on intraoral radiographs or CT scans of 36 incisor roots and could not be ruled out in six incisors. Five incisors showed signs of resorption that were difficult to differentiate from orthodontically induced resorption.

Four incisors in three subjects had been extracted posttreatment. One subject had lost two lateral incisors as a result of trauma; the pre-extraction radiographs showed some resorption, but it was not extensive. One subject had lost a lateral incisor 14 years posttreatment when playing with children; the tooth in question had shown severe root resorption 1 year before the

Table 2. Number of Subjects and Incisors Showing for Radiographic Evidence of Root Resorption at Follow-up

	No	Uncertain	Resorption	Extraction	Total
	Resorption	Resorption			
Subjects	8	4	23	3	38
Incisors	9	6	36	4	55

Table 3. Number and Locations of Resorbed Surfaces Found by Intraoral Radiography and CT^a

Incisors	Buccal,	Palatal,	Distal	Apical	Total
	Distobuccal	Distopalatal			
Lateral	2	15	4	5	26
Central	1	8	1	9	19
Σ	3	23	5	14	45

^a On some incisors, resorption affected more than one surface; thus 45 surfaces with resorption were recorded on 36 incisors.

loss. One patient with a unilateral ectopic canine and a missing lateral incisor had lost a central incisor as a result of advanced periodontitis approximately 10 years posttreatment; the remaining dentition was intact.

Examination of the 36 incisors with root resorption disclosed 45 affected root surfaces. In 23 of these, the resorption was located on the palatal or distopalatal aspect of the root; 14 had apical resorption (Table 3).

With respect to location along the roots, nine of the 36 incisors showed resorptive lesions at the apex, four lesions were in the apical third of the root, 18 were in the middle third, and five were located in the cervical third (Table 4).

Severity of resorption was denoted as slight, moderate, or severe, as described earlier. Twelve incisors, seven of them central incisors, showed severe resorption (Table 5).

Table 6 shows the results of the comparison of radiographs taken at follow-up with those taken immediately posttreatment. The follow-up radiographs revealed slight improvement in three teeth. In 26 teeth the condition was unchanged. However, in 21 of these, the periodontal ligament and lamina dura were more clearly defined; trabeculation of the periapical area was greatly improved, with further maturation and smooth edges. In one subject with two resorbed central incisors and a resin-bonded partial prosthesis, the pulps were obliterated and the lamina dura could not be distinguished. In one case the lamina dura was well defined but its edges were still uneven. Resorption was more pronounced in seven teeth; in one, progression of the lesion had necessitated endodontic treatment and the lamina dura was still undefined at the resorption area.

Table 4. Locations of Diagnosed Resorbed Root Surfaces According to Combined Intraoral and CT Investigation^a

Incisors	Cervical	Middle	Apical	Apex	Total
	Third	Third	Third		
Lateral	3	14	2	2	21
Central	2	4	2	7	15
Σ	5	18	4	9	36

^a Only one surface from each tooth is registered.

Table 5. Severity of Resorptive Lesions, Induced by Ectopically Positioned Canines, on the Roots of 36 Maxillary Incisor Teeth

Incisors	Slight	Moderate	Severe	Total
Lateral	5	11	5	21
Central	2	6	7	15
Σ	7	17	12	36

Clinical Results

Twenty-four of the 36 subjects underwent clinical examination. With respect to satisfaction with the esthetic outcome, all 36 expressed general satisfaction, although some commented on the rotation or inclination of the laterals and two were not happy with the color of the maxillary incisors. The clinical findings are summarized in Table 7.

One unexpected observation during clinical examination was that some of the incisors examined showed a delayed reaction to the electric vitality test compared to neighboring teeth within the same subject. It was therefore decided to note cases in which a tooth reacted at a minimum of 10 levels higher than adjacent maxillary incisors. Teeth with resorption reacted later to the vitality test in 42% of the 24 examined cases, compared to 25% of those without detectable resorption. None of the incisors showed signs of increased mobility.

