

Root resorption associated with ectopically erupting maxillary permanent canines: a computed tomography study

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SUMMARY The aims of this retrospective computed tomography (CT) study were to determine the occurrence of severe root resorption involving the pulpal canal of adjacent permanent teeth associated with ectopically erupting canines, and to verify the existence of related factors. The sample consisted of 255 consecutive patients (159 females and 96 males, mean age 18.4 and 16.8 years, respectively). Three hundred and thirty-four ectopic maxillary canines and adjacent teeth were analysed using CT images. Statistical significance was evaluated with chi-square and Fisher's exact tests.

The results showed that severe root resorption of adjacent permanent teeth occurred in 17.7 per cent of ectopic canines and was equally common in females and males. Severe root resorption affected 12.6 per cent of the lateral incisors, 4.8 per cent of the first premolars, and 2.1 per cent of the central incisors. No relationship was found between the type or side of ectopic eruption, inclination of the longitudinal axis of the ectopic canine and the occurrence of severe root resorption. A significant relationship was found between a bucco-lingual position of the ectopic canine and root resorption ($P < 0.05$). Root resorption mainly occurred in the apical third (57.6 per cent) and apical and middle thirds (27.1 per cent). A significant relationship existed between the occurrence of root resorption and complete loss of space for the erupting canine ($P < 0.05$). No association was found between alignment of the upper permanent incisor and root resorption. A widened dental follicle occurred in 15 per cent of ectopic canines but did not cause root resorption of the adjacent permanent teeth. Since root resorption is asymptomatic, early detection by radiographic examination is essential for correct diagnosis and treatment.

Introduction

The incidence of impacted or ectopically erupting maxillary permanent canines has been reported to be 0.9 to 2.0 per cent (Thilander and Jakobsson, 1968; Ericson and Kurol, 1986). There are variations between different ethnic groups and genders (Becker, 2007). Many studies comprising orthodontic patients have shown a strong prevalence for this anomaly in females (female:male = 2.3:1 or 3:1; Dachi and Howell, 1961; Becker *et al.*, 1981; Oliver *et al.*, 1989). However, a random Israeli population study showed this to be approximately equal in males and females (Brin *et al.*, 1986).

Ectopically erupting and untreated impacted canines may cause several complications, such as displacement of the adjacent incisors, formation of follicular cysts, canine ankylosis, canine internal resorption, external resorption of the canine and roots of adjacent teeth, shortening of the dental arch, and/or combinations of these conditions (Shafer *et al.*, 1984). Root resorption of the adjacent permanent teeth is one of the most important and frequent complications. The results of several studies using computed tomography (CT) as a diagnostic method have shown that 48 per cent of ectopic canines caused root resorptions of varying severity (Ericson and Kurol, 2000b; Bjerklin and Ericson, 2006). It

may be present from 9 years of age. Root resorption can be difficult to diagnose because its progress is asymptomatic and rapid. Root resorption penetrating into the pulpal canal and/or radically reducing crown root ratio may result in loss of the affected teeth.

The exact aetiology of root resorption associated with ectopic maxillary canines is unknown. Several possible causative factors have been considered, such as pressure and inclination of the erupting canine, follicular activity, orthodontic forces, genetics, trauma, developmental insufficiencies of immature roots, and their susceptibility to resorptive enzymes (Ericson and Kurol, 1988; Arens, 1995; Ericson *et al.*, 2002; Becker, 2007; Falahat *et al.*, 2008).

The presence or absence of root resorption determines the optimal treatment strategy. When root resorption occurs, surgical exposure and orthodontic traction of the canine are carried out. Orthodontic traction directing the canine from the roots of the affected teeth eliminates pressure and the resorptive processes caused by the ectopically erupting canine. Extraction of the affected tooth may be the method of choice in subjects with severe root resorption.

The aims of the present study were to determine the occurrence of root resorption of adjacent permanent teeth associated with ectopically erupting canines in the Czech

population and to verify the existence of related factors. This study evaluated only severe resorption involving the pulpal canal due to its clinical importance.

Subjects and methods

The sample consisted of 255 consecutive Caucasian patients with ectopically erupting or impacted maxillary permanent canines. The patients were referred for consultation or treatment to the Orthodontic Department of the Clinic of Stomatology from January 2001 to May 2009. One hundred and seventy-six (69 per cent) patients had unilateral and 79 (31 per cent) bilateral disturbance of canine eruption. A total of 334 ectopically erupting or impacted maxillary canines were evaluated in this retrospective study.

