Dentoskeletal characteristics in patients with palatally and buccally displaced maxillary permanent canines

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SUMMARY The aim of this retrospective study was to analyse dentoskeletal characteristics in patients with eruption disturbances of the maxillary permanent canines. Pre-treatment panoramic radiographs and lateral cephalograms of 636 consecutive orthodontic patients were assessed. The control group included 456 patients with physiologically erupted maxillary permanent canines (261 females and 195 males, mean age 12.6 and 12.4 years, respectively). The other groups comprised 144 subjects with palatally displaced canines (PDCs) (92 females and 52 males, mean age 14.2 and 14.7 years, respectively) and 36 patients with buccally displaced canines (BDCs) (16 females and 20 males, mean age 12.4 and 12.8 years, respectively). The selected dentoskeletal parameters were compared with classic cephalometric norms using the method of analysis of variance, chi-square, and Fisher's exact tests. The PDC patients showed a significantly more prognathic maxilla, a significantly more frequent occurrence of skeletal class I, retroinclination of maxillary central incisors, hypodivergent relationship, and mandibular anteriorotation and less frequent posteriorotation. A significantly more frequent retrognathic maxilla and skeletal class III and less frequent retroinclination of the maxillary central incisors were found in the BDC patients. The results of this study indicate the existence of different facial morphology and more likely also etiopathogenesis of eruption disturbances of the canines in the PDC and BDC patients.

Introduction

Maxillary permanent canines are the second most frequently impacted tooth after the third molars (Alling and Catone, 1993); the occurrence in the general population given in the literature ranges from 0.8 to 3 per cent (Kurol *et al.*, 1997; Becker, 2007). To avoid confusion, we use the term impacted canine to refer to the canine in an anomalous intraosseous position after the expected time of eruption. The term ectopically erupting canine refers to the canine in an anomalous intraosseous position before the expected time of eruption. Interceptive treatment strategies have been suggested for the ectopically erupting canines, whereas a surgical–orthodontic approach is required in the impacted canines (Baccetti *et al.*, 2007). Interceptive treatment of ectopically erupting canines is important as treatment of the impacted canines is longer and more expensive and more complex orthodontic mechanics are needed (Zuccati *et al.*, 2006; Barlow *et al.*, 2009). Ectopically erupting canines can cause the root resorption of adjacent teeth (Ericson and Kurol, 2000; Liu *et al.*, 2008; Cernochova *et al.*, 2010).

Two major theories explaining the occurrence of the ectopic eruption of the maxillary permanent canine have been presented, i.e. the 'guidance theory' and the 'genetic theory'. The guidance theory (Miller, 1963; Bass, 1967; Brin *et al.*, 1986; Becker, 2007) underlines a role of the lateral incisor root in guiding the erupting canine crown in the proper direction towards the dental arch. In aplasia or hypoplasia of the lateral incisor, this function fails and the canine crown is palatally displaced. According to the genetic theory (Peck *et al.*, 1994, 1995), the palatal displacement of the canine is genetically determined. This theory is supported by other dental anomalies frequently occurring in patients with the ectopically erupting canines, so-called microsymptoms (e.g. small teeth, enamel hypoplasia, aplasia of second premolars, infraocclusion of primary molars, etc.) (Hoffmeister, 1977; Bjerklin *et al.*, 1992; Baccetti, 1998; Leifert and Jonas, 2003; Stahl *et al.*, 2003; Shalish *et al.*, 2009).

Spatial conditions in the upper jaw are possible etiological factors associated with eruption disturbances (ectopic eruption and impaction) of the maxillary permanent canines. Lack of space in the upper dental arch and in the area of the maxillary apical base is often suggested as an etiological factor in the buccally displaced canines (BDCs) (Jacoby, 1983; Zilberman *et al.*, 1990). The palatal position of the ectopic canine is associated with excess space in the maxillary apical base, or a more frequent occurrence of Angle Class II, Division 2 (Peck *et al.*, 1994; Leifert and Jonas, 2003; Al-Nimri and Gharaibeh, 2005; Lüdicke *et al.*, 2008).

The aim of this retrospective study was to analyse the occurrence of the selected dentoskeletal characteristics measured on the lateral cephalometric radiographs in

patients with palatally and buccally displaced maxillary permanent canines. In addition, possible differences between patients with palatally displaced canines (PDCs) and BDCs not only in spatial conditions in the area of the maxillary apical base but also in the inclination of the maxillary central incisors and vertical facial configuration were considered.