DISCUSSION

In treatment planning of patients with ectopically positioned maxillary canines, evaluation of the condition of the roots of the adjacent incisors is of great importance. There is little information available about whether, in the long term, the resorptive lesions on retained lateral incisors undergo progression, arrest, or repair. The effect of root resorption on the long-term prognosis of the affected incisors should be taken into account when deciding whether to extract and which tooth or teeth to extract.

Although the study was restricted to include only cases of severely ectopic canines, resorption was found in only 61% of incisors at risk. This has also been the experience of other authors²⁹ and highlights the uncertainty of predicting when resorption will occur.

Treatment was undertaken during the period 1976 to 1993. At that time CT was used only infrequently as a diagnostic tool. In some cases where root resorption of

Table 6. Comparison of Resorptive Lesions on the Incisor Roots as Shown on Radiographs Obtained Immediately Posttreatment and at Follow-up

Incisors	Improved	Unchanged	Increased	Total
Lateral	1	15	5	21
Central	2	11	2	15
Σ	3	26	7	36

Table 7. Summary of Clinical Findings at Follow-up Registration in 20 Subjects, in Whom 29 Lateral and/or Central Incisors Were Suspected of Being Resorbed by the Ectopically Positioned Canine^a

	Resorption (n = 19)	No Resorption (n = 10)	Total (n = 29)
Discoloration	1	1	2
Sensitive tooth	0	1	1
Pockets >4 mm	2	1	3
Percussion sound	2	0	2
Tenderness on palpation	1	1	2
Vitality test ^b	5	2	7
Root treatment	1	0	1
Rotation, malposition	8	6	14
Increased mobility	0	0	0

^a Two incisors with orthodontically induced resorption were excluded.

^b Defined as reacting more than 10 levels later than other maxillary incisors.

teeth adjacent to ectopically positioned canines was suspected, the incisors had been extracted as part of the orthodontic treatment.

Thirty-six cases were examined with intraoral radiographs. Thirty-three of these were referred for CT or CBCT examination; in the remaining three cases the resorptions were detectable on the intraoral radiographs. Twenty-four of the 36 individuals also underwent clinical examination.

Subsequent studies have disclosed that as many as 50% of patients with ectopically positioned maxillary canines experience resorption on adjacent incisor roots. However, this was not known at the time our subjects were undergoing treatment, and we therefore anticipated that there would be a considerable number of resorbed incisors in the subject material.

Our results disclosed 12 incisors with severe resorption, 17 with moderate resorption, and seven with slight resorption. Many incisors with severe root resorption are extracted on the assumption that the long-term prognosis is poor.^{3,21,23} However, there are reports indicating that severely resorbed incisors can be retained.^{30,31}

There are very few follow-up studies on incisors resorbed by ectopic canines. The root resorption associated with orthodontic treatment may be similar to that induced by an ectopically positioned canine. Orthodontically induced resorption is a sterile inflammation that causes loss of hard tissue.³² This also applies to resorption as a result of an ectopically positioned canine. Many case reports indicate that orthodontically induced resorption ceases when the force is removed; similarly, when an ectopic canine is distanced from the incisor root, the resorptive process ceases.³³ A literature review by Brezniak and Wasserstein³⁴ concluded that even extensive resorption induced by orthodontic forces does not affect the functional capacity or the effective life of the tooth.

