Is the Etiology Behind Palatal Unilateral and Palatal Bilateral Maxillary Canine Ectopia Different?

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Abstract

**Introduction:** The purpose of this study is to elucidate whether dentitions and craniofacial profiles are different in unilateral and bilateral maxillary canine ectopia. **Materials and Methods:** Radiographic materials from 75 patients with non-syndromic palatally displaced maxillary canines were studied. Bilateral ectopia occurred in 37 patients and unilateral ectopia in 38 patients. Orthopantomograms were analyzed for dental deviation including taurodontic morphology, abnormal crown morphology, invaginations of the incisors and short root lengths. Skeletal morphology was studied cephalometrically according to Björk. Statistic analysis were included. **Results:** Significant more females than males had palatally ectopic maxillary canines. Gender differences were not observed between the uni- and bilateral ectopia groups. Orthopantomograms; the occurrence of taurodontia was significantly higher in the bilateral group while invaginations were significantly higher in the unilateral group. Patients with palatally displaced maxillary canines had an increased occurrence of agenesis. Profile radiographs; in the unilateral group significantly retroclined maxillary incisors in females and males and a significantly posterior inclined maxilla in females occurred. In the bilateral group a significantly reduced slope of the maxillary incisors was demonstrated. Compared to the individuals without palatally displaced maxillary canines, the maxillary incisors were significantly retroclined in both groups. **Conclusion:** The present paper indicates a difference in the dentition and craniofacial profile in palatal unilateral and palatal bilateral maxillary canine ectopia. It is presumed that the unilaterally displaced canines have a dental origin while the bilateral cases have a skeletal origin. If this is so, the diagnosis of the dental morphology (invagination and taurodontia) might help to distinguish between cases with dental etiology and cases with skeletal etiology. This distinguish may improve orthodontic treatment.

**Keywords:** Canine, cepalometry, ectopia, human, orthpantomogram, profile radiographs

INTRODUCTION

The etiology behind maxillary canine ectopia is still debated. Several studies have focused on differences between labially displaced maxillary canines and palatally displaced canines. It has been concluded that the labially displaced canines occur in normally developed dentitions, and it has been proposed that the etiology behind this dental deviations is lack of space in the dental arch.

The palatally displaced canines have received much interest in the literature specially focusing on treatment problems. The dentition in cases with palatally displaced canines has been described with deviation such as invaginations, taurodontia, agenesis and root deviation. The precise etiology behind palatally displaced canines has not been proposed. Seemingly sufficient space in the dental arch occurs in these dentitions.
right maxillary half originate from the right neural crest, while teeth on the left maxillary half originate from the left neural crest. From a developmental point of view, studies on the neural crest fields in the palate have demonstrated three bilateral fields – these are as well in the right maxillary half as in the left maxillary half the naso-palatine field (anterior) the maxillary field (medial) and the palatal field (posterior)\textsuperscript{[23-27]} [Figure 1].

In a former study on maxillary canine transpositions, distinctions were made between unilateral transposition and bilateral transposition. This recent study demonstrated dental and skeletal differences, which could indicate different etiology.\textsuperscript{[28]}

Former studies have also demonstrated that dental deviations can occur within neural crest developmental fields.\textsuperscript{[24-27]} Focus on these fields has been elaborated in cleft-lip-and palate patients, where different dental deviations within the different fields characterized the three cleft types, cleft-lip, cleft-palate, and combined cleft-lip and palate.\textsuperscript{[29]} Of specific interest is the observation of taurodontic molars in isolated cleft palates. This association might indicate a developmental inter-relationship between abnormal palatal shelves and molar development. Also the premolars were malformed and with short roots within the palatal shelves.\textsuperscript{[29]} The genetic aspect in ectopic maxillary canines has been discussed in several clinical cases\textsuperscript{[30-34]} also the inter-relationship between first maxillary molar ectopia and canine ectopia have been elucidated.\textsuperscript{[26]} The eruption process has also been in focus in the discussion of etiology.\textsuperscript{[35-43]}

On the background of former mentioned studies on dental differences in palatally and buccally displaced canines and maxillary canine transpositions and furthermore on the studies on the dentitions in cleft-lip and palate the hypotheses in this study is that the etiology behind unilateral and bilateral maxillary canine ectopia might be different. It is therefore the goal to analyze dental and skeletal conditions in unilateral and bilateral ectopia cases.