Material and methods

This retrospective study comprised 636 consecutive Caucasian orthodontic patients who were referred to the Orthodontic Department of Clinic of Stomatology of St. Anne's University Hospital in Brno, Czech Republic, from January 2000 to April 2010. All the patients included in this study had to fulfil following criteria—the first orthodontic examination between the ages of 11–17 years; no previous orthodontic treatment; available complete pre-treatment anamnestical and clinical data and; good-quality dental panoramic and lateral cephalometric radiographs taken using the same machine. The patients with supernumerary teeth, odontomas, cysts, sequelae of traumatic injuries, impacted maxillary incisors, syndromes, and clefts in the orofacial region were excluded from the study.

This retrospective study analysed three groups of patients. The control group was made up from regular orthodontic patients treated by the first author. It consisted of 456 subjects (261 females and 195 males) with physiologically erupting permanent maxillary canines. The other two groups contained 180 patients (108 females and 72 males) with the displaced permanent maxillary canines who had been referred to this Clinic of Stomatology for CT examination and/or consultation of their treatment plans. Diagnosis was based on the analysis of dental panoramic radiographs. The patients with mesially inclined canines (angle between the longitudinal axis of canine and midline greater than or equal to 20 degrees) and with overlapping of the canine crown with roots of the adjacent incisors were included in these groups. A more superiorly positioned canine crown in maxilla on the affected side was apparent in unilateral cases (Ericson and Kurol, 1988). These patients were further divided according to the position of the ectopic canine crown relative to the dental arch into two groups— subjects with PDCs and BDCs. The canine crown position was evaluated on the basis of clinical examination, assessment of dental panoramic and occlusal radiographs using the parallax method based on Clark's tube shift rule (Jacobs, 1999a, 1999b) and/or CT examination performed by the same investigator (first author) and verified visually during the surgical exposure. In patients with the ectopically erupting canines, treatment usually started with extraction of the deciduous canine in combination with a transpalatal arch or rapid maxillary expansion in cases with lateral crossbite. In patients with impacted canines, the orthodontic–surgical approach based on surgical uncovering and followed by forced eruption using orthodontic traction was preferred.

Lateral pre-treatment cephalometric radiographs were hand traced for each patient with a 0.5 mm pencil on matte acetate tracing paper. All cephalometric measurements were performed by the same investigator (CP). Following characteristics were measured and assessed on the lateral cephalometric radiographs (Athanasiou, 1995): SNA angle, ANB angle, 1+1/SN angle, ML/SN angle, SpL/ML angle, and analysis of the general vertical facial configuration.

The sagital position of the maxilla to the skull base (SNA angle) was defined according to the Steiner's analysis (Proffit *et al.*, 2007) as orthognathic (SNA = 80–84 degrees), prognathic (SNA > 84 degrees), and retrognathic (SNA < 80 degrees). Definitions of the sagittal skeletal relationship between the maxilla and mandible (ANB angle) and vertical skeletal relationship between the mandible and cranial base (ML/SN angle) were taken from the study of Sacerdoti and Baccetti (2004) with the aim to compare results of both studies—skeletal class I (ANB = 0–4 degrees), skeletal class II (ANB > 4 degrees), skeletal class III (ANB < 0 degrees), normodivergent (ML/SN angle = 27–37 degrees), hypodivergent (or decreased vertical face height, ML/SN angle < 27 degrees), and hyperdivergent (or increased vertical face height, ML/SN angle > 37 degrees). Inclination of the maxillary central incisors in the sagittal plane (measured as the angle between the longitudinal axis of the most prominent maxillary central incisor and anterior cranial base, 1 + 1/SN angle) were defined according to Jarabak (Jarabak and Fizzell, 1972) as standard inclination (1 + 1/SN angle = 100–104 degrees), proclination (1 + 1/SN angle > 104 degrees), and retroinclination of the maxillary central incisors (1 + 1/SN angle < 100 degrees). The SpL/ML angle describes the inclination of the mandible (ML) in relation to the maxillary base (SpL, bispinal line or also palatal line or nasal line). It is used for the evaluation of the maxillary–mandibular skeletal relationship in the vertical plane, normodivergent (SpL/ML angle = 23–33 degrees), hypodivergent (SpL/ML angle < 23 degrees), and hyperdivergent (SpL/ML angle > 33 degrees). A modified table of selected skeletal characteristics after Schopf (Table 1) was used for the analysis of vertical facial configuration, i.e. a facial type (Schopf, 1982, 1994). This table contains

Table 1 General vertical facial configuration assessment table (modified after Schopf, 1982, and Schopf, 1994).

