European Journal of Orthodontics 31 (2009) 367–373
doi:10.1093/ejo/cjp014
Advance Access publication 28 April 2009

Dental and occlusal features in patients with palatally displaced maxillary canines

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SUMMARY The aim of the present study was to determine the dental and occlusal features that could contribute to the aetiology of palatally displaced canines (PDCs). The material consisted of pre-treatment dental casts of 50 patients (36 females and 14 males) with unilateral and bilateral PDCs aged 14–16 years (mean 15.6 ± 1.6 years). These were compared with a control group of 50 treated subjects (25 males and 25 females) of the same age with normally erupted maxillary canines. The following parameters were measured on the dental casts: the mesiodistal (MD) and buccolingual (BL) width of each maxillary tooth, the maxillary interpremolar and intermolar widths, overjet and overbite, dentoalveolar arch relationship (based on incisor classification), and missing or anomalous teeth. The differences between the PDC group and controls were determined using a Student's *t*-test. *P* values less than 0.05 were considered significant.

PDCs occurred most frequently in subjects with a Class I occlusion. Sixteen per cent of the PDC subjects had congenital absence or peg-shaped lateral incisors or congenital absence of the second premolar, demonstrating a clear association between palatal impaction of the maxillary canine and anomalous or congenital tooth absence. The overjet was significantly smaller in the PDC female subjects, especially in those with unilateral impaction ($P < 0.05$). Overbite was significantly greater in PDC male subjects compared with the controls, especially in bilateral impaction cases. There was no statistically significant difference between the groups with regard to the maxillary transverse dimensions, maxillary MD widths, or palatal height for either gender.

Introduction

The maxillary canine, excluding the third molars, is the most frequently impacted tooth in the permanent dentition with the reported prevalence ranging from 0.8 to 2.8 per cent (Dachi and Howell, 1961; Grover and Norton, 1985). Seventy to 85 per cent of impactions in European populations are characterized by palatal displacement (Nordenram and Stromberg, 1966; Peck *et al.*, 1994). Palatally displaced canines (PDCs) occur twice as frequently in females as in males and bilateral occurence has been reported to be in the range of 19–45 per cent (Peck *et al.*, 1994). PDCs are five times more common in Caucasians than Asians (Bishara, 1992). Jacoby (1983) reported that 85 per cent of impacted canines are located palatally and concluded that they occur in patients with adequate arch length. The aetiology of PDCs is unclear. It is known that PDCs often occur with other dental anomalies (Becker *et al.*, 1981; Bjerklin *et al.*, 1992; Peck *et al.*, 1996;). These anomalies, which occur in families, suggest an heredity component, including small or missing lateral incisors (Becker *et al.*, 1981, 1999; Zilberman *et al.*, 1990; Mossey *et al.*, 1994; Baccetti, 1998), other missing teeth (Peck *et al.*, 1996), spaced dentitions (Jacoby, 1983; Zilberman *et al.*, 1990), and late developing dentitions (Newcomb, 1959; Zilberman *et al.*, 1990; Becker and Chaushu, 2000). There is also evidence that PDCs may occur due to local environmental factors related to agenesis, anatomical abnormalities, or late development of the adjacent lateral incisor tooth (Becker *et al.*, 1981; Brin *et al.*, 1986; Oliver *et al.*, 1989; Zilberman *et al.*, 1990; Mossey *et al.*, 1994).

An association between PDCs and lateral incisors of smaller than average crown width was reported by Mossey *et al.* (1994), while Brenchley and Oliver (1997) found no statistically significant evidence to support the view that PDCs are associated with diminutive maxillary lateral incisors. Most PDC cases are characterized as being non-extraction cases (Jacoby, 1983, Zilberman *et al.*, 1990, Peck *et al.*, 1994), but whether this is due to small teeth or a large jaw size is unclear. Regarding aetiology, McConnell *et al.* (1996) found an association between PDC and maxillary transverse deficiency. On the contrary, Langberg and Peck (2000a) reported no statistically significant difference in either anterior or posterior maxillary arch widths between PDC subjects and controls, while Kuftinec and Shapira (1995) stated that maxillary excess can be associated with PDCs.

The aim of the present investigation was to determine the dental and occlusal features associated with PDCs. A null hypothesis was proposed based on the assumption that the height of the palate may be a contributing factor towards PDCs and that the mesiodistal (MD) and buccolingual (BL) size of the incisor in PDC patients does not differ from that found in a control group.