**Material and Methods**

**Material**

Radiographic materials from 75 patients with palatally displaced maxillary canines (PDC) were included in this study. The materials were from 74 patients below 18 years of age and referred to the Dental School, University of Copenhagen, Denmark from different community dental clinics in Denmark after approvals from patients and parents. Material from one adult patient was included. The material was composed of profile radiographs and orthopantomograms, all taken in connection with diagnostics and orthodontic treatment planning. Figure 2 demonstrates a case with a unilateral palatally displaced maxillary canine, and Figure 3 demonstrates a case with bilateral palatally displaced maxillary canines.

Bilateral ectopia occurred in 37 patients and unilateral ectopia occurred in 38 patients. The distribution of the patients according to gender appears in Figure 4 and according to ages in Table 1.

The criteria for submitting the material to this investigation were that the patients had either unilateral or bilateral palatally ectopic maxillary canines and that none of the patients were diagnosed with a syndrome.

**Figure 2:** Orthopantomogram of a female 16 years and 8 months old with unilateral displaced right maxillary canine. Invaginations appear in the maxillary incisors and there is agenesis of the right mandibular second premolar

**Figure 3:** Orthopantomogram from a female 15 years of age with bilateral displaced maxillary canines. Taurodontia is observed in the maxillary molars and in the mandibular second molars. The lateral maxillary incisors appear narrow
METHOD

The study consisted of two parts:
(1) Orthopantomograms were analyzed for dental deviation.
(2) Cephalometric analyses were performed with focus on sagittal and vertical dimensions.

Radiographic materials available in the different groups are shown in Table 2.

Comparison was performed between the unilateral group and bilateral group.

Ad 1. Orthopantomograms. The following dental criteria were registered:
- Agenesis, inclusive agenesis of third molar.
- Morphologic deviations. These were as follows:
  (a) Taurodontic morphology according to morphology of the pulp cavity;
  (b) Crown morphology of the maxillary lateral such as narrow crowns;
  (c) Invaginations of the incisors;
  (d) Root length and short root were defined as root length equivalent to or less than the height of the crown.
- Eruption deviations, others than the maxillary displaced canines.

Ad 2. Profile radiographs were digitized according to modification of Björk’s method.\[44\] As the magnification of the radiographs was unknown, angular measurements were performed. The angular measurements are listed in Table 3. The measurements were expressed in standard deviations (SD) calibrated after age and gender. Due to ethical reasons radiographs of a control group without orthodontic indications for radiography was not available.

Statistics

Fishers exact test was used for the evaluation of differences in dental deviations. For the evaluation of the inter-rater reliability, the kappa statistic was used.

For the evaluation of the cephalometric angular measurements, the Spearman rank correlation and the chi-square test were used. Also Levenes test was used for demonstrating the homogeneity of the groups.

P-values $<0.05$ were considered as significant.

RESULTS

Distribution of material: unilateral maxillary ectopia occurred in 38 cases (50.7%), They had 19 cases ectopia in the right side and 19 cases ectopia in the left side. Bilateral ectopia occurred in 37 cases (49.3%). The gender distribution of the 75 cases was: 21 males and 54 females responding to a ratio 1:2.7. The bilateral group had 70.3% females, and the unilateral group had 73.7% females.

Analysis of orthopantomograms: the prevalence of dental deviations was high in both groups. Only four cases in the bilateral group and six cases in the unilateral group were without dental deviations. An overview of dental deviations is given in Table 4, which are graphi graphically illustrated in Figure 5.
Significant findings were the observation of taurodontia in the bilateral group \((P=2.02)\) and invaginations in the unilateral group \((P=0.009; \text{Table 4})\).

Significant differences were not observed between left and right sides [Figure 6].

Taurodontia: the percentage of taurodontia was higher in males compared to females, which is graphically illustrated in Figure 7.

Agenesis: the prevalence of agenesis was high in both groups, that is, 38% in the bilateral and 42% in the unilateral group [Figure 8]. There was no significant difference between agenesis in females and males.

Invaginations: in the bilateral group 24% had invaginations in one or several maxillary incisors and 55% had invaginations in the unilateral group [Figure 9]. The difference between the groups was significant. There was no significant difference between females and males.

