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Maxillary tooth size variation in dentitions with palatal canine displacement

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SUMMARY The association between the presence of palatally displaced maxillary canines (PDC) and other anomalies is well known, particularly with regard to the size and form of the lateral incisor. The present study investigated the connection between the maxillary canine anomaly and the existence of a reduction in the size of the other teeth in the maxilla in 58 consecutively treated patients (37 females, 21 males) aged 11–15 years, and compared these with a control group of 40 consecutively treated subjects (20 males, 20 females) with normally erupted maxillary canines.

The findings indicate that the teeth of PDC males are reduced in size and similar to those of PDC females, in sharp contrast to the general population, where males have larger teeth. This is the result of a dimensional reduction in the teeth of PDC males, which was statistically significant for all teeth ($P < 0.01$) in the bucco-lingual (B–L) dimension, and for the first premolars and first molars in the mesio-distal (M–D) dimension. The sole teeth affected for both sexes were the lateral incisors in their B–L dimension. Bilaterally and unilaterally affected subjects presented differing M–D and B–L tooth dimensions.

Introduction

From earlier studies, it is known that palatally displaced maxillary canine teeth (PDC) are frequently found in dentitions that exhibit various anomalies. These anomalies include small, peg-shaped, and missing lateral incisors (Becker *et al*., 1981, 1999; Zilberman *et al*., 1990; Mossey *et al*., 1994; Baccetti, 1998), other missing teeth (Bjerklin *et al*., 1992; Peck *et al*., 1996), spaced dentitions (Jacoby, 1983; Zilberman *et al*., 1990), late developing dentitions (Newcomb, 1959; Zilberman *et al*., 1990; Becker and Chaushu, 2000), and several other features. Most of these associated anomalies are themselves linked with a reduction in size of other teeth in the dentition.

These anomalies are almost entirely genetic in origin. It is believed that the association of these anomalies with PDC has a similar genetic association (Peck *et al*., 1996; Pirinen *et al*., 1996), although there is evidence to show that palatal displacement may occur due to local environmental factors related to the absence, anatomical abnormality, 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; Shapira *et al*., 2000).

In dentitions featuring PDC, reduction in tooth size, particularly lateral incisors, has been recorded (Becker *et al*., 1981; Brin *et al*., 1986; Oliver *et al*., 1989; Zilberman *et al*., 1990; Langberg and Peck, 2000; Shapira *et al*., 2000). Most of the PDC cases are characterized as being 'non-extraction' cases (Jacoby, 1983; Zilberman *et al*., 1990; Peck *et al*., 1994), and the question arises as to whether this is due to small teeth or to large jaw size. In the English language literature only a single investigation reports the size of additional teeth and this was restricted to mandibular central and lateral incisors (Langberg and Peck, 2000). In that study mesio-distal (M–D) and bucco-lingual (B–L) measurements of the maxillary and mandibular incisors

only were reported for the sample as a whole. There was no attempt to investigate male/female or unilateral/bilateral differences.

The present study was initiated to measure the size of the maxillary teeth in PDC dentitions and to determine:

1. Differences in size between the PDC and a matched sample of patients in whom the canine erupted normally.
2. Differences in size between the affected (with the PDC) and non-affected sides in cases with unilateral PDC.
3. Differences in size in cases with unilateral PDC from those with bilateral PDC.
4. Differences between male and female subjects.

Subjects and methods

Records of patients from three private orthodontic practices in Jerusalem and Tel Aviv, comprising 58 consecutively treated cases exhibiting PDC, were collected. This PDC group was made up of 37 females and 21 males, aged 11–15 years. The unequal distribution between the sexes for this anomaly, as illustrated in this sample of consecutive cases, is characteristic (Dachi and Howell, 1961; Johnston, 1969; Becker *et al*., 1981; Oliver *et al*., 1989). The diagnosis was made on the basis of clinical examination and standardized radiographs (Seward, 1963; Hunter, 1981; Becker, 1998), and confirmed visually at the time of surgical exposure.

A second group of 40 consecutively treated subjects, in whom the maxillary canine teeth had erupted normally as diagnosed from the plaster casts, comprised 20 females and 20 males. 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, there was no reason to disturb the consecutive nature of the control series by artificially matching the actual numbers of control subjects.