	Vertical growth pattern	Neutral	Horizontal growth pattern
Ratio SGo:NMe (%)	50 54 58	62–65	67 71 75
Angle ML/SN (°)	47 42 37	32	27 22 17
Angle SpL/ML (°)	43 38 33	28	23 18 13
Angle NGoMe (°)	86 82 78	70–75	68 65 62
Sum angle* (°)	411 406 401	396	391 386 381

*Sum angle – sum of basic skeletal angles (sum of saddle angle, NSAr; articular angle, SArGo, and gonial angle, ArGoMe).

values of five skeletal characteristics: ratio of posterior to anterior face height (ratio SGo:NMe), ML/SN angle, SpL/ML angle, lower gonial angle (angle NGoMe), sum angle (sum of saddle, articular, and gonial angles) (the first left column). It also shows values typical for vertical (i.e. posterior or 'clockwise') rotation of the mandible and values indicating horizontal growth pattern (i.e. mandibular anterior or 'counter-clockwise' rotation).

Statistical methods

The power calculation was performed and estimated for the given size of the controls ($N = 456$) and PDC patients ($N = 144$) and at the 0.05 level of significance moved for the selected characteristics (the SNA, ANB, 1 + 1/SN, ML/SN, and SpL/ML angles) within the range of 0.961–0.999. However, number of subjects in the BDC group which reflects representation of this anomaly in a population of the orthodontic patients is relatively small, resulting thus in low power of study; therefore, these results must be taken as preliminary only and further verification in a more extensive study is necessary.

All the characteristics measured were described by means of the methods of descriptive statistics. Arithmetic mean, standard deviation, median, and quartiles 25 75 were determined and compared between the individual groups (controls, PDC and BDC subjects). Because normal distributions for the angles SNA, ANB, 1 + 1/SN, ML/SN, and SpL/ML were found, the method of analysis of variance (ANOVA) was employed. Subsequently, *post hoc* test (Tukey's honestly significance difference [HSD] test) was carried out to assess the differences in the characteristics measured between the individual groups.

Then, the selected characteristics (the SNA, ANB, 1 + 1/SN, ML/SN angles) were split into the diagnostic subgroups (as given above in the methods) based on the criteria used clinically. The significance of differences in frequencies of the individual characteristics between the groups was tested by chi-square or Fisher's exact tests (when a number of subjects in any group were <5). Level of significance of all tests was set at $P < 0.05$. The Statistica version 8.0 (Statsoft Inc., Tulsa, Oklahoma, USA) program package was used for statistical analyses.

Method error

Cephalograms of 50 randomly selected patients were repeatedly measured by the same examiner after a 2 months interval. The method error for each variable was calculated according to Dahlberg's formula ($S = \sqrt{\Sigma d^2/2n}$), where *d* is the difference between two measurements and *n* is the number of double registrations (Houston, 1983). Dahlberg's formula has been widely used in the orthodontic cephalometric literature. According to this formula, the greatest measurement error was found for 1 + 1/SN ($S = 0.84$ degrees) and SpL/ML ($S = 0.85$ degrees) angles probably due to more difficult reproducibility of points and

lines caused by summation of anatomical structures and/or double contours. Nevertheless, the values of Dahlberg's error were 'acceptably low'. The systematic error was calculated with dependent Student's *t*-test, for $P < 0.05$ and measurement error of none of the characteristics was statistically significant.