Materials and methods

The material consisted of the pre-treatment dental casts of 50 (14 males and 36 females) non-syndromic orthodontic patients with PDCs (unilateral or bilateral). This group comprised all subjects diagnosed with PDCs at the University Clinic of Zagreb, Croatia, in the period between 2000 and 2007. The ages of the subjects were restricted to 14–16 years, with a mean of 15.6 years (±1.6). The upper limit was set at 16 years because few subjects are undiagnosed beyond 16 years of age and the lower limit at 14 years, as the canines are normally erupted by that age.

The control reference sample, randomly selected from orthodontic patients at the same university clinic, comprised plaster casts of 50 subjects (25 males and 25 females) of the same age (rounded to a whole year) in whom the maxillary canine had erupted normally, as diagnosed from their pre-treatment plaster casts. All the investigated subjects (both PDCs and controls) were Caucasian. Neither PDC subjects nor the controls had a previous history of mouth breathing or thumb sucking. No measurements were carried out where restorations obscured one of the surfaces or where the teeth were not fully erupted. Each PDC subject was matched with a control according to the type of malocclusion based on incisor classification.

The prevalence of females exhibiting PDC is characteristic and well documented in the literature (Dachi and Howell, 1961; Johnston, 1969; Becker *et al.*, 1981; Oliver *et al.*, 1989).

There was no reason to alter the consecutive nature of the control series by artificially matching the actual numbers of control subjects since the male and female experimental and control groups were not combined for comparison in their unequal proportions and since each of these groups was of sufficient size for statistical comparison.

The diagnosis of a PDC was made on the basis of clinical examination, dental pantomograms, and occlusal radiographs and confirmed visually during surgical exposure, performed at an appropriate time in the overall treatment plan. The subjects were selected based on the following criteria: (1) presence of the primary canine in the dental arch when the impressions were taken, (2) existence of unilateral or bilateral canine impaction whose position was determined by the parallax technique, (3) the impacted canines should have no sign of eruption into the oral cavity, and (4) the impacted canines should have a fully formed root apex. Plaster casts were available for all patients in both groups and all the measurements were carried out using digital callipers with ground tips and a Korkhaus three-dimensional ruler (Dentaurum, Ispringen, Germany, cat. number: 028-353-00) both with an accuracy of 0.1 mm.

The following parameters were obtained from the dental casts:

MD and BL dimension of each tooth: The MD dimension was measured as the greatest distance from the anatomic mesial contact point to the anatomic distal contact point parallel to the incisal surfaces of the teeth as the individual tooth was measured. The BL distance was measured as the largest BL measurement when the callipers were perpendicular to the MD axis of the tooth. The results for males and females were recorded separately.

Missing or anomalous teeth: Anomalies of the maxillary lateral incisor (peg-shaped or missing) were identified by direct observation of the dental cast and confirmed by clinical and radiographic examination. Aplasia of the second premolars was diagnosed from the panoramic radiographs. The incisors were defined as peg-shaped using established criteria (Becker *et al.*, 1981).

Dentoalveolar arch relationship: This was determined directly from the dental casts based on incisor classification according to the following: Class I, the lower incisor edges occlude with the cingulum plateau of the upper central incisors; Class II division 1, the lower incisor edges lie posterior to the cingulum plateau of the upper central incisors with the upper central incisors proclined; Class II division 2, the lower incisor edges lie posterior to the cingulum plateau of the upper central incisors with the upper central incisors retroclined; and Class III, the lower incisor edges lie anterior to the cingulum plateau of the upper central incisors.

Interpremolar and intermolar widths of the upper arch: Interpremolar width was recorded with the calliper tips placed into the deepest portion of the central fossae of the upper first premolars at their junctions with the most lingual aspect of the buccal cusp. Intermolar width was measured by placing the calliper tips into the deepest portion of the central fossae at its junction with the most lingual aspect of the mesiobuccal cusp.

Overjet and overbite: Overjet was defined as a horizontal overlap of the incisors and overbite as a vertical overlap of the incisors. Regarding overjet, normally, the incisors are in contact with the upper incisors ahead of the lower by only the thickness of their incisal edges (i.e. a 2–3 mm overjet is the normal relationship). Both overjet and overbite were mesured using digital callipers (Levior S.R.O., Kokory 381, Czech Republic) accurate to 0.1 mm.