### Table 3: Overview of the angles measured on the profile radiographs

<table>
<thead>
<tr>
<th>Angular measurements</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal jaw relationship (ss-n-pg)</td>
<td>Angle between the bone markers sella (s), nasion (n) og subspinal (ss)</td>
</tr>
<tr>
<td>Maxillary prognathia (s-n-ss)</td>
<td>Angle between the bone markers subspinal (ss), nasion (n) og pogonion (pg)</td>
</tr>
<tr>
<td>Mandibular prognathia (s-n-pg)</td>
<td>Angle between the bone markers sella (s), nasion (n) og pogonion (pg)</td>
</tr>
<tr>
<td>Vertical jaw relationship (NL-ML)</td>
<td>Angle between the nasal line (NL) og, mandibular line (ML)</td>
</tr>
<tr>
<td>Maxillary inclination (NSL-NL)</td>
<td>Angle between the line connecting the bone markers nasion and sella (NSL) and the nasal line (NL)</td>
</tr>
<tr>
<td>Mandibular inclination (NSL-ML)</td>
<td>Angle between (NSL) and the mandibular line (ML)</td>
</tr>
<tr>
<td>Upper incisor inclination (ILs/NL)</td>
<td>Angle between the midaxes of the maxillary incisor (ILs) and the nasal line (NL)</td>
</tr>
<tr>
<td>Cranial base angle (n-s-ba)</td>
<td>Angle between the bone markers nasion (n), sella (s) og basion (ba)</td>
</tr>
</tbody>
</table>

### Table 4: Overview of dental deviations in the bilateral displaced canine group and in the unilateral displaced canine group

<table>
<thead>
<tr>
<th>Groups</th>
<th>Taurodontia</th>
<th>Agenesis</th>
<th>Agenesis third molar</th>
<th>Agenesis lateral incisor</th>
<th>Agenesis premolar</th>
<th>Invagination</th>
<th>Narrow laterals</th>
<th>Ectopia of other teeth</th>
<th>Short roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral PDC</td>
<td>23 (62%)</td>
<td>14 (38%)</td>
<td>12 (32%)</td>
<td>3 (8%)</td>
<td>0 (0%)</td>
<td>9 (24%)</td>
<td>3 (8%)</td>
<td>5 (14%)</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>95% CL</td>
<td>45–78</td>
<td>22–56</td>
<td>18–50</td>
<td>22–90</td>
<td>0</td>
<td>12–42</td>
<td>2–22</td>
<td>5–29</td>
<td>1–19</td>
</tr>
<tr>
<td>Unilateral PDC</td>
<td>13 (34%)</td>
<td>16 (42%)</td>
<td>13 (34%)</td>
<td>2 (5%)</td>
<td>5 (13%)</td>
<td>21 (55%)</td>
<td>6 (16%)</td>
<td>4 (11%)</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>95% CL</td>
<td>20–51</td>
<td>26–59</td>
<td>20–51</td>
<td>1–18</td>
<td>5–29</td>
<td>35–75</td>
<td>7–32</td>
<td>3–25</td>
<td>1–18</td>
</tr>
<tr>
<td>P-value</td>
<td>0.02*</td>
<td>0.8</td>
<td>1.00</td>
<td>0.67</td>
<td>0.05</td>
<td>0.009*</td>
<td>0.48</td>
<td>0.74</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note significant findings marked with asterisks of taurodontia in the bilateral group and of invaginations in the unilateral group.

Figure 5: Overview of dental deviations in unilateral and bilateral palatally displaced maxillary canines

Figure 6: The distribution of dental deviations according to the maxillary right (3+) and maxillary left (+3) side

Figure 7: Overview of taurodontia according to gender in cases with bilateral and unilateral palatally displaced maxillary canines
Eruption deviations: there was no significant difference between the groups.

The inter-rater liability demonstrated compliance.

Analysis of profile radiographs
A total of 73 cases were analyzed cephalometrically twice. A total of 35 cases in the bilateral group were compared to 38 cases in the unilateral group. The mean value for each angular measurements were compared to normal values given by Björk. The results are demonstrated in Table 5.

