European Journal of Orthodontics 30 (2008) 381–385
doi:10.1093/ejo/cjn023
Advance Access publication 3 June 2008

A randomized clinical study of two interceptive approaches to palatally displaced canines

Tiziano Baccetti, Maria Leonardi and Pamela Armi
Department of Orthodontics, University of Florence, Italy

SUMMARY This study evaluated the effectiveness of two interceptive approaches to palatally displaced canines (PDC), i.e. extraction of the primary canines alone or in association with the use of a cervical-pull headgear. The randomized prospective design comprised 75 subjects with PDC (92 maxillary canines) who were randomly assigned to three groups: extraction of the primary canine only (EG), extraction of the primary canine and cervical-pull headgear (EHG), and an untreated control group (CG). Panoramic radiographs were evaluated at the time of initial observation (T1) and after an average period of 18 months (T2). At T2, an evaluation of the success of canine eruption was undertaken. Between-group statistical comparisons, Kruskal–Wallis test with Bonferroni correction, were performed on the T1–T2 changes of the diagnostic parameters on panoramic radiographs and the prevalence rates of success in canine eruption. A superimposition study on lateral cephalograms at T1 and T2 was carried out to evaluate the changes in the sagittal position of the upper molars in the three groups.

The removal of the primary canine as an isolated measure to intercept palatal displacement of maxillary canines showed a success rate of 65.2 per cent, which was significantly greater than that in the untreated controls (36 per cent). The additional use of a headgear resulted in successful eruption in 87.5 per cent of the subjects, with a significant improvement in the measurements for intraosseous canine position. The cephalometric superimposition study showed a significant mesial movement of the upper first molars in the CG and EG when compared with the EHG.

Introduction

Palatal displacement of the maxillary canines is defined as the 'developmental dislocation […] to a palatal site often resulting in tooth impaction requiring surgical and orthodontic treatments' (Peck *et al.*, 1996). While a genetic aetiology has been postulated for palatal displacement of upper canines, the pathogenesis of the displacement involves both the long duration and the anatomical complexity of the eruption pathway of this tooth (Peck *et al.*, 1996). The prevalence of palatally displaced canines (PDC) fluctuates between 0.8 and 5.2 per cent (Thilander and Jakobsson, 1968; Brin *et al.*, 1986; Ericson and Kurol, 1987; Baccetti, 1998; Chu *et al.*, 2003). The most frequent consequence of PDC is impaction of the canine. If orthodontic treatment is not started in subjects with PDC, some other possible sequelae may occur, such as resorption of the roots of the neighbouring permanent teeth (Rimes *et al.*, 1997; Ericson and Kurol, 2000; Ericson *et al.*, 2002) and cysts (Ericson and Kurol, 1987; Bishara, 1992; McSherry, 1998). Despite extensive interest in both the aetiology and the therapy of PDC, only a few studies in the last 20 years have focused on preventive measures for canine palatal impaction (Ericson and Kurol, 1988; Power and Short, 1993; McConnell *et al.*, 1996; Jacobs, 1998; Olive, 2002; Leonardi *et al.*, 2004). The clinical protocols proposed include the extraction of the corresponding primary canine, with or without orthodontic procedures to gain space in the upper arch (i.e. distalization of the upper buccal segments and maxillary expansion; McConnell *et al.*, 1996; Olive, 2002).

The procedure of reducing the prevalence of impacted PDC by extracting the primary canine was reported by Buchner (1936). The outcomes in several individual subjects during the subsequent 50 years corroborated the clinical recommendation for this interceptive measure (Jacobs, 1998). Finally, the prospective study by Ericson and Kurol (1988) analysed the effects of extraction of the primary canine on PDC in terms of rate and time of 'spontaneous' eruption. In 36 out of 46 canines (78 per cent), palatal eruption normalized, with the eruption time ranging from 6 to 12 months. In a longitudinal 2 year investigation, Power and Short (1993) described the achievement of a normal eruptive position of PDC in 62 per cent of subjects following the extraction of the primary canines. Those authors suggested the combination of tooth extraction with procedures to increase arch length, such as distalization of the upper buccal segments. A recent study by Leonardi *et al.* (2004) failed to find significant effectiveness of primary canine extraction for the treatment of PDC. However, no study in the literature has used a randomized prospective approach to the interceptive treatment of PDC with the incorporation of untreated controls and a statistically appropriate number of subjects enrolled in the investigation.