Palatal height: This was measured at the midsagittal of the upper first molars, at the level of the occlusal plane using a Korkhaus three-dimensional orthodontic divider, with an accuracy of 0.1 mm (Dentaurum). Height was defined as the distance of the perpendicular from a connecting line between the midpoint of the fissures of both upper molars to the surface of the palate (Korkhaus, 1939).

All the measurements, carried out under natural light, were performed by the same author (SV) who did not exceed eight casts per day in order to avoid eye fatigue and to minimize the possibility of subjective error.

In order to establish consistency of the recorded measurements, a method described by Bishara *et al.* (1989)

was adopted. Fifteen plaster casts were selected at random and were remeasured by the same operator after a period of 2 months. The experimental error was analysed and assessed with Student's *t*-tests in order to determine the significance of the differences in the measurements. Intraexaminer reliability was predetermined at 0.2 mm. Discrepancies greater than this limit necessitated a new set of measurements, and the nearest three measurements were averaged. The measurement error was calculated according to the formula of Dahlberg's (1940): $ME = \sqrt{d^2 / 2n}$, where d is the difference between duplicated measurements and n is the number of replications.

The results of the measurement error were 0.44 for MD, 0.55 for BL tooth widths, 0.38 and 0.56 for interpremolar and intermolar arch widths, 0.58 and 0.63 for overjet and overbite, and 0.85 for palatal height, respectively. Thus, on this basis, the experimental error was unlikely to bias the accuracy of the measurements. The error of the method showed good reliability and reproducibility.

Statistical analysis

The means and standard deviations for the two groups were calculated for all variables using the Statistical Package for Social Sciences (SPSS Inc., Chicago, Illinois, USA). The differences between the PDC group and controls were determined using a Student's *t*-test. P values less than 0.05 were considered significant.

Results

The distribution of unilateral and bilateral subjects in the PDC sample is shown in Table 1 and comparison between the MD and BL dimensions of the upper incisors on the affected and unaffected sides in unilateral PDC subjects in Table 2. In unilateral PDC cases, the MD dimensions of the central and lateral incisors were similar for the affected and unaffected sides for both genders, while BL dimensions of the central and lateral incisors were greater for the unaffected than for the affected side both for females, and in total (Table 2). Considerable gender dichotomy was found in the control group for MD dimensions, with the teeth in males being larger, while there were no gender differences in the PDC group (Tables 3 and 4). Among the males, there were no statistically significant differences ($P > 0.05$) in BL or MD dimensions between the groups (Table 4), while among the females, the only statistically significant differences in BL dimensions were found for the lateral incisors which were significantly smaller in bilateral PDC subjects (Table 3).

There was no statistically significant difference between the groups with regard to maxillary transverse dimensions or palatal height for either gender (Tables 5 and 6). Overjet was significantly smaller in PDC female subjects (Table 5), especially in those with unilateral impaction ($P < 0.05$). The amount of overbite was significantly greater in PDC male subjects (Table 6) compared with the controls, especially in bilateral impaction cases.

Table 1 Distribution of subjects with palatally displaced canines.

Gender	Bilateral	Unilateral right	Unilateral left	Total
Female	8	11	17	36
Male	3	7	4	14
Total	11	18	21	50

A PDC occurred most frequently (44 per cent) in subjects with a Class I occlusion (Table 7).

The number of subjects with anomalous or missing lateral incisors was significantly greater in the PDC group. Three subjects (6 per cent) had bilateral peg-shaped laterals; one bilateral PDC subject with one side peg-shaped lateral and the other side with congenital absence of the maxillary lateral incisor; two subjects with unilateral peg-shaped laterals and congenital absence of the lower second premolar on the affected side; one bilateral PDC subject with congenital absence of the maxillary lateral incisor on one side and congenital absence of the mandibular second premolar on the contralateral side; and one subject with congenital absence of the maxillary lateral incisor on the affected side (Table 8). None of these anomalies was found in the comparison group.