The diagnosis of eruption disturbance was established on the basis of clinical examination and evaluation of the dental pantomogram. CT examination was performed for all patients at the Clinic of Medical Imaging and Radiology, St. Anne's University Hospital, Faculty of Medicine, Masaryk University, Brno, Czech Republic. A spiral CT scanner Mx8000 (Philips, Eindhoven, The Netherlands) was used to obtain the axial CT scans of the teeth and maxillary alveolar bone. The scan parameters were a matrix size of 768×768 , pitch 0.875, 120 kV, and 100 mAs. The bone algorithm was used for high resolution and the window setting was approximately 2000 Hounsfield units (HU) with a central value of 400 HU. Contiguous axial CT scans of the maxillary alveolar bone were taken parallel to the occlusal plane with a slice thickness of 1.3 mm and increments of 0.6 mm. Individual axial scans were analysed at the satellite console MxView (Philips). Multiplanar reconstructions (MPR; Figure 1b) and three dimensional (3D) reconstructed images (Figure 1c and 1d; Figure 2b, 2c, and 2d) were created using software (shaded surface display and volume rendering). These 2D and 3D reconstructions enabled 3D inspection and evaluation of the jaws and separated teeth. All diagnostic images were stored in a Picture Archiving and Communication System in Digital Imaging and Communications in Medicine (DICOM) 3.0 format. The DICOM data sets of each patient were imported into software (TomoCon 3.0 Viewer, TatraMed, Bratislava, Slovakia) for analysis. The CT machine is calibrated twice weekly on a phantom and dimensions, volumes, and densities are verified. The effective dose of 0.09 mSv and equivalent dose of 2.04 mSv correspond to the above stated setting of the exposure parameters and type of CT machine (Černochová and Krupa, 2005).

The following parameters were analysed on axial CT scans, MPR, and 3D reconstructed images (Figure 1 to Figure 3) by an experienced clinicians.

1. Type of ectopic eruption—unilateral, bilateral.
2. Side of ectopically erupting canine—unilateral right or left, bilateral right or left.

