Prevalence rate and dentoskeletal features associated with buccally displaced maxillary canines

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SUMMARY The aim of the study was to analyse the prevalence and distribution of buccally displaced canines (BDCs) in subjects scheduled for orthodontic treatment and to investigate the association between BDC and sagittal, vertical, and transverse dentoskeletal relationships. A study sample of 1852 subjects was examined, and it was divided randomly into two groups. A first group of 252 subjects served as control group: the ‘reference’ prevalence rates for the examined parameters were calculated in this group. The remaining 1600 subjects comprised the sample from which the experimental BDC group was derived. Presence of unilateral or bilateral maxillary BDC, ANB, and SN GOGn angles for sagittal and vertical skeletal relationships, intercanine and intermolar distances, and tooth crowding at the maxillary arch were recorded for each subject. The statistical significance of differences between the BDC and the control groups in transverse relations and tooth crowding at the upper arch was tested by means of independent sample t-tests. Chi-square tests were performed to compare the prevalence rates of BDC and also sagittal and vertical skeletal features in the two groups. The prevalence rate of BDC was 3.06 per cent with a male-to-female ratio of 1:1. BDC subjects exhibited a significant association with hyperdivergent skeletal relationships (38.8%), reduced maxillary intercanine width, and crowding in the upper arch. The presence of specific dentoskeletal characteristics can be considered as a risk indicator for developing a buccal displacement of upper permanent canines.

Introduction

Most canine eruption anomalies diverge from the normal eruptive site in either of two directions: palatal or buccal (Peck et al., 1994). The occurrence of palatal impaction exceeds that of buccal impaction with a ratio that ranges from 3:1 to 6.6:1 (Fournier et al., 1982; Peck et al., 1994). Both genetic and local factors have been shown to be intimately associated with eruption disturbances of the maxillary permanent canine (Chaushu et al., 2003a).

Before becoming impacted, the upper permanent canine is defined displaced when it features an anomalous intraosseous position prior to the expected time of physiological eruption (Peck et al., 1994). The timely diagnosis of displacement before it evolves into impaction has an important clinical meaning as it allows for the implementation of interceptive measures aimed to prevent the final impaction (Baccetti, 2010). A palatally displaced canine (PDC) often occurs in association with several genetically interrelated dental anomalies that include tooth agenesis, tooth size reductions, and other ectopically positioned teeth (Peck et al., 1994; Baccetti, 1998). A buccally displaced canine (BDC) is more commonly related to insufficient arch length; it has been suggested that BDC is strongly associated with crowding (Artmann et al., 2010).

Several studies have analysed the interrelationship between BDC and space conditions with regard to the presence of crowding and tooth size/arch size discrepancy. Chaushu et al. (2003b) showed that bilateral BDC in females is associated with a severe degree of crowding and that BDC can be accompanied by larger dimensions of the maxillary incisors (Chaushu et al., 2009).

Despite extensive analyses of displaced or impacted canines, studies that relate displaced canines to craniofacial characteristics are scarce. Basdra et al. (2001) did not find any relationship between canine impaction and craniofacial skeletal characteristics on the sagittal plane (maxillomandibular antero-posterior discrepancy; skeletal Class I, II, or III). Sacerdoti and Baccetti (2004) showed a significant association between vertical craniofacial features and PDCs with a prevalence rate for hypodivergent cases in the PDC subjects three times greater than in control subjects. With regard to the correlations between BDC and sagittal and vertical craniofacial relationships, the literature does not provide information. Only one study (Larsen et al., 2010) analysed the transverse, sagittal, and vertical dimensions of the maxillary complex in cases with ectopic maxillary canines with the aid of both cephalometrics and dental casts. The authors concluded that in subjects with...
displaced canines, the size of the maxillary complex was excessive transversally, while it was deficient sagittally and vertically. However, no distinction between PDCs and buccally displaced canines was performed in that investigation.

The aim of the present study was to analyse the prevalence and distribution of buccally displaced maxillary canines (BDCs) in a large population of subjects scheduled for orthodontic treatment and to investigate the association between BDC, sagittal, vertical, transverse skeletal relationships, and crowding at the upper dental arch when compared with a control group.