Discussion

The findings of the present study confirm earlier reports of an unequal distribution between the genders for a PDC (Dachi and Howell, 1961; Johnston, 1969; Becker *et al.*, 1981; Oliver *et al.*, 1989). PDCs were more prevalent among females (72%) than males (28%). Gender could be an aetiological factor, as twice as many females are diagnosed with PDC compared with males (Bishara, 1992). The finding that both genders showed bilateral occurence in one-third of the cases was confirmed (Nordenram and Stromberg, 1966; Becker *et al.*, 1981; Zilberman *et al.*, 1990).

Missing and impacted teeth are considered evolutionary alterations. Rajic *et al.* (1996) indicated that impaction also occurred in prehistoric man (2700–2400 BC). In a specimen found in Croatia (Vucedol) of a female subject, the sagittal dental relationship corresponded to Class I and interestingly, there was a missing lateral incisor on the affected side. Baccetti (1998) pointed out the association between PDCs and other dental anomalies, while Peck *et al.* (1994) reported that 33 per cent of PDC patients have other congenitally missing teeth. Sixteen per cent of the PDC subjects in the present investigation had congenital absence or peg-shaped lateral incisors, or congenital absence of the second premolar, demonstrating a clear association between palatal impaction of the maxillary canine and anomalous or congenital absence of other teeth. This is in agreement with the findings of Becker *et al.* (1981), Peck *et al.* (1994), and Al-Nimri and Gharaibeh (2005).

Table 2 Unilateral palatally displaced canine subjects: comparison of the mesiodistal (MD) and buccolingual (BL) dimensions in millimetres of the upper incisors on the affected and unaffected sides.

Gender		Central incisor		*P*	Lateral incisor		*P*
		Affected	Unaffected		Affected	Unaffected	
Female (n = 28)	MD	8.64 ± 0.53	8.60 ± 0.59	NS	6.40 ± 0.70	6.38 ± 0.70	NS
	BL	6.78 ± 0.55	6.97 ± 0.60	*	5.65 ± 0.82	5.90 ± 0.71	*
Male (n = 11)	MD	8.63 ± 0.60	8.61 ± 0.60	NS	6.83 ± 0.80	6.80 ± 0.92	NS
	BL	7.24 ± 0.52	7.30 ± 0.46	NS	6.29 ± 0.76	6.37 ± 1.00	NS
Total (N = 39)	MD	8.64 ± 0.54	8.61 ± 0.58	NS	6.52 ± 0.74	6.50 ± 0.78	NS
	BL	6.91 ± 0.57	7.06 ± 0.58	*	5.84 ± 0.85	6.04 ± 0.82	*

Table 3 Mesiodistal (MD) and buccolingual (BL) dimensions in millimetres in females with palatally displaced canines, total (T), unilateral (U), and bilateral (B) compared with the control group (C).

Tooth	Total (N = 36)	Unilateral (n = 28)	Bilateral (n = 8)	Controls (n = 25)	*P* T/C	*P* U/B	*P* U/C	*P* B/C
MD11	8.58 ± 0.58	8.63 ± 0.58	8.42 ± 0.59	8.43 ± 0.55	NS	NS	NS	NS
MD21	8.58 ± 0.56	8.61 ± 0.54	8.47 ± 0.63	8.51 ± 0.59	NS	NS	NS	NS
BL11	6.86 ± 0.67	6.95 ± 0.57	6.54 ± 0.90	6.89 ± 0.50	NS	NS	NS	NS
BL21	6.75 ± 0.67	6.81 ± 0.59	6.54 ± 0.91	6.95 ± 0.43	NS	NS	NS	NS
MD12	6.32 ± 0.73	6.32 ± 0.72	6.30 ± 0.82	6.59 ± 0.47	NS	NS	NS	NS
MD22	6.41 ± 0.72	6.45 ± 0.65	6.23 ± 0.98	6.61 ± 0.46	NS	NS	NS	NS
BL12	5.66 ± 0.86	5.80 ± 0.81	5.19 ± 0.91	6.21 ± 0.67	*	NS	NS	*
BL22	5.70 ± 0.84	5.77 ± 0.74	5.40 ± 1.18	6.12 ± 0.65	*	NS	NS	*
MD14	6.99 ± 0.45	6.99 ± 0.46	6.96 ± 0.43	6.91 ± 0.30	NS	NS	NS	NS
MD24	6.99 ± 0.46	7.02 ± 0.48	6.93 ± 0.34	6.93 ± 0.30	NS	NS	NS	NS
BL14	9.16 ± 0.59	9.15 ± 0.62	9.21 ± 0.48	9.18 ± 0.53	NS	NS	NS	NS
BL24	9.13 ± 0.61	9.15 ± 0.65	9.07 ± 0.48	9.20 ± 0.53	NS	NS	NS	NS
MD15	6.63 ± 0.60	6.55 ± 0.60	6.90 ± 0.53	6.76 ± 0.39	NS	NS	NS	NS
MD25	6.57 ± 0.41	6.56 ± 0.40	6.58 ± 0.49	6.74 ± 0.39	NS	NS	NS	NS
BL15	9.37 ± 0.53	9.39 ± 0.59	9.29 ± 0.29	9.39 ± 0.58	NS	NS	NS	NS
BL25	9.30 ± 0.52	9.33 ± 0.57	9.20 ± 0.34	9.40 ± 0.54	NS	NS	NS	NS
MD16	10.33 ± 0.48	10.31 ± 0.41	10.40 ± 0.70	10.20 ± 0.58	NS	NS	NS	NS
MD26	10.38 ± 0.42	10.41 ± 0.43	10.20 ± 0.39	10.31 ± 0.59	NS	NS	NS	NS
BL16	11.28 ± 0.48	11.29 ± 0.49	11.22 ± 0.43	11.25 ± 0.58	NS	NS	NS	NS
BL26	11.27 ± 0.49	11.29 ± 0.48	11.19 ± 0.53	11.15 ± 0.50	NS	NS	NS	NS