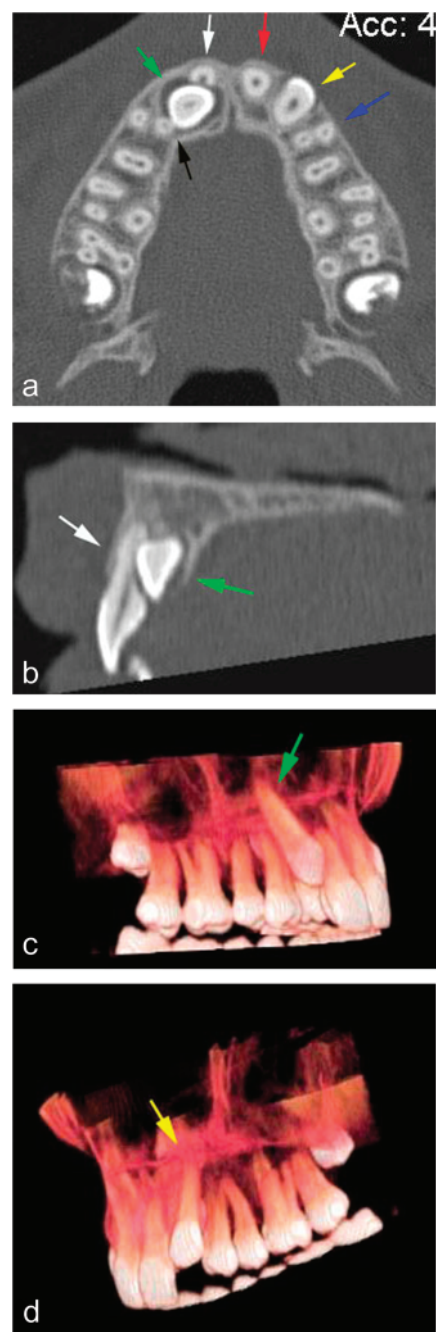


Figure 1 Computed tomography (CT) views of a 13-year-old girl with bilateral aplasia of the maxillary permanent lateral incisors. (a) Axial CT scan. The maxillary left permanent canine (yellow arrow) is erupting ectopically within the dental arch with no sign of root resorption of the adjacent first premolar (blue arrow) and central incisor (red arrow). The maxillary right permanent canine (green arrow) is erupting ectopically and palatal to the dental arch causing severe root resorption of the right permanent central incisor (white arrow). The crown of the right canine (green arrow) is in close contact with palatal root of the adjacent right first premolar (black arrow) without resorption. (b) Multiplanar reconstruction shows severe root resorption involving the pulpal canal of the middle and cervical thirds of the central incisor (white arrow) caused by the ectopic canine (green arrow). (c and d) Three-dimensional views (volume rendering) show a mesio-palatal inclination of the ectopic right maxillary (green arrow) and mesial inclination of the left canine (yellow arrow). The central incisors are well aligned without spacing.

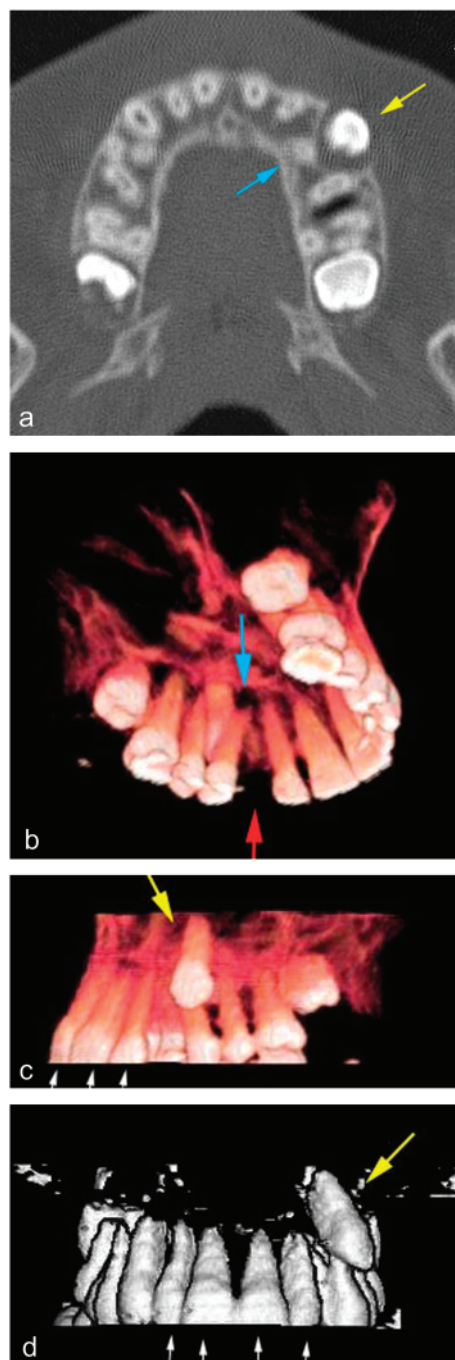


Figure 2 Computed tomography (CT) views of a 12-year-old boy. (a) Axial CT scan. The maxillary left permanent canine (yellow arrow) is erupting ectopically and buccal to the left first premolar. The apical third of the buccal root of the left first premolar is severely resorbed. There is no resorption at the palatal root of the first premolar (blue arrow). (b) Three-dimensional (3D) view (volume rendering) shows the palatal root of the first premolar (blue arrow) without resorption. There is a sufficient space without crowding in the lateral part of the dental arch (red arrow). (c) Three-dimensional view (volume rendering, lateral view) shows the spatial relationship of the bucco-vertically projected canine (yellow arrow) to the dental arch. The upper permanent incisors (white arrows) are well aligned without spacing. (d) Three-dimensional view (shaded surface display, frontal view). The maxillary left permanent canine (yellow arrow) is situated in a buccal position to the dental arch. The upper permanent incisors (white arrows) are well aligned without spacing.

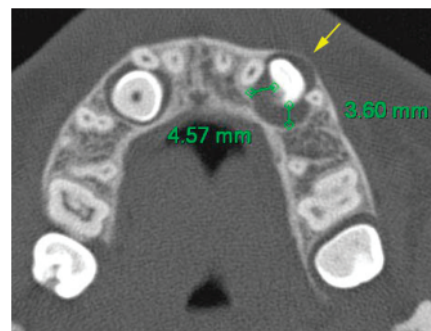


Figure 3 Axial computed tomography scan of a 16-year-old boy. Both maxillary permanent canines are erupting ectopically. The dental follicle of the left canine (yellow arrow) was evaluated as widened.

