Incidence of lateral incisor root resorption associated with impacted maxillary canines

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Introduction: The aim of this study was to determine the incidence of lateral incisor root resorption associated with impacted maxillary canines and determine predisposing factors that may be used to predict its occurrence.

Methods: Cone beam computerised tomographic images of 133 patients presenting with 186 impacted canines were examined for lateral incisor root resorption. A control sample consisted of 30 lateral incisors on the side of the non-impacted canine. The studied canine-associated variables were gender, type of impaction, location of the canine both meso-distally and vertically and the long axis angulation to the midline. Axial images were primarily used to diagnose resorption.

Results: The estimated percentage of lateral root resorption in the sample was 17% (range 11.8– 23.9%) confirmed at a 95% confidence interval. A significant association was observed between the level of overlap of the canine across the lateral incisor, measured in sectors, and the probability of lateral incisor root resorption. The probability approximately doubled for each additional sector of canine overlap. No other significant association was noted related to all the other variables examined.

Conclusions: The incidence of lateral incisor root resorption associated with impacted maxillary canines was lower in the present study compared with many previous reports. However, resorption remains a common clinical finding. In order to screen for lateral incisor resorption, it is recommended that a cone beam image be prescribed when there is a mesial overlap of an impacted canine across the lateral incisor midline.

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With an incidence of between 1% and 3%, the maxillary canine is the second most frequently impacted tooth after the third molar.1,2 An impacted maxillary canine can lead to complications related to the migration of adjacent teeth, the loss of arch length, resorption of neighbouring teeth, cysts and infections.1 These conditions can complicate orthodontic treatment and early diagnosis and interceptive treatment involving the extraction of the corresponding deciduous canine may improve the situation.3–8

A significant complication of maxillary canine impaction is lateral incisor root resorption which is generally asymptomatic and difficult to diagnose.9,10 The incidence of associated lateral incisor resorption was first reported to be 12%.11 Initial figures were based on diagnosis using two-dimensional films which had limitations due to distortion caused by overlap and the difficulty in image assessment of the labial and palatal surfaces of the lateral incisors. The advent of computerised three-dimensional tomography (CT) led to the report of an increased incidence of lateral incisor resorption of 38%.12 Further studies have identified an incidence ranging from 17% to 67%.3,13–19

Significantly, a high proportion of cases revealed severe resorption extending to the pulp of the lateral incisor12,20,21 and so the early diagnosis of the severity...
and extent of resorption is crucial. A CT examination of ectopically erupting maxillary canines led to a change in 53% of the original treatment plans of patients diagnosed with lateral incisor root resorption. It is considered that a CT investigation is an important diagnostic step in the treatment planning of children presenting with ectopically erupting maxillary canines.  

The investigation of several factors has been conducted to assess the risk of canine-induced lateral incisor root resorption. These include gender, morphology of the lateral incisor, enlarged canine follicles, the proximity of the canine to the incisor, the mesiodistal and vertical displacement of the canines, palatal or buccal impaction, the long axis angulation of the canines to the midline, and the vertical height of the canine measured from the occlusal plane. Two recent studies into severe incisor root resorption concluded that gender and an enlarged dental follicle were associated with an increased risk of lateral incisor resorption related to an impacted maxillary canine. 

The aim of the present study was to determine the incidence and severity of lateral incisor root resorption associated with impacted maxillary canines and to investigate predisposing risk factors that may be used to predict the likelihood of lateral incisor resorption.

**Materials and methods**

The investigated sample consisted of 133 consecutive cases of maxillary canine impaction of which 53 were bilateral and 80 were unilateral impactions totalling 186 impacted canines. Cases that had fixed appliances in place were not considered. There were 86 females and 47 males who were referred to a radiology clinic between January 2013 and April 2014. All had cone beam (CBCT) images taken which provided sagittal, coronal and axial views.

A control sample was selected from the first 30 patients who had at least one canine that was not impacted. This provided an opportunity to assess the incidence of lateral incisor root resorption in cases of normally erupting canines against those with impacted canines. The age range of the patients was between 10y3m and 33y2m for the sample group and 10y5m and 44y5m for the control group. The large range reflected the number of adults present in the samples.