The aims of the present randomized clinical trial, which included an untreated control group (CG), were (1) to evaluate the outcomes of the extraction of the primary

canine alone and of extraction when combined with the use of a headgear as an interceptive procedure in PDC subjects and (2) to assess the changes in the sagittal position of the upper molars following the two interceptive treatment approaches.

Subjects and methods

The examined sample consisted of subjects enrolled in a prospective study at the Department of Orthodontics of the University of Florence. The study project was approved by the Ethical Committee at the University of Florence and informed consent was obtained from the subjects and/or their parents/guardians. The following inclusion criteria had to be fulfilled:

1. Caucasian ancestry.
2. Either unilateral or bilateral PDC on a panoramic radiograph. PDC were diagnosed as an intraosseous palatal position of the maxillary permanent canines from panoramic and periapical radiographs. The displacement of the upper canine to the palatal side was checked by means of double determination of the periapical radiographs.
3. Dental age older than 8 years and younger than 13 years according to the method of Becker and Chaushu (2000).
4. Skeletal age showing active phases of skeletal growth according to the cervical vertebral maturation method (before cervical stage (CS) 3; Baccetti *et al.*, 2005).

Exclusion criteria were

1. Previous orthodontic treatment.
2. Craniofacial syndromes, odontomas, cysts, cleft lip and/or palate, sequelae of traumatic injuries to the face, or multiple and/or advanced caries.
3. Crowding in the upper arch, as evaluated by means of intraoral inspection.
4. Aplasia or severe hypoplasia of the crowns of the upper lateral incisors.

A sample of 75 subjects were enrolled in the study. The following material was collected in the PDC sample: panoramic radiographs and lateral cephalograms at the time of initial observation (T1) and after an average period of 18 months (T2). For each patient, the radiographs at T1 and T2 were taken with the same radiographic machine. All PDC subjects were assigned randomly to one of the following three groups:

1. Extraction group (EG), where only extraction of the primary canine corresponding to the PDC was performed.
2. Extraction/headgear group (EHG), where extraction of the primary canine corresponding to the PDC was followed by use of a cervical-pull headgear. The patients in this group started their headgear therapy in the 3 months following extraction of the primary canine. They were instructed to wear the headgear for 12–14 hours a day.
3. CG, who did not receive any treatment between T1 and T2.

Five subjects did not complete the clinical trial because they moved from the area or were asked to be transferred to other clinicians. The remaining 70 subjects with 86 PDC showed the following distribution.

1. EG: 23 subjects, mean age at T1 11.7 years, eight males and 15 females, with 25 PDC.
2. EHG: 24 subjects, mean age at T1 11.9 years, 10 males and 14 females, with 35 PDC.
3. CG: 22 subjects, mean age at T1 11.6 years, 9 males and 13 females, with 26 PDC.

The severity of canine displacement was similar in the three groups at T1 and was not a discriminant factor for case assignment. The power of the present study was greater than 0.85.

Measurements on panoramic radiographs

The measurements proposed by Ericson and Kurol (1988) were performed on the panoramic radiographs at T1 and T2:

1. The mesial inclination of the crown of the canine to the midline (α angle, Figure 1).
2. The distance of the cusp tip of the permanent canine from the occlusal line (*d*, Figure 1).
3. The medial crown position in sectors 1–5 (*s*1–*s*5, Figure 2).

Reproducibility of the diagnosis of PDC had been assessed in a previous pilot study by re-examining the records of 100 subjects 5 months after the first examination (Leonardi *et al.*, 2004). Reproducibility was 100 per cent. Reproducibility of the measurements of α angle, *d*, and *s*1–*s*5 was estimated by repeating all measurements and assessments for 16 patients after 5 months. Accuracy of the measurements was tested by means of a Kappa test for *s*1–*s*5 and by using Dahlberg's formula (1940) for α angle and *d*. The result of the Kappa test for *s*1–*s*5 (0.94) showed a high rate of reproducibility. The method error was 1.2 degrees for α angle and 0.5 mm for *d*.

Superimposition study on lateral cephalograms

Assessment of the changes in the sagittal position of the upper first molar with regard to stable maxillary structures were performed according to the method of Björk and Skieller (1983) by means of superimposition of the T2 film on the T1 film for each subject. The distance between the most mesial point on the crown of the molar at T1 and T2 was recorded by means of computerized cephalometric software (Viewbox, version 3.0, dHAL Software, Kifissia, Greece). A positive value would indicate mesial movement of the molar and a negative value distal movement.