Casts of the maxillary dental arch were available for each of the patients of both groups. The M–D and B–L widths of all the erupted permanent teeth mesial to the first molars were measured directly on the plaster casts, to an accuracy of 0.1 mm using a dial caliper with ground tips. Teeth that were not fully erupted were excluded and measurements were not carried out where caries or restorations obscured one of the surfaces. Measurements were obtained on both sides of the dental arch, and the results for males and females were recorded separately.

The significance of differences between the means of the groups was tested by a Student's *t*-test.

Experimental errors were analysed by a trial, in which 10 casts, selected at random, were measured on two occasions. A Student's *t*-test was used to assess the significance of the differences between the determinations. The experimental error was determined by calculating the standard deviation of a single determination (Dahlberg, 1940). Measurement errors ranged from 0.08 to 0.13 mm, the weighted average standard deviation of a single determination being 0.1 mm for both M–D and B–L dimensions was not significant. It was concluded that experimental error was unlikely to bias the accuracy of tooth measurement.

Results

Table 1 shows the distribution of unilateral and bilateral cases in the PDC sample examined.

M–D measurements

1. In unilateral PDC cases, measurement of the M–D width of the central and lateral incisors yielded similar results for the affected and unaffected sides for both males and females (Table 2). Accordingly, these were combined for further comparisons.

Table 1 Distribution of subjects with palatally displaced canines (PDC).

Sex	No. of subjects	Bilateral cases	Unilateral cases
Female	37	13 (35.1%)	24 (64.9%)
Male	21	7 (33.3%)	14 (66.6%)
Total	58	20 (34.5%)	38 (65.5%)

Table 2 Unilateral PDC subjects: comparison between mesio-distal (M–D) and bucco-lingual (B–L) width of the upper incisors in affected and unaffected sides.

Sex	Side	Central incisor			Lateral incisor		
		Affected	Unaffected	*P*	Affected	Unaffected	*P*
Female	M–D	8.6 ± 0.86	8.6 ± 0.85	NS	6.7 ± 0.74	6.6 ± 0.68	NS
(*n* = 24)	B–L	6.7 ± 0.78	6.9 ± 1.18	NS	5.4 ± 0.73	5.5 ± 0.65	NS
Male	M–D	8.4 ± 0.85	8.4 ± 0.86	NS	6.3 ± 0.92	6.4 ± 0.83	NS
(*n* = 14)	B–L	6.3 ± 0.65	6.3 ± 0.82	NS	4.9 ± 0.34	5.1 ± 0.42	NS
Total	M–D	8.5 ± 0.84	8.5 ± 0.85	NS	6.6 ± 0.80	6.6 ± 0.73	NS
(*n* = 38)	B–L	6.6 ± 0.76	6.7 ± 1.01	NS	5.2 ± 0.42	5.3 ± 0.66	NS

2. In the control group, there was considerable sexual dichotomy in the M–D width of the teeth examined, with the teeth in the males being larger, while there were no male–female differences in the PDC group (Tables 3 and 4).
3. Among the males only, there was a distinct trend towards M–D narrower teeth in the PDC group, compared with the control males, although the difference reached statistical significance only for the maxillary first premolar and first molar, which were both smaller by approximately 0.5 mm (Tables 3 and 4).
4. In general, the M–D width of female teeth with bilateral PDC was smaller than the M–D width in females with unilateral PDC, although statistical significance was reached only for the central and lateral incisors ($P < 0.01$; Table 3). The reverse was true for the bilateral PDC males, where a larger M–D width was seen, compared with the unilateral PDC males. However, statistical significance was reached only for the upper lateral incisor, which was 6.9 mm in bilateral and 6.3 mm in unilateral cases, $P < 0.05$ (Table 4).

B–L measurements

1. In unilateral PDC cases, B–L widths of the central and lateral incisors were similar for the affected and unaffected side for both sexes (Table 2). Accordingly, the B–L width of the affected and unaffected sides in unilateral cases was combined for further comparisons.
2. The mean B–L widths of all maxillary teeth in PDC males were significantly smaller by approximately 0.5 mm than in the control

Table 3 Mesio-distal (M–D) and bucco-lingual (B–L) tooth dimensions in females with palatally displaced canines (PDC), total (T), unilateral (U), or bilateral (B), compared with the control group (C).