Results

Characteristics of the evaluated groups

This retrospective study included 636 consecutive orthodontic patients. The control group consisted of 456 patients (261 females and 195 males, mean age 12.6 and 12.4 years, SD 1.9 and 1.7, respectively). A male-to-female ratio in the control group was 1:1.3. The PDC group included 144 patients (92 females and 52 males, mean age 14.2 and 14.7 years, SD 1.9 and 1.9, respectively, a male-to-female ratio 1:1.8). The BDC group comprised 36 patients (16 females and 20 males, mean age 12.4 and 12.8, SD 1.8 and 1.7, respectively, a male-to-female ratio 1.25:1). Only a tendency to a significant increased occurrence of the BDCs in males was found in this study ($P = 0.052$, two-side Fisher's exact test). No statistically significant difference in frequencies between boys and girls was found for the palatally ($P = 0.094$, one-side Fisher's exact test) or all ectopically displaced canines ($P = 0.293$, one-side Fisher's exact test). The group of 180 patients with the ectopic canines exhibited the 2.8 times more frequent unilateral than bilateral occurrence. Right–left distribution in the unilateral disturbances was equally common. The palatal position of the canine crown was recorded in 80 per cent and the buccal position in 20 per cent of patients with the displaced canines.

Descriptive statistics and comparison of the measured characteristics

Table 2 gives arithmetic means, standard deviations, medians, and quartiles 25 and 75 of the measured characteristics in the evaluated groups. The comparison of mean values of the measured characteristics in three groups of patients using the method of variance (ANOVA; Table 2) showed statistically significant differences in all the characteristics. Statistical assessment of the differences (Table 2) showed that the PDC patients had a significantly greater SNA angle and significantly smaller 1 + 1/SN, ML/SN, and SpL/ML angles compared to the controls. The BDC patients differed from the controls only in a significantly smaller ANB angle. Significant differences were also recorded between the PDC and BDC patients. The PDC patients had a significantly greater SNA angle and significantly smaller 1 + 1/SN angle than the BDC patients.

Analysis of the maxilla positions (SNA angle)

The occurrence of the individual positions of the maxilla in the studied groups is given in Table 3. A significant

Table 2 Descriptive data and comparison of mean values of the measured characteristics with analysis of variance (ANOVA) and differences between the studied groups (Tukey HSD test).

Characteristic (angle)	Control group (C)					Patients with palatally displaced canines (PDCs)					Patients with buccally displaced canines (BDCs)					Whole differences (P level)	Differences between the groups (P level)		
	Mean	SD	Median	Q25	Q75	Mean	SD	Median	Q25	Q75	Mean	SD	Median	Q25	Q75	ANOVA	C versus PDC	C versus BDC	PDC versus BDC
SNA (°)	79.5	3.8	80	77	82	80.8	3.5	81	79	83	78.4	4.3	77	75	82	0.000085	0.006*	0.441	0.016*
ANB (°)	3	2.7	3	2	5	2.9	2.2	3	1.5	4.3	1.5	2.5	1.5	0	3	0.0036	0.868	0.036*	0.068
1 + 1/SN (°)	100.7	7.8	101	96	106	97.2	8.4	97.5	92	103	102	7	102	98	107	0.000006	0.0004*	0.792	0.028*
ML/SN (°)	33.6	5.9	33	29	38	30.7	5.8	31	27	35	32.3	5.8	33	28	35.5	0.000001	0.00009*	0.620	0.462
SpL/ML (°)	25.9	6	26	22	30	23.1	5.9	23	19	27	24.2	5.7	24.5	20	27.5	0.000004	0.0002*	0.439	0.712

*$P < 0.05$.

difference was detected between the controls and PDC patients ($P = 0.002$, chi-square test). Retrognathic maxilla occurred significantly less frequently in the group with the PDCs. No significant difference in the position of the maxilla was found between the controls and BDC patients. Testing for differences in the occurrence of the individual positions of the maxilla between the PDC and BDC patients showed a significant difference ($P = 0.0090$, chi-square test). The BDC patients exhibited the retrognathic maxilla significantly more frequently ($P = 0.00053$, one-side Fisher's exact test).

Analysis of the skeletal classes (ANB angle)

Statistical comparison of the occurrence of the skeletal classes (Table 3) showed significant differences between the controls and PDC patients ($P = 0.022$, chi-square test) with a significantly more frequent occurrence of skeletal class I in the PDC group. The skeletal class III was found more frequently in BDC patients ($P = 0.0015$, one-side Fisher's exact test) when comparing the groups with the BDCs and PDCs. Similarly, the comparison of the control and BDC groups suggests that the skeletal class III occurred more frequently in BDC patients ($P = 0.021$, one-side Fisher's exact test).