The diagnosis of canine impaction and the presence of lateral incisor root resorption was established by three independent assessors, a radiologist, an orthodontist and a general dentist on the basis of radiographic examinations of cone beam computed tomographical (CBCT) images (Figure 1). Axial images were used for the diagnosis of root resorption based on the grading system proposed by Ericson and Kurol. This was confirmed by viewing sagittal images. If a diagnostic disagreement arose between the three assessors a discussion was held to achieve a consensus.

Using a dental maxillo-facial volumetric imaging system and a reconstruction volume of 16 × 13 cm, the 3-D images were obtained using an i-Cat FLX cone beam CT (Manufacturer: Imaging Science International, Hatfield, PA, United States). Volumetric isotropic data sets were obtained using a reconstruction matrix voxel of 0.25 × 0.25 × 0.25 mm. The exposure parameters were 120kVp, 5 mA and an exposure time of 7.4 sec with a 360-degree rotation. The data sets were reconstructed in the sagittal, coronal and axial planes and presented in 1mm contiguous slices.

The following parameters were evaluated.

1. Gender and Age.
2. Type of impaction – buccal, palatal, central.
3. Unilateral or bilateral.
4. Severity of root resorption was divided into grades (Figure 2).
   a. Grade 0: No resorption.
   b. Grade 1: Resorption up to half the thickness of the root wall of the lateral incisor.
   c. Grade 2: Resorption of between half the root wall until all the way but not through the wall of the lateral incisor into the pulp chamber.
   d. Grade 3: Resorption into the pulp chamber.
5. Inclination of the long axis of the impacted canine to the vertical between the upper central incisors (Figure 3).
6. Overlap of the canine over the lateral and central incisors using the classification system of Ericson and Kurol.
   a. Sector 1: Canine tip lies distal to the root of the lateral incisor.
   b. Sector 2: Between the distal margin of the lateral incisor root and the midline.
   c. Sector 3: Between the midline of the lateral incisor and the mesial margin of the root.
d. Sector 4: Between the mesial margin of the root of the lateral and the distal margin of the root of the central incisor.
e. Sector 5: Overlap of the central incisor (Figure 3).
7. Height of resorption divided into cervical, middle and apical root thirds (Figure 3).

Statistical analysis
A computational analysis was performed using the statistical package Genstat (VSN International, Hemel Hempstead, United Kingdom). It involved fitting generalised linear mixed models, which predict the probability of root resorption from the potential explanatory variables. This type of analysis is sometimes described as logistic regression with random effects and considers that some patients had one impacted canine and others had two which provides a different weighting in the determination of the incidence of resorption. Therefore, the estimated percentages of lateral incisor root resorption were generally different to raw percentages.

Results
The present study involved 133 individuals and assessed a total of 186 impacted canines. The majority of the teeth (126) were palatally impacted, 55 were buccally impacted and 5 were in the line of the arch (Figure 4). This reflected a ratio of palatal to buccal impaction of approximately two to one. There was no relationship found between the incidence and severity of resorption and whether the canine was buccally or palatally impacted (Figure 5). There were no cases of resorption noted when the canine was impacted in the line of the arch.
In the current sample of 186 impacted canines, there were 34 cases of lateral root resorption. The estimated percentage of lateral root resorption, using the generalised linear modelling was 17% (range 11.8–23.9%) at a 95% confidence interval which is considerably less than previously quoted data.2,3,18,27,28,30 There was no incidence of root resorption in the control group which comprised 30 cases.

Of the 34 cases of lateral incisor resorption, there were 17 cases of mild resorption (grade 1), 2 cases of moderate resorption (grade 2) and 15 cases of severe resorption (grade 3).