3. Position of the canine crown in relation to the dental arch—palatal, within the dental arch, buccal.
4. Inclination of the longitudinal axis of the ectopic canine—mesial, vertical, distal, horizontal.
5. Occurrence of root resorption of adjacent teeth—resorption present (i.e. resorption involving pulpal canal laterally or vertically), no resorption.
6. Type of resorbed tooth—none (no resorption), lateral incisor, central incisor, lateral and central incisors simultaneously, first premolar.
7. Location of root resorption—no resorption, apical root third (cases involving resorption at the apex were also included), apical and middle root thirds, middle root third, middle and cervical root thirds, cervical root third.
8. Alignment of the upper permanent incisors—spaced incisors, incisors well aligned without spaces, crowding in the incisor region.
9. Spatial conditions in the lateral part of the dental arch on the affected side—lack of space for the erupting canine (i.e. distance between the roots of the incisor and first premolar is smaller than width of the canine crown measured on the CT scans), complete loss of space (i.e. crown and root of the lateral incisor is near the crown and root of the first premolar on the CT scans), sufficient space without crowding.
10. Width of the dental follicle of ectopic canine—the maximum width of the dental follicle of the ectopic canine was measured as the greatest distance from the crown to the periphery of the follicle, scan by scan.

Recorded widths were divided into subgroups: dental follicle without signs of extension (i.e. the maximum width of the dental follicle measured on axial CT scans is smaller than 3.2 mm), widened dental follicle (i.e. the maximum width of the dental follicle is greater than 3.2 mm; Figure 3).

Statistical analyses

The Statistica version 8.0 (Statsoft Inc., Tulsa, Oklahoma, USA) program was used for statistical analyses. Chi-square

and Fisher's exact tests were used for analysis of the distributions and relationships among different parameters. The level of significance was set at $P < 0.05$.

Results

Age and root resorption

The youngest male and female patients were 10 years old, the oldest female patient was 51 and the oldest male was 36. The mean age was 18.4 years [standard deviation (SD) = ± 9.0 , median = 15.0] for the females and 16.8 years (SD = ± 5.98 , median = 15.0) for the males. The most frequently represented age categories were 11–16 years in females and 11–15 years in males. The youngest female/male with root resorption was 11/10 and the oldest was 34/18 years. The largest number of patients was in the 16-year age group.

Gender and root resorption

The relationship between gender and the occurrence of root resorption of adjacent permanent teeth was analysed (Table 1). The evaluated sample of 255 patients consisted of 159 (62.4 per cent) females with 211 ectopic canines and 96 (37.6 per cent) males with 123 ectopic canines. No significant relationship was found between the occurrence of root resorption and gender.

Type of ectopic eruption and root resorption

Of 176 unilateral/158 bilaterally ectopic canines, root resorption was recorded in 32/27 cases. In 17 patients, root resorption was present only on one side, while in five (i.e. 10 ectopic canines) bilateral occurrence of the root resorption was found. No significant relationship was found between the occurrence of root resorption and the type of ectopic eruption (Table 1).

Table 1 Relationship between gender, type of ectopic canine eruption, and occurrence of root resorption.

Variables	Number of canines (%)	Canines with root resorption	Canines without root resorption	<i>P</i> *
Gender distribution				
Male	123 (36.8%)	23	100	0.406
Female	211 (63.2%)	36	175	
Type of ectopic eruption				
Unilateral	176 (52.7%)	32	144	0.45
Bilateral	158 (47.3%)	27	131	
Width of dental follicle				
Without extension	284 (85%)	46	238	0.074
Widened	50 (15%)	13	37	

*Statistical significance by Fisher's exact test.

Side of ectopic canine and root resorption

Eighty-six unilaterally ectopic canines were on the right side of the dental arch and 11 of them caused root resorption. Ninety unilaterally ectopic canines were on the left side and root resorption was recorded in 21 cases. Of the 79 bilaterally ectopic canines on the right side of the dental arch, root resorption was found in 15. In the subgroup of 79 bilaterally ectopic canines on the left side, root resorption was present in 12 (Table 2). No significant relationship was found between ectopic canine side and the occurrence of root resorption. In addition, no significant difference was found for bilateral cases; however, a marginal difference was observed between the unilateral side of the ectopic canine, with a higher frequency of root resorption on the left.

