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Radiographic assessment of developing maxillary canine ectopia and its association with dental anomalies in the mixed dentition

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ABSTRACT

Introduction

Reciprocal associations have been found to exist between various dental anomalies.[1-14] Maxillary canine ectopia may, however, occur in dentitions without any anomalies.

Aims and objectives

The aim of the study was to establish the prevalence of dental anomalies in a sample of panoramic radiographs. The objective was to establish whether associations exist between canine ectopia and the presence of one or more of a range of selected developmental dental anomalies. A cross-sectional study was carried out on 574 mixed dentition panoramic radiographs in patients with a dental age ranging from 8 to 12 years.

Results

Signs of potentially ectopic maxillary canines were evident in 85% of the radiographs and of these, 80.7% showed no evidence of the selected dental anomalies which were studied. The most prevalent association of potential canine ectopia and the anomalies studied was found with supernumerary teeth (6.5%), followed by infraocclusion of primary molars (4.5%). Peg-shaped lateral incisors showed a statistically significant association (p=0.043) with mesial overlap of the cusp tip of the maxillary canine and the root of the lateral incisor. Taurodontism was significantly associated with increased angulation of the developing canine (p=0.0049) and dilaceration showed a statistically significant association (p=0.03) with non- resorption of canines.

Conclusion

In cases where dental anomalies are present, the developing canines should be carefully monitored both clinically and radiographically.

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Conflict of interest
None

Introduction

Pre-eruptive canine ectopia refers to erupting canines that show signs of moving in the wrong direction.[1] When assessing the developing canines during the mixed dentition stage, important factors need to be taken into consideration.

- These have been identified by Hudson *et al*.[1] as
- The presence of the canine bulges
- The presence of dental anomalies
- The late development of the dentition
- The size, position or absence of the lateral incisors
- The amount of space available in the arch and
- The mobility of the primary canines.

The early diagnosis of one or more developmental anomalies during the mixed dentition stage should be viewed as a potential early warning sign of possible

Table I: Dental age vs. the prevalence of potentially ectopic maxillary canines

Dental Age	n (%)	Total n (%)
8	40 (8.1)	89 (18.1)
9	49 (9.9)	
10	211 (42.8)	404 (81.9)
11	133 (27)	
12	60 (12.2)	
Total		493

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Table II: Prevalence of each radiographic marker indicating canine ectopia at various dental ages.

		n (%)					
Dental Age	Total n	Rotated Maxillary Lateral Incisors	Non-resorption of primary canines	Overlap	Angulated maxillary canines	Mx. Enlarged	Mnd. Enlarged
8	40	39 (97.5)	N	N	2 (5)	6 (15)	5 (12.5)
9	49	47 (95.9)	N	N	2 (4.1)	6 (12.2)	3 (6.1)
10	211	159 (75.3)	176 (83.4)	56 (26.5)	9 (4.3)	28 (13.2)	20 (9.5)
11	133	103 (77.4)	72 (54.1)	33 (24.8)	8 (6)	18 (13.5)	16 (12)
12	60	57 (95)	10 (16.7)	14 (23.3)	2 (3.3)	6 (10)	6 (10)
Total	493	405	258	103	23	64	50

*N= Normal observation at this age.

canine ectopia.[1] These include ectopic eruption of the first permanent molars, taurodontism, invaginations[2, 3, 4] and size and shape of the maxillary lateral incisor.[5-12] The lateral incisors are thought to guide the canines into position, therefore, in cases where the root of the lateral incisor is smaller than normal or the lateral incisor is congenitally missing, ectopia may result. [13, 14]

Significant reciprocal associations have been demonstrated between palatally displaced canines, small maxillary lateral incisors, infraocclusion of primary molars, missing second premolars and enamel hypoplasia.[15] Several authors have suggested that infraocclusion of primary molars may cause ectopic eruption of the maxillary canines, because of the effect it has on the transeptal fibres.[3,15, 16, 17] Late developing dentitions and in particular, late developing lateral incisors, may be more disruptive for canine eruption than missing lateral incisors.[18, 19, 20] Studies have shown that aplasia of the second premolars may cause ectopic eruption of the permanent maxillary canines.[3,15] However, since these premolars show a high variability in the initiation of calcification,[21, 22, 23, 24] they should only be considered congenitally missing after the dental age of 7 years in order to avoid a false positive diagnosis.[25] Some may erupt as late as a year after the eruption of the contralateral premolar.[21] Aplasia of premolars could possibly create arch-length discrepancies, making it difficult for the maxillary canine to erupt into its normal position.[26]