Analysis of the inclination of the upper central incisors

The occurrence of the inclination of the upper central incisors in the evaluated groups is given in Table 3. Statistical comparison of the groups showed a significantly more frequent occurrence of the retroinclination of incisors in the PDC patients than in the controls ($P = 0.0006$, chi-square test). On the contrary, retroinclination of the upper central incisors in the BDC patients occurred significantly less frequently than in the patients with the PDCs ($P = 0.012$, chi-square test). Comparison of the occurrence of the incisor inclinations in the BDC and the controls did not show any significant difference.

Analysis of the vertical skeletal relationship between the mandible and cranial base (ML/SN angle)

A statistically significant difference was confirmed only between the control and PDC group, where significantly more often hypodivergent (small ML/SN angle) and less often hyperdivergent vertical skeletal relationships (large ML/SN angle) occurred ($P = 0.00001$, chi-square test; Table 3).

Analysis of the SpL/ML angle

A statistically significant difference was found between the controls and the PDC patients, where a small SpL/ML angle occurs more frequently and a large SpL/ML angle is significantly less frequent ($P = 0.0002$, Tukey HSD test; Table 2).

Table 3   Distribution of dentoskeletal characteristics and statistical evaluation of differences in frequencies between the palatally displaced canines (PDC) and buccally displaced canines (BDC) groups.

	Control group	PDC group	BDC group	Differences between the groups (P level)*		
				Controls and PDC	Controls and BDC	PDC and BDC
SNA angle						
Orthognathic maxilla	191 (41.9%)	78 (54.2%)	11 (30.5%)	$P = 0.002$	P = NS	$P = 0.0090$
Prognathic maxilla	39 (8.5%)	19 (13.2%)	2 (5.6%)			
Retrognathic maxilla	226 (49.6%)	47 (32.6%)	23 (63.9%)			
ANB angle						
Skeletal class I	269 (59%)	102 (70.8%)	25 (69.5%)	$P = 0.022$	P = NS	P = NS
Skeletal class II	145 (31.8%)	36 (25%)	3 (8.3%)			
Skeletal class III	42 (9.2%)	6 (4.2%)	8 (22.2%)			
1 + 1/SN angle						
Standard inclination	114 (25%)	23 (16%)	11 (30.6%)	$P = 0.0006$	P = NS	$P = 0.012$
Proclination	138 (30.3%)	30 (20.8%)	12 (33.3%)			
Retroinclination	204 (44.7%)	91 (63.2%)	13 (36.1%)			
ML/SN angle						
Normodivergent	288 (63.2%)	100 (69.5%)	23 (63.9%)	$P = 0.00001$	P = NS	P = NS
Hypodivergent	49 (10.7%)	31 (21.5%)	6 (16.7%)			
Hyperdivergent	119 (26.1%)	13 (9%)	7 (19.4%)			
General vertical facial configuration						
Neutral growth pattern	177 (38.8%)	55 (38.2%)	16 (44.4%)	$P = 0.00001$	P = NS	P = NS
Horizontal	117 (25.7%)	66 (45.8%)	11 (30.6%)			
Vertical	162 (35.5%)	23 (16%)	9 (25%)			

*P levels were calculated by chi-square test (or Fisher's exact test when a number of subjects in any group was <5).

Analysis of the general vertical facial configuration

Comparison of the occurrence of the individual categories of vertical facial configurations between the controls and BDC patients did not show any significant differences (Table 3), whereas significant differences were detected between the PDC patients and the controls. In the PDC group, the anterior mandibular growth rotation (horizontal growth pattern) was found significantly more frequently, while posterior rotation (vertical growth pattern) was significantly less frequent ($P = 0.00001$, chi-square test). No statistically significant difference was found between the groups of patients with the PDCs and BDCs.

Discussion

Three groups of patients were compared in this retrospective study. The control group was formed by consecutive patients referred to the first author of the study for an orthodontic treatment in the studied period. Thus, the controls comprised a sample of patients representing a regular orthodontic practice. The other two groups (with PDC and BDC) represented samples of selected patients with eruption disturbances of the maxillary permanent canine who in the studied period visited the Orthodontic Department at the Clinic of Stomatology for CT examination, orthodontic consultation, or treatment.