Position of the canine crown in relation to the dental arch and root resorption

The relationship between the position of the canine crown in relation to the dental arch and root resorption is given in Table 2. Root resorption occurred most frequently with buccal canines, less often in cases with the canine crown within the dental arch, and least often with a lingual position of the canine crown. The relationship between the position of the canine crown and the occurrence of root resorption was significant.

Inclination of the longitudinal axis of the ectopic canine and root resorption

No significant relationship was found between the inclination of the longitudinal axis of the ectopic canine and the occurrence of root resorption (Table 2).

Occurrence of root resorption and type of the resorbed tooth

Root resorption of the adjacent teeth involving the pulpal canal was associated with 59 (17.7 per cent) of the 334 ectopic maxillary canines. Distribution of root resorption according to the affected tooth is given in Table 3. A peg-shaped lateral incisor was found in one female patient with root resorption of the central incisor. Aplasia of the lateral incisor was recorded for the remaining two patients (one female with unilateral and one male with bilateral occurrence of root resorption of the central incisor). In three female patients, ectopically erupting canines caused root resorption of the lateral and central incisor simultaneously. One patient had unilateral and two bilateral disturbance of canine eruption. In one subject with bilaterally ectopic canines, root resorption was present only on the left side. In the second case, three incisors were affected, both incisors on the left side and a lateral incisor on the right side of the dental arch. No patient with resorption of all four incisors was found. In total, severe root resorption related to an ectopic canine was found for 63 teeth. Forty of the 318

lateral incisors (16 aplasia) were severely resorbed, resulting in a resorption rate of 12.6 per cent. Seven of 334 central incisors were severely resorbed with a resorption rate of 2.1 per cent. Severe root resorption was recorded for 16 of 334 first premolars; resorption rate 4.8 per cent.

Location of root resorption

In 34 (57.6 per cent) cases, root resorption was located in the apical third and in 16 (27.1 per cent) in the apical and middle root thirds. Resorption affected the middle root third in three (5.1 per cent) cases, while in six (10.2 per cent) it was detected in the middle and cervical thirds of the affected root. The site of root resorption with respect to the affected tooth is shown in Table 3.

Alignment of the upper permanent incisors and root resorption

No significant relationship was found between alignment of the upper permanent incisors and the occurrence of root resorption (Table 2).

Spatial conditions in the lateral part of the dental arch on the affected side and root resorption

The relationship between the occurrence of root resorption and spatial conditions was significant (Table 2). In subanalysis, the relationship between the occurrence of root resorption in subjects with sufficient space without crowding and in those with complete loss of space was significant. However, no significant relationship was found between the

Table 2 Relationship between occurrence of root resorption and evaluated parameters.

Parameters	Number of canines (%)	Canines with root resorption	Canines without root resorption	χ^2	<i>P</i>
Ectopic canine side				3.736	0.291
Unilateral right	86 (25.7)	11	75		
Unilateral left	90 (26.9)	21	69		
Bilateral right	79 (23.7)	15	64		
Bilateral left	79 (23.7)	12	67		
Position of the canine crown in relation to the dental arch				7.34	0.025*
Palatal	192 (57.5)	25	167		
Within the dental arch	49 (14.7)	10	39		
Buccal	93 (27.8)	24	69		
Inclination of the longitudinal axis of the ectopic canine				6.34	0.096
Mesial	260 (77.8)	44	216		
Vertical	60 (18.0)	10	50		
Distal	1 (0.3)	1	0		
Horizontal	13 (3.9)	4	9		
Alignment of the upper permanent incisors				1.40	0.497
Spaced incisors	89 (26.7)	14	75		
Well-aligned incisors without spaces	158 (47.3)	32	126		
Crowding in the incisor region	87 (26.0)	13	74		
Spatial conditions in the lateral part of the dental arch on the affected side				8.45	0.015*
Sufficient space without crowding	213 (63.8)	34	179		
Lack of space	66 (19.7)	8	58		
Complete loss of space	55 (16.5)	17	38		

* $P < 0.05$.

Table 3 Occurrence of root resorption according to the affected tooth and the position of the root resorption.