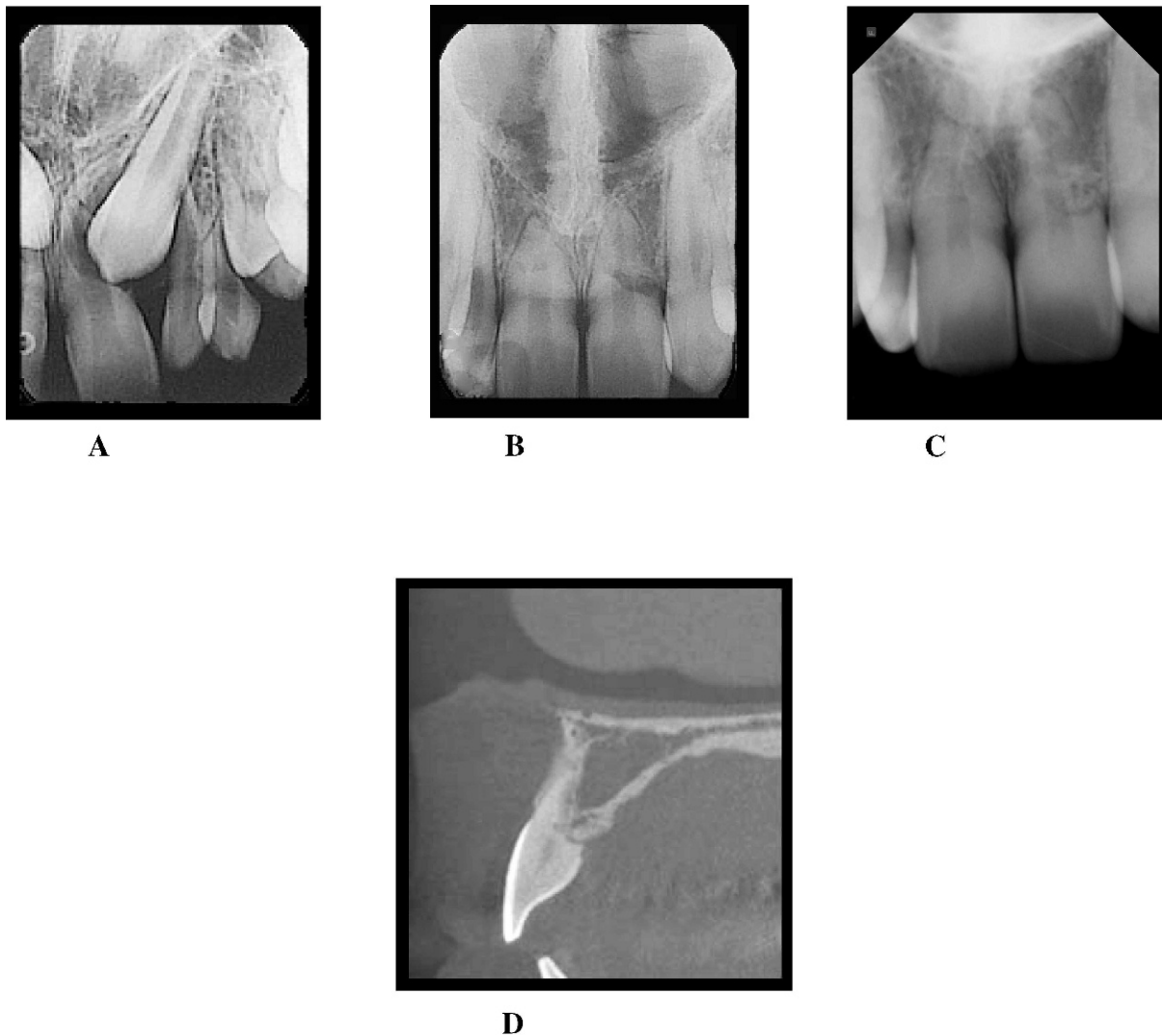


Figure 1. A 12-year-old girl with retained and ectopically positioned maxillary canines located palatal to the central incisors. (A) Severe resorption on the palatal and distopalatal aspects of the central incisor. (B) Immediately after treatment. (C) Twenty years and 9 months later, at the age of 36. (D) Lateral view from CBCT investigation at 36 years of age showing severe resorption.