Subjects and methods

The parent sample for this study consisted of 1975 subjects from the Department of Orthodontics of the University of Rome ‘Tor Vergata’. All subjects were observed prior to orthodontic treatment. For each subject, dental casts and radiographic material (panoramic radiographs and lateral cephalograms) were examined. Subjects with craniofacial anomalies, cleft lip and/or palate, sequelae of traumatic injuries on the permanent teeth, odontomas, or cysts were excluded from the study. This reduced the parent sample to a study sample of 1852 subjects (988 females and 864 males) between 8 and 14 years of age. According to the methodology of previous studies (Baccetti, 1998, 2010), the study sample was divided randomly into two groups. The first group of 252 subjects contained 115 males and 137 females, and it was used as a control group. The ‘reference’ prevalence rates for the examined parameters were calculated for this group. The remaining 1600 subjects (839 females and 761 males) included the sample from which the final experimental group was derived, and it was investigated for the presence of BDC. A total of 49 subjects with buccally displaced maxillary canines were found in the experimental group and they were identified as the ‘BDC group’ through the application of the following criteria:

- White ancestry;
- Presence of buccal displacement of maxillary canine/s (BDC/s): the intraosseous buccal position of the upper permanent canine, unilaterally or bilaterally, was evaluated on the basis of the panoramic radiograph, lateral cephalogram, and periapical radiographs (according to the technique of double determination by Clark). On the panoramic radiograph, the presence of displaced canines was identified when they overlapped the adjacent lateral incisors (Ericson and Kurol, 1988); the double determination radiographs by Clark allowed to specify the intraosseous location (palatal versus buccal) of the canine;
- Dental age older than 9 years and younger than 13 years according to the method by Becker and Chaushu (2000);
- Skeletal maturation showing active phases of skeletal growth according to the cervical vertebral maturation method (before CS 4; Baccetti et al., 2005).

The following parameters were recorded for each subject:

- Sagittal skeletal relationships, as derived from the analysis of the lateral cephalogram by means of the angular measure ANB. Sagittal skeletal relationships were defined as skeletal Class I when ANB values ranged between 0° and 4°, skeletal Class II when they were greater than 4°, and skeletal Class III when they were smaller than 0° (Steiner, 1953).
- Vertical skeletal relationships, as derived from the analysis of the lateral cephalogram by means of the angular measure SN/GoGn. Vertical skeletal relationships were defined as normodivergent when SN/GoGn values ranged between 27° and 37°., hypodivergent when they were smaller than 27°, and hyperdivergent when they were greater than 37° (Steiner, 1953).
- Transverse maxillary relationships, as calculated on dental casts by recording the intercanine and intermolar distances. Maxillary intercanine width was measured as the distance between the most mesial points on the palatal surface of the deciduous canines at the upper arch. Maxillary intermolar width was measured as the distance between the central fossae of right and the left first permanent maxillary molars (Tollaro et al., 1996).
- Tooth crowding at the upper arch, as evaluated on dental casts using the space analysis by Tweed (1966); the necessary space in cases of several unerupted permanent teeth was evaluated using the prediction tables by Moyers (Moyers, 1996).

The measurements were made with a dial caliper (Leone Orthodontic Company, Sesto Fiorentino, Italy) to the nearest 0.01 mm.

All measurements were performed with the investigator (MRR) blinded as to the group investigated.

Finally, BDC group was searched for the presence of different types of dental anomalies associated with BDC.

Statistical analysis

The statistical significance of differences in transverse relations and tooth crowding within the upper arch between the BDC and the control groups was tested by means of independent sample t-tests ($P < 0.05$). Chi-square tests with Yates’ correction were performed to compare the prevalence rates of BDC, sagittal, and vertical skeletal features in the two groups ($P < 0.05$).

Reproducibility of the diagnosis of BDC was assessed by reexamining the records of 110 subjects 5 months after the first examination. Reproducibility was 100 per cent. Reproducibility of the measurements on radiographs was estimated by repeating all those measurements and assessments on the 110 subjects after 5 months. Error of
measurements was tested using Dahlberg’s formula (Dahlberg, 1940). Method error for dental cast measurements was smaller than 1 mm. The error for angular cephalometric measurements was 0.4 degrees for ANB angle and 0.8 degrees for SN/GoGn angle. The power of the study as assessed prior to statistical analysis exceeded 0.90.

**Results**

The prevalence rate of maxillary BDC was 3.06 per cent of the experimental sample (49 subjects). Unilateral-to-bilateral ratio of BDC was 33:16 subjects. The M:F ratio in BDC subjects was 25:24, which approximates an M:F ratio of 1:1.