Affected tooth	Apical third	Apical and middle thirds	Middle third	Middle and cervical thirds	Cervical third	Total number (%)
Lateral incisor	16	12	2	6	0	36 (61)
Central incisor	0	4	0	0	0	4 (6.8)
Lateral and central incisors simultaneously	3	0	0	0	0	3 (5.1)
First premolar	15	0	1	0	0	16 (27.1)
Total (%)	34 (57.6)	16 (27.1)	3 (5.1)	6 (10.2)	0	59 (100)

occurrence of root resorption in subjects with sufficient space without crowding and in those with a lack of space. Similarly, no significant differences were recorded between cases with sufficient space without crowding and patients with complete loss of space in combination with a lack of space.

Width of the dental follicle of ectopic canines and root resorption

A dental follicle without signs of extension was found in 284 cases (85 per cent), and with root resorption in 46 cases. Root resorption was observed in 13 of 50 cases (15 per cent) with a widened dental follicle. No significant relationship was found between the occurrence of root resorption and a widened dental follicle (Table 1).

Discussion

The prevalence of ectopically erupting maxillary canines has been reported to be 0.9–2.0 per cent, depending on the population examined (Thilander and Jakobsson, 1968; Ericson and Kurol, 1986). A strong prevalence of this anomaly among females is reported in most orthodontic subjects (Dachi and Howell, 1961; Becker *et al.*, 1981; Oliver *et al.*, 1989; Becker, 2007). The present study sample included 255 (159 females/96 males, ratio 1.7:1) orthodontic patients. Unilateral/bilateral ectopic eruptions were recorded in 176/79 patients, respectively (ratio unilateral/bilateral 2.2:1). A unilateral ectopic permanent maxillary canine occurred twice as often as a bilateral canine. Among the 176 unilateral ectopic canines, 86 were on the right and 90 on the left side. Previous studies utilizing conventional radiographic methods reported that canines were most frequently palatal to the lateral incisor and only about 15 per cent were buccal (Ericson and Kurol, 1986; 1988). Later studies, based on CT examination, presented a wide range of various positions of ectopic canines in relation to the dental arch. Bjerklin and Ericson (2006) found in 113 retained canines, that 42 per cent were located palatally, 40 per cent buccally, and 18 per cent in line with the dental arch. Liu *et al.* (2008) analysed 210 impacted maxillary canines and found that 40.5 per cent were impacted palatally, 45.2 per cent buccally and 14.3 per cent in the midalveolus. In the present study, the position of the ectopic canines was palatal in 57.5 per cent, buccal in 27.8 per cent, and within the dental arch in 14.7 per cent. No significant differences in the position of the canine crown in relation to the dental arch were found in the present data and both previous studies (Bjerklin and Ericson, 2006; Liu *et al.*, 2008).

Root resorption of the adjacent permanent teeth caused by ectopically erupting and impacted maxillary canines represents both a diagnostic and treatment dilemma. The data on the occurrence of root resorptions related to ectopic canines reported in the published literature differ significantly. Hitchin (1956) reported that five of 109 impacted canines

(4.6 per cent) caused resorption of the incisors. The epidemiologic study of Ericson and Kurol (1987), utilizing intraoral radiographs and polytomography, showed that root resorption of lateral incisors occurred in 12.5 per cent of ectopic canines. Ericson and Kurol (2000b) reported that the number of root resorptions detected by CT examination was 48 per cent. Ericson and Kurol (2000a) also found high agreement in the extent and grading of the resorptions between the CT and clinical findings on the extracted teeth. There is no doubt that CT examination (or cone beam CT) provides exact diagnosis of root resorption (Peene *et al.*, 1990; Brin *et al.*, 1993; Ericson *et al.*, 2002; Bjerklin and Ericson, 2006; Falahat *et al.*, 2008; Liu *et al.*, 2008). Ericson and Kurol (2000b) suggested a grading system for the assessment of root resorption—no resorption (intact root surfaces), slight resorption (up to half of the dentine thickness to the pulp), moderate resorption (resorption midway to the pulp or more, the pulp lining being unbroken), and severe resorption (the pulp is exposed by the resorption). Differentiation between slight and moderate resorption depends on expertise in reading the CT images (Liu *et al.*, 2008). Recognition of severe resorption is usually easier. In this study, only the occurrence of severe root resorption was evaluated; it can be easily recognized and it is clinically important for the choice of treatment method and prognosis of the affected teeth.