Not much research has focused on the relationship between supernumerary teeth and ectopic maxillary canines. Baccetti[15] found that supernumerary teeth did not have any association with palatally displaced maxillary canines. The presence of supernumerary teeth within the dental arch may cause delayed eruption of teeth, space issues, displacement of adjacent teeth and ectopic eruption of teeth.[27,28] A mesiodens, for example, may prevent or delay eruption of the permanent maxillary central incisors which may cause ectopic eruption of a central incisor with a potential effect on the space remaining to accommodate canine eruption.[29] Less frequently, a mesiodens may cause dilaceration or resorption of the permanent central incisor root, which may have an effect on the positioning of the canine.[30, 31, 32]

Bjerklin *et al*.[3] suggested that there is a statistically significant association between ectopic first molars and ectopic maxillary canines. However, Baccetti[15] found no association between ectopic molars and palatally displaced canines. Becktor *et al.*,[2] showed that 23.3% of the 30 patients examined presented with ectopic eruption of the permanent first maxillary molar and root resorption of the second primary molar. This takes place prior to root resorption of the maxillary primary canines which is caused by ectopic maxillary permanent canines. Hence, the ectopic first molars could possibly be used as an early risk factor for the prediction of maxillary canine ectopia.

Methodology

The rationale for the study was to show whether or not there is a correlation between dental anomalies and canine ectopia in a South African context. An analytical, descriptive, cross-sectional, retrospective study was carried out to attempt to establish any relationship/ association between potential maxillary canine ectopia and the presence of a variety of selected developmental dental anomalies. Sequential, good quality mixed dentition panoramic radiographs (n = 574) from the UWC Paediatric Dentistry department at the Tygerberg Oral Health Centre were used. These radiographs were taken between 2011 and 2014 on patients with a dental age ranging from 8 to12 years. Patients with syndromes, cleft lip and palate, a history of previous extractions and those who received prior orthodontic treatment, were excluded.

The radiographic markers used for prediction of canine ectopia were:

- Rotated lateral incisors
- Non-resorption of primary canine roots

Table III: Prevalence of developmental anomalies in potentially ectopic maxillary canines (n=493).

Developmental Anomalies	Cases n (%)
No Developmental Anomalies present	398 (80.7)
Congenitally Missing lateral incisors	6 (1.2)
Aplasia of Premolars	12 (2.4)
Peg-Shaped Maxillary Lateral Incisors	7 (1.4)
Infraocclusion of Primary Molars	22 (4.5)
Supernumerary Teeth	32 (6.5)
Taurodontism	7 (1.4)
Dilaceration	17 (3.4)
Ectopic Molars	0

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- Overlap between the developing permanent canine and the root of the lateral incisor
- Angulation of the developing canine greater than 30^0 to the mid-sagittal plane
- Enlarged developing maxillary canines
- Enlarged developing mandibular canines

Each of the radiographs exhibiting signs of potentially ectopic canines, were examined in order to determine the presence and/ or absence of the following developmental anomalies:
- Congenitally missing lateral incisors
- Aplasia of premolars
- Peg-shaped permanent maxillary lateral incisors (where the incisal width was less than the cervical width)
- Infraocclusion of primary molars (diagnosed by a "step" in the occlusal plane)
- Supernumerary teeth
- Taurodontism
- Dilaceration of roots greater than 90^0
- Ectopic eruption of permanent first molars

The results obtained were coded accordingly and transferred to a Microsoft Excel spreadsheet.

Data processing and analysis

Pearson's correlation coefficient was used to determine the degree to which two variables were associated. For a correlation coefficient to be statistically significant, its absolute value must exceed 0.0834. This indicates an association. The Chi-square test of independence and Fisher exact test were also used to determine whether two categorical variables were dependent or independent. A p-value of <0.05 indicates that the variables have an association.

Results

Of the 574 radiographs studied, 493 displayed potentially ectopic maxillary canines (Table I).

The anomalies detected are displayed in Table III. Roughly 80% of the cases presented with ectopia with no evidence of anomalies.

Of the 493 panoramic radiographs, 95 had anomalies present, 8 of which presented with more than 1 anomaly:
- 1 case presented with a congenitally missing lateral incisor, a peg-shaped lateral incisor and a supernumerary tooth.
- 2 cases presented with a congenitally missing incisor and a supernumerary tooth.
- 2 cases presented with infraocclusion and aplasia of a premolar.
- 1 case presented with infraocclusion and dilaceration.
- 1 case presented with infraocclusion and a supernumerary tooth.
- 1 case presented with a peg-shaped lateral incisor and a supernumerary tooth.

DISCUSSION

The findings of this study confirm the conclusion of Sorenson *et al*.[4] that maxillary canine ectopia can occur in dentitions without any other dental deviations (Tables I, II and III). Other studies however suggest that the presence of one anomaly could predict another in the same case.[15,33] The reciprocal associations found by Baccetti[15] were not seen in this study. The low prevalence of developmental anomalies in this study (Table III) may be due to the genetic factors governing these various anomalies i.e. ethnicity/ hereditary factors.