NS, not significant. *$P < 0.05$.

A PDC has been reported to occur most frequently in Class II division 2 malocclusions (Basdra *et al.*, 2000) and to be associated with an increased transverse dimension of the maxillary arch, less crowding and smaller tooth sizes than other forms of malocclusion (Buschang *et al.*, 1994; Peck *et al.*, 1996). The present study group showed a high proportion (44%) of Class I malocclusions compared with the figures quoted by Brin *et al.* (1986) of 73 per cent Class I, 20 per cent Class II, and 7 per cent Class III. Al-Nimri and Gharaibeh (2005) in their study showed that PDCs occurred most frequently (44%) in subjects with a Class II division 2 incisor classification. As PDC subjects have a tendency to hypodivergence, the significant finding of a deep bite in male subjects is relevant and may have implications regarding aetiology.

The results of the present study confirmed the findings of previous investigations (Oliver *et al*, 1989, Brenchley and Oliver, 1997, Becker *et al.*, 2002) that in unilateral PDC cases, there are no differences in MD dimensions between the central and lateral incisors on the affected or unaffected sides. The only difference was in BL dimension for the central and lateral incisors which were signficantly smaller on the affected side in females. As expected, male controls displayed larger teeth than females (Tables 3 and 4) which is in agreement with previous studies (Horowitz *et al.*, 1958; Garn *et al.*, 1966; Goose, 1967; Becker *et al.*, 2002). No

Table 4 Mesiodistal (MD) and buccolingual (BL) dimensions in millimetres in males with palatally displaced canines, total (T), unilateral (U), and bilateral (B) compared with the control group (C).