In the investigated sample of 334 ectopic canines, severe root resorption was found in 59 (17.7 per cent) canines. In total, 63 adjacent permanent teeth were resorbed. Severe root resorption was present in 40 (12.6 per cent) lateral incisors, 16 (4.8 per cent) first premolars, and 7 (2.1 per cent) central incisors. In the sample of 156 ectopically erupting canines, Ericson and Kurol (2000b) recorded severe root resorption in 35 (22.8 per cent) lateral and 6 (3.8 per cent) central incisors. In the set of 210 impacted canines, Liu *et al.* (2008) registered severe resorption in 23 (10.9 per cent) canines, 11 (5.2 per cent) lateral incisors and 12 (5.7 per cent) central incisors. Differences between the present results and previous studies may be due to sampling, age distribution, or structure (number of complicated cases) of the samples. In contrast to other studies, this research also evaluated root resorption of the first premolars. A literature search provided only three articles relating to this problem. Two were case reports of patients with first premolar root resorption caused by ectopic canines as an uncommon phenomenon (Postlethwaite, 1989; Cooke and Nute, 2005), and in the third in a study of 19 patients with 27 ectopic canines, root resorption of the first premolar was found only in one case (Walker *et al.*, 2005). The current findings suggest that ectopic canine-related root resorption of the first premolars occurs more often than resorption of the central incisors.

Various parts of the roots may be affected by ectopic canine-related resorption. Sasakura *et al.* (1984) described root resorption of 12 central and 11 lateral incisors from the

loss of the apical quarter to almost a complete loss of the root structure. [Ericson and Kurol \(2000b\)](#) reported that about 60 per cent of resorption involved the middle and apical thirds. [Rimes *et al.* \(1997\)](#) found the following distribution in a sample of 35 resorbed incisors: apical third in 31.4 per cent, apical and middle thirds in 60 per cent, middle and cervical thirds in 5.7 per cent, and cervical third in 2.9 per cent. In the present study sample, a high proportion of the involvement of the apical third (57.6 per cent) was detected. The apical and middle thirds were affected in 27.1 per cent, the middle third in 5.1 per cent, and middle and cervical thirds in 10.2 per cent of cases. Apical resorption was found in almost all first premolars (15 of 16 resorbed first premolars).

The aetiology of root resorptions associated with ectopic canines remains unclear. Most authors have focussed on factors significantly associated with the occurrence of root resorptions, such as gender. A higher prevalence of root resorption has been found in females ([Sasakura *et al.*, 1984](#); [Ericson and Kurol, 1988](#); [Brin *et al.*, 1993](#); [Arens, 1995](#); [Rimes *et al.*, 1997](#); [Walker *et al.*, 2005](#); [Bjerklin and Ericson, 2006](#)). However, no significant relationship between the occurrence of root resorption and gender was found in the present study. The occurrence of root resorption reflected the age distribution of the studied sample. These findings are consistent with the results of [Ericson and Kurol \(2000b\)](#). In the current investigation, the type of ectopic eruption (unilateral or bilateral), side, or inclination of the longitudinal axis of the ectopic canine did not significantly affect the prevalence of root resorption. However, a significant relationship was found between a buccolingual position of the canine crown and the occurrence of root resorption. Thus root resorption occurred most frequently in the buccal canines, less often in cases with the canine crown within the dental arch, and least often with a lingual position of the canine crown. The occurrence of lateral incisors root resorption associated with buccally displaced maxillary canines was first reported by [Knight \(1987\)](#). [Brin *et al.* \(1993\)](#) found, in 20 children with 23 resorbed lateral incisors, that the position of the unerupted canines was predominantly palatal. In the study of [Rimes *et al.* \(1997\)](#), root resorption of 35 incisors was caused by 32 ectopic maxillary canines, 14 of them (43.8 per cent) were in a palatal position, 6 (18.7 per cent) in the line of the arch, and 12 (37.5 per cent) buccal. However, these studies utilized conventional radiographs for evaluation of the occurrence of root resorption and did not evaluate the extent of root resorption. Moreover, they comprised only a small sample of patients with resorbed incisors. No other studies appear to have evaluated the relationship between the occurrence of root resorption and the buccolingual position of the ectopic canine crown.