A significant association was observed between the level of overlap (measured in sectors) and the grade of root resorption. The percentages suggested that there was an increase in the incidence and severity of lateral incisor root resorption with an increase in the level of canine overlap across the adjacent lateral and central incisors (Table I). This was confirmed by a highly significant ($p < 0.001$) ordinal-by-ordinal correlation (assessed using the gamma statistics). This was analogous to the usual correlation coefficient for continuous variables but used ordering rather than assigning actual values to the categories.

The major finding was that the probability of lateral incisor root resorption was estimated to increase by a factor of 1.98 (95% confidence interval) for each additional increase of incisor overlap. The likelihood approximately doubled as the canine was displaced more medially and radiographically moved from one overlap category (sector) to the next (Figure 6). This is shown in Table I in sectors 4 and 5 in which the incidence of severe root resorption was 9.1% and 16%, respectively. Overall, 15 of the 34 cases of lateral incisor root involvement had severe resorption penetrating into the pulp chamber. There were only 2 cases of grade 2 resorption and the remaining 17 grade 1 cases were within half the thickness of the lateral incisor wall.

It was found that 112 of the 186 impacted canines in the study group were angulated between 30° and 60° to the midline vertical. Despite a greater number of cases of resorption in this category, the severity of the resorption was spread evenly throughout the groups (Figure 7). The majority of the resorption cases were detected at the mid root level (68%), followed by apical.
Table I. Overlap of canine, by sectors correlated to severity of resorption by grade.

| Sectors | Grade | 0   | 1   | 2   | 3   | Total |
|---------|-------|-----|-----|-----|-----|-------|
|         | Count | 24  | 0   | 0   | 0   | 24    |
|         | % within overlap | 100% | 0%  | 0%  | 0%  | 100%  |
| 1       | Count | 53  | 3   | 1   | 1   | 58    |
|         | % within overlap | 91.4% | 5.2% | 1.7% | 1.7% | 100%  |
| 2       | Count | 26  | 2   | 0   | 4   | 32    |
|         | % within overlap | 81.2% | 6.3% | 0%  | 12.5% | 100%  |
| 3       | Count | 18  | 2   | 0   | 2   | 22    |
|         | % within overlap | 81.8% | 9.1% | 0%  | 9.1%  | 100%  |
| 4       | Count | 31  | 10  | 1   | 8   | 50    |
|         | % within overlap | 62.0% | 20.0% | 2.0% | 16.0% | 100%  |
| Total   | Count | 152 | 17  | 2   | 15  | 186   |
|         | %     | 81.7% | 9.1% | 1.1% | 8.1% | 100%  |

The ratio of impacted canines in males to females was 59 to 127 in favour of females and also the majority of resorption cases involved females in 26 of the 34 cases (Figure 8).

**Discussion**

The aim of the present study was to determine the incidence and severity of lateral incisor root resorption associated with impacted maxillary canines. A secondary aim was to identify factors associated with impacted canines that could be used to predict the likelihood of damage to the lateral incisor. The advantage of a predictive model is that it allows better treatment planning and earlier intervention to reduce the possibility of compromising the lateral incisor.
In the present study sample of 133 patients, there were 186 impacted canines of which 34 displayed signs of associated lateral incisor root resorption. The estimated percentage of lateral incisor root resorption was 17% which is significantly below previously reported figures of between 38% and 74%.[2,3,8,27,28,30]

A possible reason for the higher published rates of resorption compared to the present study could be due to partial volume averaging. This is a radiographic phenomenon that occurs when the separation between objects being imaged is smaller than the slice thickness and the individual voxels. When tissues of widely different absorption characteristics, such as tooth material and bone, are encompassed in the same voxel, attenuation of the beam occurs which is proportional to the average values of the tissues.[4] Axial images within a slice thickness of 0.5 mm or less, allow excellent differentiation of structures separated by 0.5 mm. However, sagittal images which are a composite of a number of slices and therefore thicker, compromises the ability to differentiate structures between the slices. If the sagittal slices are 3 mm in thickness, individual structures that are smaller or separated by less than 3 mm will be difficult to differentiate. Therefore, determining resorption by observation of the sagittal slices of a tooth may give a false positive resorption reading whilst observation in the axial plane is likely to provide a more reliable indication of the presence of resorption.