Unilateral group: in the unilateral group the analysis demonstrated significantly retroclined maxillary incisors (ILs-NL) in females and males. In the unilateral group also, the females demonstrated a significantly posterior inclined maxilla (NSI-NL).

Bilateral group: in the bilateral group the males demonstrated a significantly reduced slope of the maxillary incisors (ILs-NL) but this could not be demonstrated in females.

Compared to individuals without palatally displaced maxillary canines the maxillary incisors were significantly retroclined in both groups ($P = 0.005$).

SUMMARY OF FINDINGS
Orthopantomograms:
- Significant more females than males had palatally ectopic maxillary canines. There were no gender differences between the groups.
- The occurrence of taurodontia was significantly higher in the bilateral group.
- The occurrence of invaginations was significantly higher in the unilateral group.
- Patients with palatally displaced maxillary canines had an increased occurrence of agenesis.

Profile radiographs:
- Unilateral group: a significantly retroclined maxillary incisors were observed in males and females. Furthermore females demonstrated a significantly posterior inclined maxilla.
- Bilateral group: the males demonstrated a significantly reduced slope of the maxillary incisors, but his was not demonstrated in females.

DISCUSSION

The main new findings in the dental analysis in this investigation is the significant occurrence of taurodontia in the bilateral group, while the significant occurrence of invagination occurred in the unilateral group. The normal prevalence of taurodontia have been described in a German population.[45]

Furthermore, former results concerning gender distribution were confirmed, such as findings of females showing more often ectopic displaced maxillary canines than males[3] and the information on high prevalence of third molar agenesis[14] were high in both groups.

In the cephalometric analysis of the craniofacial profile, the significant findings were the observation of retroclined maxillary incisors in the unilateral group (males and females) and in the bilateral group (males only). Furthermore, females demonstrated a significantly inclined maxilla in the unilateral group.

It can be discussed if the dental findings in this investigation can be compared to dental findings in the study on maxillary canine transposition by Danielsen et al.[28] They found in their study on canine transposition that taurodontia occurred more often in cases with transposition of first premolar and the maxillary canine compared to cases with transpositions of maxillary canines and lateral incisors.

In the dental analysis, published in the paper by Riis et al. on Cleft-lip and palate dentitions[29] taurodontia occurred more often in isolated cleft-palate patients compared to other cleft types. Isolated cleft palate is a malformation of the maxillary 80%
Influence of the supporting bone (ectomesenchymal origin) has been given to the innervation of the root of the tooth.

Dental deviations have been mentioned in connection with maxillary canines.

Prediction of ectopia is important for treatment planning. One might cause ectopia.

It could be suggested that one of these different processes seems to be dependent on different biological processes.

The importance of the crown follicle (ectodermal origin) is highlighted in a series of papers.[27,40,41] Also the shelves.[29] Concerning the normal eruption process and the etiology behind this process several proposals have been discussed. The observations in the present study could indicate that a developmental deviation in the palatal processes possibly are related to the findings of taurodontia in the bilateral group. If so then the bilateral group of displaced maxillary canines could indicate a skeletal etiology (ectomesenchymal origin) while the etiology behind the unilateral group of displaced maxillary canines could have a non-skeletal origin (ectodermal origin). This is schematically illustrated in Figure 10.

In a recent paper, normal dentitions have been described in dentitions with agenesis of maxillary canines, not associated with other agenesis in the dentition.[47] Inheritance in cleft lip and palate is well known. Also skeletal observations have been associated with canine ectopia.[46] The observations in the present study could indicate that a developmental deviation in the palatal processes possibly are related to the findings of taurodontia in the bilateral group. If so then the bilateral group of displaced maxillary canines could indicate a skeletal etiology (ectomesenchymal origin) while the etiology behind the unilateral group of displaced maxillary canines could have a non-skeletal origin (ectodermal origin). This is schematically illustrated in Figure 10.

In a recent paper, normal dentitions have been described in dentition with agenesis of maxillary canines, not associated with other agenesis in the dentition.[47]

Diagnosis and treatment of palatal displaced canines are a clinical problem which creates a multiple disciplinary collaboration. Some palatally displaced cases can be associated with canine ectopia.[3,4,13] And also skeletal dentitions have been mentioned in connection with birth defects.