Alio-Snaz *et al.* (2011) found that sagittal growth of the maxilla was constant from the age of 8–18 years with an average increase of 0.2 mm/year. Therefore, only patients who at the time of the first orthodontic examination were between the ages of 11 and 17 years were selected in the study. The age structure of the three studied groups of patients shows that the mean age of the PDC patients was slightly higher than those with BDC and controls. This difference can be explained by a more frequent occurrence of PDCs in patients with Class I uncrowded malocclusions (Bass, 1967; Brin *et al.*, 1986; Leifert and Jonas, 2003; Černochová and Izakovičová-Hollá, 2011). If the eruption path of the maxillary permanent canine is not followed consistently in these patients, the diagnosis of impaction is often determined only at the age when the maxillary permanent canines should erupt into the oral cavity or even later when the restoration of an unsightly carious lesion on an over-retained maxillary deciduous canine is necessary (Becker, 2007).

The male-to-female ratio was 1:1.3 in the control group. Similarly, the male-to-female ratio was 1:1.5 in the group of all ectopic canines. Therefore, this study did not confirm the statement of most authors that eruption disturbances of the maxillary permanent canine occurred more frequently in females than in males. It is only possible to state that women are more frequent patients in the orthodontic offices. This opinion was also supported by Brin *et al.* (1986), Oliver *et al.* (1989), and Leifert and Jonas (2003).

Characteristics expressing sagittal (the SNA and ANB angles) and vertical skeletal relationship (the ML/SN and SpL/ML angles and analysis of the general vertical facial configuration) were used for the assessment of craniofacial

skeletal and dental morphology. These selected skeletal characteristics in the groups of patients were assessed using two approaches. The first method was based on the comparison of characteristics by the ANOVA. Using the second approach, each patient was assigned to a certain diagnostic subgroup for the given characteristic measured according to the criteria used clinically. Subsequently, the chi-square or Fisher's exact tests for small values in the BDC group were used to assess the significance of differences in frequencies of the diagnostic subgroups in the studied groups. Both the methods gave the same results.

The comparison of the selected cephalometric characteristics showed statistically significant differences especially between the controls and PDC group. The PDC patients exhibited a significant difference in the maxillary position, i.e. the SNA angle. Unlike orthognathic and prognathic positions, the retrognathic position of the maxilla occurred significantly less frequently. Skeletal class I and retroinclination of the maxillary central incisors occurred more frequently in the PDC patients. Differences in the maxilla–mandibula relationship in the vertical plane were also statistically significant. In the PDC patients, a significantly more frequent occurrence of hypodivergent relationship (a short face syndrome, i.e. smaller ML/SN and SpL/ML angles) and significantly less frequent hyperdivergent relationship (a long face syndrome) were found. These vertical skeletal anomalies of face morphology are determined by the growth pattern or type of the mandibular growth rotation. Mandibular anteriorotation occurred significantly more frequently and posteriorotation was significantly less frequent in the PDC patients. These dentoskeletal characteristics (retrognathic maxilla, retroinclination of maxillary central incisors, and hypodivergent relationship), especially in combination with the other associated dental anomalies (tooth-size reductions, aplasia of second premolars, infraocclusion of primary molars, delayed tooth eruption, ectopic eruption of permanent first molars, etc.) may help identify candidates for interceptive treatment option in PDC patients.

No statistically significant differences of the studied characteristics between the control group and BDC patients were found. This result may be due to a relatively small number of patients with the BDC crown included in this study. Conversely, the comparison of the BDC and PDC groups showed a significantly more frequent occurrence of the retrognathic maxilla and skeletal class III and less frequent retroinclination of the maxillary central incisors in the first group of patients. These results may confirm the existence of differences in the facial morphology between the patients with BDCs and PDCs.

Skeletal class III, e.g. the ANB angle smaller than 0 degrees, and retrognathic maxilla occurred significantly more frequently in the BDC patients. Generally, skeletal class III includes several morphological variants, one of them, a so-called syndrome of maxillary deficiency, is

characterized by insufficient development of the middle facial region. In these patients, the occurrence of a small size of the maxillary apical base may be expected. According to many authors (Jacoby, 1983; Peck *et al.*, 1995), a small size of the maxillary apical base results in buccal displacement of the canine crown leading either to the ectopic eruption or impaction or in some cases buccal eruption of the canine outside the dental arch. Findings of this study support the validity of this claim, however, considering a small number of patients included in this BDC group, they must be assessed carefully and confirmed in a more extensive study with a higher number of BDC patients.