Tooth	Total (N = 14)	Unilateral (n = 11)	Bilateral (n = 3)	Controls (n = 25)	P T/C	P U/B	P U/C	P B/C
MD11	8.65 ± 0.53	8.63 ± 0.59	8.70 ± 0.19	8.77 ± 0.52	NS	NS	NS	NS
MD21	8.69 ± 0.56	8.61 ± 0.60	8.96 ± 0.22	8.90 ± 0.60	NS	NS	NS	NS
BL11	7.34 ± 0.51	7.28 ± 0.57	7.52 ± 0.18	7.09 ± 0.74	NS	NS	NS	NS
BL21	7.32 ± 0.41	7.26 ± 0.40	7.55 ± 0.42	7.21 ± 0.60	NS	NS	NS	NS
MD12	6.92 ± 0.78	6.82 ± 0.83	7.28 ± 0.51	6.90 ± 0.49	NS	NS	NS	NS
MD22	6.85 ± 0.83	6.81 ± 0.89	7.12 ± 0.45	6.89 ± 0.48	NS	NS	NS	NS
BL12	6.37 ± 0.76	6.35 ± 0.86	6.47 ± 0.26	6.49 ± 0.59	NS	NS	NS	NS
BL22	6.36 ± 0.85	6.32 ± 0.92	6.58 ± 0.12	6.50 ± 0.77	NS	NS	NS	NS
MD14	7.28 ± 0.42	7.25 ± 0.46	7.37 ± 0.24	7.24 ± 0.42	NS	NS	NS	NS
MD24	7.19 ± 0.46	7.15 ± 0.50	7.35 ± 0.26	7.25 ± 0.29	NS	NS	NS	NS
BL14	9.58 ± 0.53	9.57 ± 0.60	9.59 ± 0.55	9.62 ± 0.52	NS	NS	NS	NS
BL24	9.60 ± 0.54	9.57 ± 0.59	9.71 ± 0.28	9.59 ± 0.49	NS	NS	NS	NS
MD15	6.81 ± 0.43	6.83 ± 0.42	6.71 ± 0.61	6.92 ± 0.35	NS	NS	NS	NS
MD25	6.76 ± 0.37	6.74 ± 0.33	6.82 ± 0.58	6.93 ± 0.35	NS	NS	NS	NS
BL15	9.83 ± 0.63	9.71 ± 0.60	10.48 ± 0.38	9.89 ± 0.62	NS	NS	NS	NS
BL25	9.82 ± 0.59	9.77 ± 0.64	10.02 ± 0.34	9.82 ± 0.61	NS	NS	NS	NS
MD16	10.74 ± 0.67	10.70 ± 0.68	10.92 ± 0.72	10.64 ± 0.43	NS	NS	NS	NS
MD26	10.69 ± 0.66	10.68 ± 0.74	10.72 ± 0.32	10.72 ± 0.46	NS	NS	NS	NS
BL16	11.72 ± 0.54	11.67 ± 0.60	11.88 ± 0.22	11.80 ± 0.61	NS	NS	NS	NS
BL26	11.69 ± 0.60	11.66 ± 0.65	11.79 ± 0.42	11.75 ± 0.57	NS	NS	NS	NS

NS, not significant.

Table 5 Interpremolar and intermolar arch widths, overjet, overbite, and palatal height in millimetres in females with palatally displaced canines (T, total; U, unilateral; B, bilateral; C, control).

	Total (N = 36)	Unilateral (n = 28)	Bilateral (n = 8)	Controls (n = 25)	P T/C	P U/B	P U/C	P B/C
Interpremolar arch width	33.78 ± 0.41	33.85 ± 0.47	33.54 ± 0.91	33.85 ± 0.62	NS	NS	NS	NS
Intermolar arch width	45.05 ± 0.52	45.26 ± 0.60	44.17 ± 0.92	43.95 ± 0.62	NS	NS	NS	NS
Overjet	3.43 ± 0.35	3.34 ± 0.38	3.73 ± 0.87	4.62 ± 0.44	*	NS	*	NS
Overbite	3.83 ± 0.47	3.73 ± 0.58	4.16 ± 0.72	3.77 ± 0.33	NS	NS	NS	NS
Palatal height	31.40 ± 0.81	31.38 ± 0.92	31.50 ± 1.85	33.23 ± 1.25	NS	NS	NS	NS

NS, not significant. *$P < 0.05$.

significant difference was found in the MD dimension of the maxillary teeth between the PDC and control group, in agreement with the results of Al-Nimri and Gharaibeh (2005), but contrary to the findings of Langberg and Peck (2000a), who reported that the MD crown diameters of the maxillary incisors were smaller in their PDC sample compared with a control group. The BL dimension of the lateral incisor in the present study was the only parameter in which the females showed a reduced size. When further divided into unilateral and bilateral cases, tooth size reduction was seen in bilaterally affected females, similar to the findings of Becker *et al.* (2002).

An association of PDC with spaced dentitions has been reported (Jacoby, 1983; Zilberman *et al.*, 1990). Zilberman *et al.* (1990) pointed out that in only 16 per cent of patients with PDC was some crowding observed, leading to the conclusion that PDC is not related to crowding (Langberg and Peck, 2000b). Dewel (1949) stated that a PDC occurs most often in subjects with a normal arch form and sufficient space.

Langberg and Peck (2000a) also found no statistically significant difference in interpremolar and intermolar widths of PDC patients and controls. They believed that there is strong evidence pointing to a genetic influence. Saiar *et al.* (2006), who measured maxillary skeletal width

Table 6 Interpremolar and intermolar arch widths, overjet, overbite, and palatal height in millimetres in males with palatally displaced canines (T, total; U, unilateral; B, bilateral; C, control).