Significant findings in the unilateral group are retroclined maxillary incisors in females and males (ILs-NL). Furthermore females demonstrated a significantly lower mean angle compared to males. This was not found in females.

Table 5: Overview of the cephalometric findings in patients with bilateral displaced maxillary canines and unilateral displaced maxillary canines according to gender (M = males and F = females)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Gender</th>
<th>Number</th>
<th>Angle (SD)</th>
<th>Mean</th>
<th>Min.</th>
<th>Max.</th>
<th>Lower quartile</th>
<th>Upper quartile</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Bilateral M 10</td>
<td>ss-n-pg</td>
<td>–0.07</td>
<td>–1.50</td>
<td>1.25</td>
<td>–0.80</td>
<td>0.60</td>
<td>0.8195</td>
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<tr>
<td></td>
<td>s-n-ss</td>
<td>0.07</td>
<td>–1.00</td>
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<td>s-n-pg</td>
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<td>0.7837</td>
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<tr>
<td></td>
<td>ml-nl</td>
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<tr>
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<td>nsl-nl</td>
<td>–0.34</td>
<td>–2.90</td>
<td>1.70</td>
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<td>0.20</td>
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<td>Unilateral F 25</td>
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<td>–3.30</td>
<td>2.20</td>
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<td></td>
<td>s-n-ss</td>
<td>–0.06</td>
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<td>0.2929</td>
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<td>Unilateral F 28</td>
<td>ss-n-pg</td>
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<td>s-n-ss</td>
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<td>–1.80</td>
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<td>0.0363*</td>
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Significant findings in the unilateral group are retroclined maxillary incisors in females and males (ILs-NL). Furthermore females demonstrated a significantly posterior inclined maxilla (NSL-NL). Note three asterisks indicating significance. Significant finding in the bilateral group is a reduced slope of the maxillary incisors (ILs-NL) in males marked with an asterisk. This was not found in females.

and palatal fields which have arisen from the palatal shelves.[29]

Inheritance in cleft lip and palate is well known. Also inheritance in dental deviations has been described.

Concerning the normal eruption process and the etiology behind this process several proposals have been discussed. The importance of the crown follicle (ectodermal origin) is highlighted in a series of papers.[27,40,41] Also the influence of the supporting bone (ectomesenchymal origin) has been described.[27] Furthermore, the focus has been given to the innervation of the root membrane.[27] As a conclusion, the eruption process seems to be dependent on different biological processes. It could be suggested that one of these different processes might cause ectopia.

Prediction of ectopia is important for treatment planning. Dental deviations have been mentioned in connection with prediction of canine ectopia.[3,4,13] And also skeletal deviations have been associated with canine ectopia.[46] The observations in the present study could indicate that a developmental deviation in the palatal processes possibly are related to the findings of taurodontia in the bilateral group. If so then the bilateral group of displaced maxillary canines could indicate a skeletal etiology (ectomesenchymal origin) while the etiology behind the unilateral group of displaced maxillary canines could have a non-skeletal origin (ectodermal origin). This is schematically illustrated in Figure 10.

In a recent paper, normal dentitions have been described in dentition with agenesis of maxillary canines, not associated with other agenesis in the dentition.[47]

Diagnosis and treatment of palatal displaced canines are a clinical problem which creates a multiple disciplinary collaboration. Some palatally displaced cases can be...
treated interceptively with extraction of the primary canine followed by natural eruption of the permanent canine.\cite{7,10,11}

Other cases require orthodontic and surgery treatment. In recent papers by Naoumova et al.\cite{10,11} the cone beam computerized tomography (CBCT) scanning has been used to predict normal eruption. CBCT scanning has renewed the possibility for the prediction of eruption of the permanent canine after extraction of the primary canine.

Still many cases are treated in troublesome and complicated treatments. For these types of treatments, distinguishing between skeletal and dental etiology could be valuable.

As a conclusion, the present paper might indicate that the unilaterally displaced canines have a dental origin while the bilateral cases have a skeletal origin. If this is so then diagnose of the dental morphology (invagination and taurodontia) might help to distinguish between cases with dental etiology and cases with skeletal etiology. This distinguish may improve not only the diagnostics, but concurrently also the treatment.

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**Conflicts of interest**

The corresponding author has editorial involvement with **Dental Hypotheses**.

**References**