Table IV: The presence of developmental anomalies and their association with the selected radiographic markers predicting potential canine ectopia.

	n (%)					
Developmental Anomalies	**Rotated Laterals (n=405)**	**Non-resorption of primary canines (n=258)**	**Overlap (n=103)**	**Angulation (n=23)**	**Mx. Enlarged (n=64)**	**Mnd. Enlarged (n=50)**
No Developmental Anomalies	333 (82.2)	209 (81)	80 (77.7)	18 (78.3)	51 (79.7)	43 (86)
Congenitally Missing Lateral incisors	2 (0.5)	5 (1.9)	0	1 (4.3)	0	0
Aplasia of Premolars	10 (2.5)	7 (2.7)	2 (1.9)	0	2 (3.1)	0
Peg-Shaped Maxillary Lateral Incisors	3 (0.7)*	5 (1.9)	2 (1.9)**	0	2 (3.1)	1(2)
Infraocclusion of primary molars	17 (4.2)	14 (5.4)	3 (2.9)	1 (4.3)	3 (4.7)	1(2)
Supernumerary Teeth	24 (5.9)	16 (6.2)	9 (8.7)	2 (8.7)	5 (7.8)	3 (6)
Taurodontism	6 (1.5)	3 (1.2)	2 (1.9)	2 (8.7)	0	1(2)
Dilaceration	14 (3.5)	5 (1.9)****	4 (3.9)	2 (8.7)***	1 (1.6)	1(2)
Ectopic Molars	0	0	0	0	0	0

* p = 0.01
** p = 0.043
*** p = 0.0049
**** p = 0.03

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No statistically significant associations ($p > 0.05$) were found to exist between congenitally missing lateral incisors and each of the radiographic markers when assessed separately (Table IV). This concurs with the findings of a study by Peck *et al*.[10] which found no statistical significance in the relationship between missing maxillary lateral incisors and palatally displaced maxillary canines. Some studies have found that roughly 5% of congenitally missing maxillary lateral incisors occur with palatally displaced maxillary canines[7,9], whilst others noted the frequent presence of palatally displaced canines.[11,12] Nanda[8] suggested that non-resorption of primary canines was likely to occur in cases with congenitally missing lateral incisors. These authors emphasized Broadbent's original 1941 observation, where the absence of a maxillary lateral incisor deprives the erupting permanent maxillary canine of the normal guidance provided by the root of the maxillary lateral incisor. This in turn leads to the high occurrence of palatally displaced canines. In the present study, the low number of cases with a congenitally missing maxillary lateral incisor may have accounted for the difference in the findings. Further investigations of congenitally missing maxillary lateral incisors using a bigger sample size may reveal a different association with maxillary canine ectopia.

The Chi-square independence test revealed no statistically significant associations between any of the potential markers of canine ectopia and aplasia of premolars (Table IV). The present study did not confirm the significant inverse relationship that Baccetti[34] found between the maxillary lateral incisor rotation and aplasia of premolars. The difference in findings may be due to the low prevalence of aplasia of premolars within the selected sample.

A statistically significant association was found between peg-shaped maxillary lateral incisors (Table IV) and mesial overlap of the maxillary canine cusp tip over the root of the maxillary lateral incisor ($p= 0.043$).

The statistically significant association with mesial overlap supports the work of several authors who have reported the high incidence of peg-shaped maxillary lateral incisors in children with ectopic maxillary canines.[6,9,10,15,35] All other radiographic markers showed no statistically significant association with peg-shaped maxillary lateral incisors. The significance of the mesial overlap may be understated because of the age limit on the study sample. Other studies have also demonstrated weak or no association between peg-shaped maxillary lateral incisors and the failure of eruption of the maxillary canine.[36,37]

A statistically significant association was found between peg-shaped maxillary lateral incisors (Table IV) and rotated maxillary lateral incisors ($p= 0.01$). The probability test showed that:

- There was a 0.74% chance for peg-shaped maxillary lateral incisors to occur when a rotated maxillary lateral incisor existed.
- There was a 33% chance for a rotated maxillary lateral incisor to occur in the presence of a peg-shaped maxillary lateral incisor.

Radiographically, the normal maxillary lateral incisor appears with the incisal edge of the crown parallel to the occlusal plane. The mesial and distal ridges are present and the V-shaped lingual fossa is visible. In the case of a rotation, only one of the ridges would be visible. The curvature of the cervical line is distinct in the direction of the incisal edge when the maxillary lateral incisor is rotated.[38] The peg-shaped lateral presents with cervical margin broader than the crown tip with no ridges visible. Thus, radiographically, rotated maxillary lateral incisors could appear peg-shaped (depending on the severity of the rotation). This highlights a limitation of the present study in that it was a radiographic study without a clinical examination.