	Total (n = 14)	Unilateral (n = 11)	Bilateral (n = 3)	Control (n = 25)	P T/C	P U/B	P U/C	P B/C
Interpremolar arch width	35.95 ± 1.02	35.82 ± 1.27	36.42 ± 1.28	35.18 ± 0.43	NS	NS	NS	NS
Intermolar arch width	46.80 ± 0.66	46.76 ± 0.79	46.93 ± 1.29	46.48 ± 0.58	NS	NS	NS	NS
Overjet	4.32 ± 0.32	4.09 ± 0.37	5.16 ± 0.46	4.32 ± 0.44	NS	NS	NS	NS
Overbite	5.43 ± 0.56	5.05 ± 0.61	6.84 ± 1.13	3.66 ± 0.44	*	NS	NS	*
Palatal height	31.63 ± 1.52	30.89 ± 1.48	34.1 ± 4.78	32.76 ± 1.02	NS	NS	NS	NS

NS, not significant. *$P < 0.05$.

Table 7 Incisor classification in the palatally displaced canines (PDC) group.

Incisor classification	PDC			
	Unilateral left	Unilateral right	Bilateral	Total (%)
Class I	9	10	3	22 (44)
Class II division I	3	2	3	8 (16)
Class II division 2	6	5	4	15 (30)
Class III	3	1	1	5 (10)

Table 8 Distribution of palatally displaced canines with respect to different anomalies (peg-shaped laterals and missing teeth).

Type of anomaly	n	%	Cumulative %
Missing teeth	2	4.0	4.0
Peg-shaped	3	6.0	10.0
Peg-shaped and missing	3	6.0	16.0
None	42	84.0	100.0
Total	50	100	

on antero-posterior cephalograms, occlusograms, and dental casts, supported the hypothesis of Langberg and Peck (2000a) that maxillary skeletal width is not a primary contributory factor in PDCs. On the contrary, McConnell *et al.* (1996), who also used dental casts to measure maxillary widths, concluded that patients with PDCs have transverse deficiencies in the anterior portion of the arch. Therefore, they speculated that expansion therapy might decrease the need for extractions, reduce the risk of lateral root resorption, and possibly prevent PDCs.

Ferrario *et al.* (1998) derived a three-dimensional mathematical description of normal human hard tissue palatal size and shape and concluded that neither the size nor shape of the palate was significantly influenced by gender. Because of a lack of research concerning palatal height measurements in PDC subjects, the results of the present investigation could not be compared with other studies. The null hypothesis proposed that the height of the palate may be a contributing factor towards PDCs could not be proved.

Jacoby (1983) stated that 85 per cent of PDC patients have sufficient space for eruption of the canine in the dental arch. Zilberman *et al.* (1990) found crowding in only 16 per cent of patients with PDC. Stellzig *et al.* (1994) also found arch length sufficiency in 82 per cent of subjects with a PDC. From the evidence in the study by Becker *et al.* (2002), it becomes clear that small teeth may be responsible for the spacing in many instances, particularly in males, but small teeth are not always present and spacing may be the result of an excessive arch length. No statistically significant difference between the groups with regard to the maxillary transverse dimensions for both genders was found in the present study which could possibly explain why typical orthodontic treatment of PDCs in the majority of cases involved neither palatal expansion nor permanent tooth extractions. From the results of the present investigation, clinically, it becomes clear that extractions are usually not the method of choice for orthodontic treatment in PDC patients due to the fact that the maxillary arch width is normal, not constricted and the MD tooth size of the incisors in PDC patients does not differ from that found in a typical orthodontic population.

Conclusions

1. There was no statistically significant difference between the groups with regard to palatal height for both genders so the height of the palate may not have implications regarding the aetiology of PDCs.
2. PDCs occurred most frequently in subjects with a Class I malocclusion.
3. There was a clear association between PDCs and a missing or anomalous lateral incisor and second premolars on the affected side.
4. The MD widths of the maxillary teeth were not significantly different in the impaction and control groups, but there was a difference in BL widths.

5. As PDC subjects have a tendency to hypodivergence, the significant finding of a deep bite in male subjects is relevant.

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Funding

Croatian Ministry of Science, Education and Sport (065-0650444-0436).

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