As reported in Table 1, the prevalence rates for sagittal skeletal relationships in BDC subjects were 5 Class III subjects (10.2%), 14 Class II (28%), and 30 Class I subjects (61.21%). These data were very similar to the standard prevalence rates in the control group.

The prevalence rates of vertical skeletal relationship in BDC subjects were 19 hyperdivergent subjects (38.8%), 4 hypodivergent subjects (8.1%), and 26 normodivergent (53.1%). The prevalence rate for hyperdivergent subjects in the control group was significantly smaller (21.8%), while the prevalence rate for normodivergent subjects was significantly greater (69.9%; Table 1).

The BDC group showed significantly smaller average maxillary intercanine width (25.70 mm) when compared with the control group (29.52 mm; \( P < 0.001 \)). No significant differences were assessed for the comparisons of maxillary intermolar width in the BDC group (average value of 44.79 mm) when compared with the control group (average value of 44.65 mm; Table 2).

The BDC group showed a significantly greater amount of tooth crowding within the upper arch (5.48 mm) with respect to the controls (1.33 mm; Table 2, \( P < 0.001 \)).

A total of 11 subjects showed the association between BDC and dental anomalies (Table 3). Of these, five subjects presented with small-sized lateral incisors (10.2%), three subjects with infraocclusion of primary molars (6.12%), one subject with maxillary canine-first premolar transposition (2.04%). Incisor impaction was found in two subjects (4.08%) and anomalous intraosseous second premolar position in one subject (2.04%).

**Discussion**

The prevalence rate of maxillary BDC in the examined sample was 3.06 per cent. This prevalence rate reflects the occurrence of the dental anomaly in an orthodontic population and therefore does not indicate the absolute prevalence rate of BDC in the general population. The

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**Table 1**  Prevalence rate and distribution study of sagittal and vertical craniofacial features.

<table>
<thead>
<tr>
<th>Sagittal and vertical features</th>
<th>Experimental group ( N = 49 )</th>
<th>Control group ( N = 252 )</th>
<th>( \chi^2 )</th>
<th>Significance ( P &lt; 0.001 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeletal Class I</td>
<td>30 61.21</td>
<td>149 59.1</td>
<td>0.94</td>
<td>0.85</td>
</tr>
<tr>
<td>Skeletal Class II</td>
<td>14 28.0</td>
<td>83 32.9</td>
<td>1.76</td>
<td>0.53</td>
</tr>
<tr>
<td>Skeletal Class III</td>
<td>5 10.2</td>
<td>20 7.9</td>
<td>2.24</td>
<td>0.35</td>
</tr>
<tr>
<td>Normodivergent</td>
<td>26 53.1</td>
<td>176 69.9</td>
<td>59.3</td>
<td>*</td>
</tr>
<tr>
<td>Hyperdivergent</td>
<td>19 38.8</td>
<td>55 21.8</td>
<td>64.6</td>
<td>*</td>
</tr>
<tr>
<td>Hypodivergent</td>
<td>4 8.1</td>
<td>21 8.3</td>
<td>0.84</td>
<td>0.87</td>
</tr>
</tbody>
</table>

**Table 2**  Prevalence rate and distribution study of transverse maxillary relationships and tooth crowding within the upper arch. SD, standard deviation.

<table>
<thead>
<tr>
<th>Transverse skeletal and dental features</th>
<th>Experimental group ( N = 49 )</th>
<th>Control group ( N = 252 )</th>
<th>Difference</th>
<th>Significance ( P &lt; 0.001 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary intercanine width</td>
<td>25.7 1.12</td>
<td>29.52 1.23</td>
<td>–3.8</td>
<td>*</td>
</tr>
<tr>
<td>Maxillary intermolar width</td>
<td>44.79 1.45</td>
<td>44.65 1.6</td>
<td>0.1</td>
<td>0.82</td>
</tr>
<tr>
<td>Tooth crowding</td>
<td>5.48 0.87</td>
<td>1.33 0.56</td>
<td>4.15</td>
<td>*</td>
</tr>
</tbody>
</table>
prevalence rate of buccally displaced canines has been reported rarely, whereas many authors reported the prevalence rate of PDCs that ranged from 1 to 3 per cent in population samples (Peck et al., 1994; Langberg and Peck, 2000; Sacerdoti and Baccetti, 2004). The M:F ratio was 1:1, whereas the occurrence of PDC is significantly more frequent in females (Peck et al., 1994; Sacerdoti and Baccetti, 2004).