Whilst it is clear that CBCT imaging produces greater sensitivity and specificity in diagnosing root resorption defects compared to panoramic radiography, there are sensitivity differences between various CBCT systems.[5,6] This may also account for the variation in the rates of resorption detected in other studies.

Three clinicians assessed resorption in the present study by primarily viewing axial images which were also checked against the sagittal views. However, if the sagittal view suggested resorption which was unconfirmed in the axial view, a negative result was recorded.

The current study also showed that the more mesially-displaced the canine, the greater the incidence and the severity of the incisor resorption and that the likelihood of resorption approximately doubled for each subsequent sector overlapped. This finding relating to mesial displacement and the incidence and severity of lateral incisor resorption has been shown in previous studies.[3,24,30,31]

Even though the incidence of resorption in the present study was considerably lower compared with previous reports, it was still high and of concern. It is therefore important to identify those cases of impaction which are more likely to result in resorption so that treatment plans are adequately addressed. An extraction pattern might be altered to consider the removal of a damaged lateral incisor. Alternatively, the impacted canine might be retained and a resorbed lateral incisor sacrificed to turn a non-extraction case into an extraction approach. However, even if there is no change to the treatment plan, it affords the clinician the opportunity to inform the patient and provide advice regarding the prognosis of the damaged incisor.

The site of resorption of the lateral incisor occurred most frequently in the middle third of the root. This is in agreement with several previous studies,[1,24,27] but others have found that resorption occurred most often in the apical third.[25,26] Ethnic variations are said to account for the differences in location of resorption with an Asian population experiencing more apical resorption[25,26] but a Caucasian population showing mid-root damage.[9] In the present study, there was no relationship observed between the incidence and severity of resorption and the site of resorption on the lateral incisor root.

The pattern of canine-induced root resorption of the lateral incisor is often described as more oblique than horizontal.[24] In the present study, the incidence of severe root resorption penetrating to the pulp chamber was 44% of all the resorption cases. This agrees with the ranges of 12–60% identified in similar studies.[9,20,27] It is of interest that the present study showed few cases of grade 2 resorption as most were recorded as either grade 1 or 3. This suggested that if severe resorption was likely to occur, it would progress to grade 3. This finding has not been previously observed in other studies.[4,14,16]

The angle of impaction did not seem to be associated with the severity of resorption and could not be used to predict incidence. This contradicts an earlier study in which canine angulation was found to be significant.[3,15,26] The consensus in the literature confirms that canine angulation does not appear to be related to the prevalence nor the severity of incisor root resorption.[27–19,29]

The number of females in the present study presenting with impacted canines was more than double that of males but there was no apparent association between gender and the incidence or severity of
lateral incisor resorption. While there is some agreement,9,12,17 earlier studies found that the risk of severe incisor resorption was disproportionately greater in females.23,24

Whether the canine impaction was labial or palatal to the lateral incisor or involved left or right sides could not be correlated with an increased risk of root resorption. The present findings are consistent with studies that found that labially impacted canines were not more frequently associated with resorption9,18 but other studies are contradictory.24,27,35

The present study therefore revealed that the only factor that could be correlated with an increased risk of lateral incisor root resorption was the radiographic level of incisor overlap by the impacted canine.

Summary

1. The incidence of lateral incisor root resorption related to impacted canines in the present study was 17%.
2. The diagnosis of incisor root resorption should be made using 3D computerised images in the axial plane.
3. The probability of lateral incisor root resorption related to an impacted canine approximately doubled for each additional sector of canine overlap across the lateral incisor.
4. Gender, impaction site, tooth number, the height of the canine or angulation of the canine to the midline did not seem to be predictive factors in determining the probability of incisor root resorption.
5. The significance of determining incisor root resorption, apart from medico-legal issues is that, the information may affect the treatment plan and may have long-term implications regarding the dental health of the patient.

Conflict of interest

The authors declare that there is no conflict of interest.

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