Tooth no.		Total (*n* = 37)	Unilateral (*n* = 24)	Bilateral (*n* = 13)	Controls (*n* = 20)	*P* T/C	*P* U/B	*P* U/C	*P* B/C
1	M–D	8.5 ± 0.82	8.6 ± 0.89	8.1 ± 0.56	8.2 ± 0.32	NS	<0.01	<0.05	NS
	B–L	6.6 ± 0.91	6.8 ± 0.78	6.2 ± 0.73	6.8 ± 0.64	NS	<0.01	NS	<0.01
2	M–D	6.5 ± 0.61	6.7 ± 0.74	6.3 ± 0.51	6.4 ± 0.54	NS	<0.01	NS	NS
	B–L	5.3 ± 0.70	5.5 ± 0.72	5.0 ± 0.75	5.8 ± 0.75	<0.01	<0.01	<0.05	<0.001
4	M–D	6.6 ± 0.68	6.7 ± 0.77	6.5 ± 0.66	6.6 ± 0.37	NS	NS	NS	NS
	B–L	8.7 ± 0.65	8.9 ± 0.46	8.5 ± 0.69	8.9 ± 0.66	NS	<0.01	NS	<0.01
5	M–D	6.5 ± 0.65	6.6 ± 0.75	6.4 ± 0.43	6.3 ± 0.31	NS	NS	NS	NS
	B–L	9.2 ± 0.45	9.4 ± 0.52	9.0 ± 0.34	9.3 ± 0.52	NS	<0.01	NS	NS
6	M–D	10.1 ± 0.88	10.2 ± 0.72	9.9 ± 0.56	9.9 ± 0.45	NS	NS	NS	NS
	B–L	10.5 ± 0.56	10.6 ± 0.55	10.3 ± 0.61	10.4 ± 0.43	NS	0.05	NS	NS

Table 4 Mesio-distal (M–D) and bucco-lingual (B–L) tooth dimensions in males with palatally displaced canines (PDC), total (T), unilateral (U), or bilateral (B), compared with the control group (C).

Tooth no.		Total (n = 21)	Unilateral (n = 14)	Bilateral (n = 7)	Controls (n = 20)	P T/C	P U/B	P U/C	P B/C
1	M–D	8.4 ± 0.78	8.4 ± 0.85	8.4 ± 0.70	8.7 ± 0.47	NS	NS	NS	NS
	B–L	6.4 ± 0.65	6.3 ± 0.65	6.7 ± 0.44	6.9 ± 0.54	<0.05	NS	<0.001	NS
2	M–D	6.5 ± 1.00	6.3 ± 0.92	6.9 ± 0.38	6.8 ± 0.38	NS	<0.05	<0.05	NS
	B–L	5.2 ± 0.62	5.0 ± 0.34	5.7 ± 0.60	5.9 ± 0.68	<0.01	<0.01	<0.001	NS
4	M–D	6.6 ± 0.51	6.5 ± 0.56	6.7 ± 0.44	7.1 ± 0.52	<0.01	NS	<0.01	NS
	B–L	8.8 ± 0.69	8.6 ± 0.68	8.8 ± 0.59	9.4 ± 0.59	<0.01	NS	<0.01	<0.01
5	M–D	6.4 ± 0.52	6.3 ± 0.54	6.6 ± 0.49	6.6 ± 0.58	NS	NS	<0.05	NS
	B–L	9.0 ± 0.65	8.7 ± 0.48	9.3 ± 0.57	9.5 ± 0.80	<0.01	<0.01	<0.001	NS
6	M–D	10.1 ± 0.73	10.0 ± 0.56	10.4 ± 0.84	10.6 ± 0.81	<0.05	<0.05	<0.01	NS
	B–L	10.6 ± 0.54	10.5 ± 0.53	10.7 ± 0.64	10.9 ± 0.57	<0.05	NS	<0.001	NS

male group (Table 4), although this was true only for the upper lateral incisor, in the female controls (Table 3).