BDC did not demonstrate significant associations with any specific craniofacial pattern in the sagittal plane (skeletal Class I, II, or III) when compared with the control group. The distribution of categories of sagittal skeletal relationships in subjects with intraosseous buccal malposition of the maxillary canines is very similar to reference normative orthodontic populations. Our results are in agreement with data of the literature with regard to the lack of association between PDC and craniofacial skeletal characteristics in the sagittal plane (Basdra et al., 2001; Sacerdoti and Baccetti, 2004).

A significant association between BDC and vertical craniofacial features was revealed in the present study. The prevalence rate for hyperdivergent cases in BDC subjects was almost two times greater than in control subjects, which was mirrored by the prevalence rate for normodivergent cases in BDC subjects being significantly reduced when compared with controls. In a recent study, Larsen et al. (2010) analysed the morphology of the craniofacial maxillary complex in cases with ectopic canines and they reported a reduced vertical dimension of the maxillary complex measured by N–ANS length; no other vertical craniofacial features, however, were described in association with displaced canines. Our findings differ significantly from the results reported by Sacerdoti and Baccetti (2004) with regard to the relationship between PDC and vertical skeletal characteristics. These authors described a significant association between hypodivergency and PDC, with a prevalence rate for hypodivergent cases in PDC subjects three times greater than in control subjects.

With regard to the occlusal characteristics in the transverse plane, subjects with BDC showed a significant reduction of the maxillary intercanine width when compared with the control group. However, no significant difference between the two groups for maxillary intermolar width was found. Larsen et al. (2010) reported that the maxillary complex is significantly enlarged transversally in patients with ectopic canines, but in that study, maxillary width had been evaluated using intermolar distance only. It must be underlined that the results reported by Larsen et al. (2010) for sagittal, vertical, and transversal dimensions of the maxillary complex did not present any distinction between buccal and palatal displacement of the canines.

The present investigation aimed also to verify the possible significant association of crowding and BDC. BDC subjects showed a significant greater prevalence of crowding in the upper arch when compared with the control group. This result confirms previous evidence that buccal canine eruption often occurs when the canine area is characterized by a reduced space. Chaushu et al. (2003b) analysed tooth size in dentitions with buccal canine ectopia and observed that BDC females presented larger than normal teeth when compared with controls and PDC groups. The authors reported that the bilateral occurrence of BDC in females is associated with a severe degree of crowding, whereas unilateral BDC, more frequent in males, is associated with a localized loss of space. The same research group in a recent study (Chaushu et al., 2009) showed that patients with BDC in absence of crowding present special features like anomalous lateral incisors and/or reduced mesiodistal width of these teeth. In the BDC group analysed in our study, the prevalence rate of anomalous lateral incisors was 10.2 per cent, similar to the prevalence rate found in the BDC/crowding group (8.6%) examined by Chaushu et al. (2009).

To summarize, BDC is significantly associated with crowding at the upper arch, reduced maxillary intercanine width, and facial hyperdivergency. Further, no differences in prevalence rate of BDC between genders were found (contrary to PDC), the ratio of unilateral expression of BDC is greater than the bilateral one (differently from PDC; Fournier et al., 1982; Jacoby, 1983; Peck et al., 1994; Baccetti, 1998, 2010; Chaushu et al., 2003), and the prevalence rate of associated dental anomalies is not significantly greater than in reference populations (contrary to PDC; Baccetti, 1998). All these features suggest that the aetiopathogenesis for buccal displacement of upper permanent canines is not under a predominant genetic control as it is the case for PDC. Therefore, the findings of the present study add evidence to local dentoskeletal features (tooth size/arc length discrepancy, commonly increased in hyperdivergent subjects, Solow and Sonnesen, 1998, with contracted maxillary arches in their anterior portion) as causative environmental factors for buccal displacement of upper permanent canines during eruption. BDC and PDC, therefore, have to be considered two different tooth eruption disturbances as to aetiology and associated phenotypes.
Conclusion

The prevalence rate of BDC in subjects scheduled for orthodontic treatment was 3.06 per cent. Unilateral buccal displacement of canine was more prevalent than the bilateral distributed equally in female and male subjects. The intraosseous buccal displacement of the canine was significantly associated with hyperdivergent vertical skeletal relationships, contraction of the anterior region of the maxilla, and crowding in the upper arch. These three characteristics can be considered as risk indicators for developing a buccal displacement of the maxillary canine, thus reflecting local environmental causes in the aetiology of the dental anomaly.

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