Crowding is often associated with ectopic maxillary canine eruption. Nevertheless, there is only minimal evidence of the influence of crowding on the occurrence of root resorption

associated with ectopic canines. [Ericson and Kurol \(1988\)](#) found a lack of space for only three of 40 canines with resorbed lateral incisors and stated that a lack of space was of minor importance. However, when studying the literature a lack of space was obvious in most published case reports describing severe root resorption ([Andreassen, 1987](#); [Knight, 1987](#); [Shellhart *et al.*, 1998](#); [Otto, 2003](#); [Saldarriaga and Patino, 2003](#); [Milberg, 2006](#)). Thus, the relationship between alignment of the upper permanent incisors, spatial conditions in the lateral part of the dental arch, and the occurrence of root resorption was investigated. The results suggest that alignment of the upper incisors (i.e. spacing or crowding) has no significant influence on the occurrence of root resorption. Conversely, a significant relationship was found between the occurrence of root resorption and complete loss of space in the dental arch for the erupting canine.

A causal link between widened dental follicles and root resorption has been discussed. [Ericson and Kurol \(1988\)](#) found an enlarged canine follicle in 23 per cent of patients with root resorption, and in 24 per cent of patients without root resorption. [Ericson and Bjerklin \(2001\)](#) determined the maximum width of the canine follicle as 0.5–7.0 mm, with a mean of 2.9 mm and a 95 per cent confidence interval of 2.7–3.2 mm. They also confirmed that a widened dental follicle of an ectopic canine did not cause root resorption ([Ericson *et al.*, 2002](#)). [Liu *et al.* \(2008\)](#) detected a dental follicle larger than 3 mm in 27 of 210 impacted canines (13 per cent). Similar to these results, a widened follicle was found in 15 per cent of canines in the present study. No significant relationship was observed between the occurrence of root resorption and a widened dental follicle of the ectopic canine. At present, the physical pressure due to ectopically erupting maxillary canines has been considered the most probable cause of root resorption of adjacent teeth. The canine crown gets close contact with the root and high pressure leads to activation of the resorptive processes.

Early diagnosis of ectopic eruption of maxillary permanent canines is important. If the canines are not buccally palpable in a normal position between 9 and 12 years of age, if there is contralateral asymmetry in palpation, or if the adjacent teeth are tipped, a conventional radiographic examination is recommended. For clinical reasons, CBCT should be considered for the localization of ectopic canines, particularly for severely displaced canines, and for those with suspected root resorption or cystic degeneration. Nevertheless, the amount of radiation should be considered in each individual patient. The effective dose contribution from panoramic examination ranges from 2.9 to 9.6 μSv ([Danforth and Clark, 2000](#)). [Becker \(2007\)](#) presented the following values of the effective dose for selected types of CBCT machines (after Hatcher): NewTom 9000—50 μSv , NewTom 3G—44.7 μSv , CB MercuRay—487 or 869 μSv , and i-CAT—68.7 μSv . For the machine used in the present

research, the calculated values of the effective dose corresponded to 0.09 mSv, i.e. 90 µSv. The level of emitted ionizing radiation of CBCT machines is relatively low and the risk/benefit ratio is significantly reduced.

Conclusions

The results of the present retrospective study of 255 consecutive patients with 334 ectopically erupting or impacted maxillary canines support the following conclusions:

1. Severe root resorption of the adjacent permanent teeth occurred in 17.7 per cent of ectopic canines.
2. Severe root resorption was equally common in both females and males.
3. Severe root resorption affected 12.6 per cent of the lateral incisors, 4.8 per cent of the first premolars, and 2.1 per cent of the central incisors.
4. No relationship existed between the type or side of ectopic eruption, the inclination of the longitudinal axis of the ectopic canine, and the occurrence of severe root resorption.
5. A significant relationship existed between a buccolingual position of the ectopic canine and root resorption. Severe root resorption was most frequent for buccal canines, less often for canines within the dental arch, and least often for a palatal position of the canine crown.
6. The most severe root resorption occurred in the apical third (57.6 per cent) and apical and middle thirds (27.1 per cent). All affected first premolars showed apical root resorption.
7. A significant relationship existed between the occurrence of root resorption and complete loss of space for the erupting canine. There was no correlation between alignment of the upper permanent incisors and root resorption.
8. A widened dental follicle occurred in 15 per cent of ectopic canines but did not cause root resorption of the adjacent permanent teeth.

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