3. The B–L width of teeth in PDC bilateral female patients was significantly smaller than in unilateral patients ($P < 0.01$; Table 3). Comparison of the bilateral cases and the control group also revealed significantly smaller B–L dimensions in the PDC bilateral group, which were obscured when the unilateral and bilateral cases were taken together. In bilateral PDC males, the teeth were similar in size to the control group, and significantly larger than in the unilateral cases (Table 4).

Discussion

It is known from earlier studies that palatally displaced maxillary canines are more prevalent among females than males. Nevertheless, the finding that males and females show bilateral occurrence in approximately one-third of the cases (Nordenram and Stromberg, 1966; Becker *et al*., 1981; Zilberman *et al*., 1990) is confirmed.

In agreement with earlier work (Becker *et al*., 1981; Oliver *et al*., 1989; Brenchley and Oliver, 1997), the present study confirmed that in unilaterally affected cases of PDC, there are no M–D or B–L size differences between the central and lateral incisors on the affected and unaffected sides.

Typically, male controls display larger teeth than females (Horowitz *et al*., 1958; Garn *et al*., 1966, 1967; Goose, 1967; Alvesalo, 1971; Tables 2 and 3). In contrast, M–D tooth size in male and female PDC cases, and in female controls, is remarkably similar for all tooth types and the trend for tooth size reduction exists only in males, reaching statistical significance only for the maxillary first premolars and first molars (Table 3).

In the present study, all the maxillary teeth in PDC males were significantly narrower (bucco-lingually) than the controls, while most of the teeth in PDC females were similar in size to the controls. The only tooth that showed significant reduction in B–L dimensions ($P < 0.01$) in both sexes was the upper lateral incisor.

No explanation is readily available regarding the gender-associated size reductions in first premolars and first molars. These teeth are significantly smaller (M–D and B–L) than the controls ($P < 0.01$) in PDC males. This is despite the fact that these teeth are ontogenically ‘stable’ teeth (Garn *et al*., 1963; Sofaer, 1970) and this trend is not reflected in the M–D width of the more variable second premolars. Excessive space in the canine region has been proposed as a cause of PDC (Jacoby, 1983). Based on the present study, it can be seen that this may be due to size reductions of the lateral incisor and first premolar in males, although PDC is two to three times more frequent in females (Dachi and

Howell, 1961; Johnston, 1969; Becker *et al*., 1981; Oliver *et al*., 1989).

The results of the present investigation reveal significant differences between unilateral and bilateral affected PDC cases. The teeth in the unilaterally affected females are larger than those in bilaterally affected females (Table 3), suggesting that a more severe expression of size reduction is compatible with a more severe expression (i.e. bilateral occurrence) of the trait (Johnston, 1969; Mossey *et al*., 1994). However, the same parameters among the males show the reverse, with larger teeth found in bilateral cases. No explanation is readily available for this apparent paradox (Table 4).

The data yielded by the present study reveal important differences between PDC males and females, relating to tooth size, which may have implications regarding aetiology. When a PDC group is studied as a whole, without subdividing the genders into separate groups, these contrasting features become obscured by a mutual cancellation.

Several authors have commented on the existence of PDC in association with spaced dentitions (Jacoby, 1983; Becker, 1984; Zilberman *et al*., 1990; Peck *et al*., 1996). From the evidence in the present study, it becomes clear that small teeth may be responsible for the spacing in many instances, particularly in males. Nevertheless, small teeth are not always present and the spacing may be the result of excessive arch length.

Conclusions

In studies of random population samples, the tooth dimensions of males are larger than those of females. In contrast, a PDC sample shows:

1. No overall difference between the sexes. Both males and females have teeth that are comparable in size to the female control group.
2. No difference between the size of teeth on affected and unaffected sides, in unilateral PDC.
3. The males show significant B–L reduced dimensions of all maxillary teeth, while a M–D reduction was only significant for the first premolars and first molars.
4. The teeth in unilaterally affected females are larger and in unilaterally affected males smaller, than the bilaterally affected teeth of their respective sexes.

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