No statistically significant associations were found between infraocclusion of primary molars and the radiographic markers assessed. However, other studies showed significant associations between infraocclusion of primary molars and displaced maxillary canines.[3,15,17] The difference in the results could possibly be due to the low prevalence of infraoccluded primary molars within the study sample.

No statistically significant association was found between supernumerary teeth and any of the radiographic markers. This study concurs with Baccetti's[15] study, which found that the group with supernumerary teeth did not show any significant associations with palatally displaced maxillary canines. Gomes *et al.*[39] also found that supernumerary teeth were common in his study of patients aged 9 to 10 years and noted that non-resorption of the primary maxillary canines occurred simultaneously.

Taurodontism showed no statistically significant association with potentially ectopic maxillary canines as determined by all the considered radiographic markers in Table II ($p= 0.48$). Nagpal *et al.*[40] found a statistically significant relationship between maxillary canine ectopia and taurodontism. In the present study, however, taurodontism showed a statistically significant association (Table IV) with the angulation of the canine ($p= 0.0049$). When the angulation of the maxillary canine was greater than 30^0, the probability test found that:

- There was a 22% chance of taurodontism occurring.
- There was only a 9% chance of angulation of the maxillary canine being greater than 30^0 when taurodontism existed.

Dilaceration (Table IV) showed a statistically significant association with non-resorption of primary maxillary canines ($p= 0.03$). When non-resorbed primary maxillary canines existed, the probability test showed that:

- There was a 29% chance of dilaceration occurring.
- There was only a 2% chance for non-resorption of the primary maxillary canines to occur when dilaceration existed.

A total of three premolars and fourteen molars presented with dilacerations, whereas only four central incisors and two lateral incisors displayed dilaceration. This is consistent with studies conducted by Malcic *et al*.[41] which recorded a 1.43% prevalence of dilaceration (90^0 or greater) of lateral incisors on panoramic radiographs. The question remains as to whether a dilaceration of 45^o is normal or abnormal. No literature has specified the normal anatomical angle for dilaceration, which is why researchers use various criteria. This study found no statistically significant association between dilaceration and potentially ectopic maxillary canines as determined by the six radiographic markers ($p= 0.24$) (Table III).

In a sample size of 480 cases, Chohayeb[42] reported that

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disto-labial dilaceration occurred in 52% of the maxillary lateral incisors. He disregarded angles less than 20^0 when recording dilaceration. Maxillary lateral incisors have a normal anatomical distal curvature[43] for which, the exact degree of angulation is unknown. This result is therefore still questionable, because the normal anatomical curvature could have been 30^0 or more and these cases may have been included as an anomaly when Chohayeb[42] was recording the prevalence of dilaceration, thus, bringing about the high prevalence of dilaceration of the maxillary lateral incisors in their study. The data reported by Chohayeb[42] is not consistent with Malcic *et al*.'s[41] results, where the prevalence of dilaceration for the lateral incisors was 1.43% in a sample size of 488 panoramic radiographs and 7% on periapical radiographs. Malcic *et al*.[41] only recorded root dilacerations greater than or equal to 90^0, which is a strict criterion compared to Chohayeb's[42] criteria. Hamasha *et al.*[44] reported a prevalence of 1.2% for dilaceration in the maxillary lateral incisors in a sample size of 812 periapical radiographs. They also recorded all dilacerations of 90^0 and above. However, compared to Malcic *et al*.'s[41] study, they found a lower prevalence for dilaceration using periapical radiographs. The present study used panoramic radiographs to identify the presence of root dilacerations. Hence, Hamasha *et al.*'s[44] prevalence could not be compared with the present study.

The diagnosis of an ectopic first molar may be made clinically upon the eruption between a dental age of 5 to 7 years. Since the current study only used panoramic radiographs from dental age 8 years and above, the only way to determine if a first molar had ectopically erupted, was to identify the presence of resorption in the disto-buccal root of the second primary molar.[2, 45] This study did not find any statistically significant associations with the various radiographic markers, thus supporting the findings of Baccetti's study.[15] However, Bjerklin *et al.*[3] found a statistically significant association between ectopic maxillary canines and ectopic molars.

CONCLUSION

When clinicians identify taurodontism prior to dental age 10, they should be aware of the possibility of angulation of the maxillary canines of greater than 30^0. This enables them to take interceptive measures (like the timeous extraction of the primary canines[1]) by monitoring the movement of the maxillary canine.

In the case of peg-shaped lateral incisors which can be clinically diagnosed on eruption at a dental age of 8 years, the overlap between the developing canines and lateral incisors should be monitored for signs of ectopia. The same holds true for supernumerary and infraoccluded teeth which demonstrated the strongest association with canine ectopia.

Should any root dilacerations of the lateral incisors or canines be identified prior to the dental age of 10 years, the resorption of the primary canine roots should be monitored for ectopia.

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