Reviewing the literature, we found just two studies (Sacerdoti and Baccetti, 2004; Lüdicke *et al.*, 2008) dealing with similar issues. The Italian authors Sacerdoti and Baccetti (2004) compared controls only with patients with PDCs and found a more significant occurrence of hypodivergent vertical jaw base relationship in PDC subjects, similarly as this study. Unlike the present study, however, they did not find any differences in the occurrence of skeletal classes. Skeletal class I was determined in 48 per cent of controls and 52 per cent of PDC patients, class II in 32 per cent of controls and 31 per cent of PDC patients, class III in 20 per cent of controls and 17 per cent of PDC patients (Sacerdoti and Baccetti, 2004). Distribution of the skeletal classes in the control group, representing a sample of Czech orthodontic patients, evaluated in the current study was as follows: class I, 59 per cent; class II, 31.8 per cent; and class III, 9.2 per cent. A lower occurrence of the skeletal class III in Czech patients was apparent in the control group and first of all in the PDC patients (4.2 per cent). Conversely, a significantly higher occurrence of skeletal class III (22.2 per cent) was recorded in the BDC patients. Differences in results may be also affected by a different number and age of the patients in the individual groups. The Italian study compared 88 patients with 1000 controls between the ages of 7 and 17 years; the present study compared 144 PDC patients with 456 controls between the ages of 11 and 17 years.

Lüdicke *et al.* (2008) assessed inclination of the maxillary central incisors and position of the upper jaw in their retrospective study of 199 patients (120 females and 79 males, 12.7 ± 3.6 years) with 298 impacted canines. One hundred and forty-eight patients (74.4 per cent) had palatally and 51 patients (25.6 per cent) BDC crown. Patients with impacted canines had greater SNA angle and retroinclination of the maxillary central incisors. The authors correlated these parameters with greater palatal space availability on the apical level of the incisors and loss of the role of the lateral incisor root as a navigator of the canine crown at its eruption. Thus, they support the guidance theory. They considered the Angle Class II Division 2 as a risk factor for palatal impaction of the maxillary permanent canine. The present study showed consistent results in the group of PDC patients but nearly opposite results in the group of BDC patients.

In contrast to the above-mentioned studies (Sacerdoti and Baccetti, 2004; Lüdicke *et al.*, 2008), the results of this study indicate the existence of different facial morphology and more likely also etiopathogenesis of both types of ectopic eruption of the maxillary permanent canine. Several methods of interceptive treatment of ectopically erupting canines have been described in the literature. These methods included extraction of the deciduous maxillary canine (single extraction approach) or concomitant deciduous canine and first molar extractions (double extraction approach) (Williams, 1981; Ericson and Kurol, 1988; Power and Short, 1993; Bonetti *et al.*, 2010). Some authors support the use of a rapid maxillary expansion and/or transpalatal arch and/or headgear therapy in combination with the deciduous canine extraction (Leonardi *et al.*, 2004; Baccetti *et al.*, 2008, 2009, 2010). However, all the published studies dealing with the interceptive approaches were performed in PDC patients only. To our knowledge, no study evaluating the interceptive treatment of BDC patients has been published. The differences in dentoskeletal morphology between the PDC and BDC patients suggest differences in selection of the interceptive approach applied. Early interceptive treatment can prevent root resorption of adjacent permanent teeth. Results of our previous study have shown a significant relationship between the buccolingual position of the ectopic canine and severe root resorption (Cernochova *et al.*, 2010).

Early diagnosis of ectopic eruption of maxillary permanent canine is very important. In case the canines are not buccally palpable in a normal position between 8 and 12 years of age, there is contralateral asymmetry in palpation, or the adjacent teeth are tipped, a conventional radiographic examination is recommended.

Conclusions

The study confirmed correlations between PDC and dentoskeletal cephalometric characteristics in sagittal and vertical plane. The PDC patients showed a significantly more prognathic maxilla, a significantly more frequent skeletal class I, retroinclination of maxillary central incisors, hypodivergent relationship, and mandibular anteriorotation and less frequent posteriorotation. A significantly more frequent retrognathic maxilla and skeletal class III and less frequent retroinclination of the maxillary central incisors were found in the BDC patients. The results from this study indicate the existence of different facial morphology and more likely also etiopathogenesis of eruption disturbances of the canines in the PDC and BDC patients.

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