CT is useful for examining the contour of the root and the area of resorption and improving the potential of a correct diagnosis, although in some cases some uncertainty may remain. With CT or CBCT it is possible to locate areas of resorption that are not detectable on intraoral radiographs. Limited three-dimensional CBCT is recommended.^{17,20,35} This method yields information about the size of the follicle, relative buccal and palatal positions, the thickness of bone covering the tooth, and three-dimensional proximity and resorption of roots of adjacent teeth, but at only one-sixth the radiation exposure of conventional CT and at considerably lower cost.³⁶

The particular merit of the present study is its long follow-up time, 13–28 years posttreatment. During this period, most of the resorptive lesions remained unchanged, but in some cases improvement was

noted in terms of better definition of the lamina dura and improved trabeculation of the periapical area, with further maturation and smoother edges. Active resorption is characterized by poorly defined lamina dura and periodontal ligament.³⁷

The results of the present study are in agreement with those of Becker and Chaushu²⁵ and Falahat et al.,²⁶ which also showed minimal risk of further resorption when these teeth were moved orthodontically.

Clinical Evaluation

The clinical examination was limited to 24 subjects because the author who performed the clinical examinations had left the clinic before the remaining 12 subjects presented for evaluation. Only radiograph-

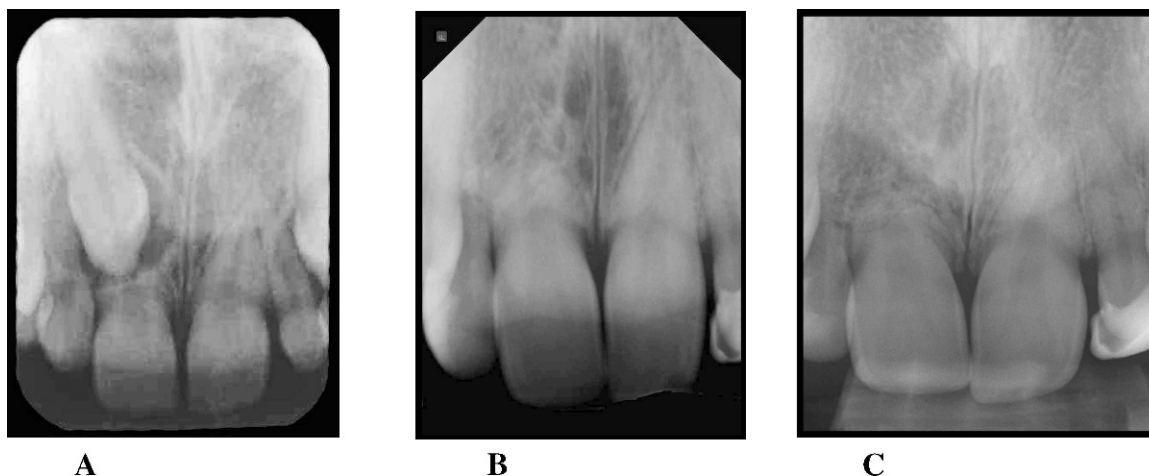


Figure 2. A 14-year-old girl with severe apical resorption. (A) The resorption affected more than half the root length. (B) Three years after treatment. (C) A further 5 years later at the age of 25.

ic examination was undertaken on these subjects. Clinically, there was no sign of increased mobility or discoloration, which is also in agreement with the study of Becker and Chaushu.²⁵

CONCLUSIONS

- Thirteen to 28 years after the completion of orthodontic treatment, four teeth had been lost, partly because of resorption.
- In most cases, incisor root resorption caused by an ectopic canine did not progress.
- Incisors with root resorption caused by ectopic canines showed no clinically relevant symptoms at long-term follow-up.
- There is no indication for endodontic treatment to arrest further resorption.
- Apical and periodontal health around a resorbed root often normalized and the lamina dura was more well-defined at follow-up.
- The prognosis for long-term survival of teeth with resorbed roots is good (Figures 1 and 2), but where extraction is indicated, lateral incisors with severe root resorption should be extracted in preference to healthy premolars.

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