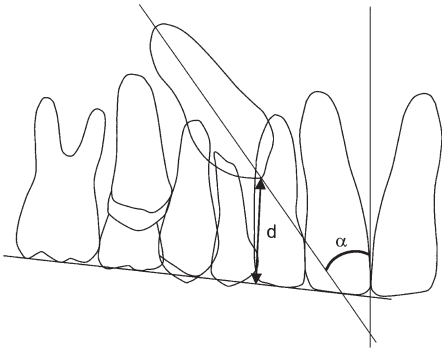

Figure 1 Inclination of the upper canine to the midline (α) and distance to the upper occlusal plane (*d*).

Figure 2 Sectors of medial crown position of the upper canine (modified from Ericson and Kurol, 1988)—1: corresponding to the primary canine (present or absent); 2: from the distal aspect to the midline of the lateral incisor; 3: from the midline of the lateral incisor to the distal aspect of the central incisor; 4: from the distal aspect to the midline of the central incisor; and 5: from the midline of the central incisor to the midline of the maxillary arch.

Assessment of a successful outcome

A successful outcome for a PDC was defined as the full eruption of the tooth, thus permitting bracket positioning for final arch alignment when needed. The outcome was considered as unsuccessful when there was a lack of eruption of the permanent canine at the completion of the clinical observation period (T2, 18 months after the initial observation).

Statistical analysis

Effectiveness of the extraction of the primary canine alone and of the combined therapy including the extraction of the primary canine followed by cervical-pull headgear as interceptive procedures for PDC. The prevalence rates of successful and unsuccessful subjects in the EG were compared with those in EHG and CG by means of chi-squared tests. The T2–T1 changes of α angle, *d*, and *s*1–*s*5 in the EHG were contrasted with those in the EG and CG by means of the Kruskal–Wallis test with Bonferroni correction for multiple comparisons ($P < 0.016$). Non-parametric statistics was used to prevent type I statistical errors due to the lack of normal distribution of the examined variables.

Comparison of changes in the sagittal position of the upper first molars associated with the two interceptive approaches to PDC. A Kruskal–Wallis test with Bonferroni correction for multiple comparisons ($P < 0.016$) was used to evaluate the differences between the three groups with regard to the amount of molar movement as assessed in the cephalometric superimposition study.

All statistical computations were carried out with the aid of the Statistical Package for Social Sciences, release 10.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Effectiveness of the two interceptive procedures

A statistically significant difference was found for the prevalence of successful subjects (chi-square = 8.7, $P < 0.01$) between the EG and CG. The prevalence of subjects with successful eruption of the permanent canine in the group of patients treated with a cervical-pull headgear in addition to the extraction of the primary canine was significantly greater than that in both the CG (chi-square = 23.5, $P < 0.001$) and the EG (chi-square = 5.2, $P < 0.01$). The variables, α angle and *d*, exhibited statistically significant changes between T1 and T2 in both the EHG and the EG when compared with the CG. The variable *s*1–*s*5 did not show significant differences in T1–T2 changes between the EG and EHG or between the EG and CG, whereas a significant improvement in this variable was found in the EHG when compared with the group who underwent extraction of the primary canine in combination with headgear therapy (Table 1).

Change in the sagittal position of the upper first molars

The amount of mesial movement of the upper first molars was significantly less in the EHG when compared with both the EG and the CG ($P < 0.01$). The average amount of sagittal displacement of the upper first molar in the EHG was close to zero (0.24 mm), while it was 2.65 mm in the EG and 2.32 mm in the CG. It should be noted that none of the examined subjects presented with exfoliation of the upper second primary molars at T2.

Discussion

This prospective randomized longitudinal study on the effectiveness of two interceptive procedures in subjects with maxillary PDC followed a preliminary report (Leonardi *et al.*, 2004). The present investigation achieved an adequate power (greater than 0.85) due to a greater number of subjects enrolled in the examined groups. Several characteristics of the study should be emphasized:

Table 1 Comparison of the maximum (Max) and minimum (Min) changes between T1 (initial observation) and T2 (18 months after T2) for diagnostic parameters of canine position on panoramic radiographs.

Measurements at T1	Extraction group (EG), $n = 23$				Extraction/headgear group (EHG), $n = 24$				Control group (CG), $n = 22$				Significance		
	Median	Range	Min	Max	Median	Range	Min	Max	Median	Range	Min	Max	EG–EHG	EG–CG	EHG–CG
α angle	−12.5	26.5	−20.5	6.0	−19.0	34.0	−26.0	8.0	−3.0	48.0	−11.0	37.0	NS	*	*
Distance (*d*)	−6.5	13.5	−13.0	0.5	−7.8	20.5	−17.0	3.5	−1.2	15.0	−11.0	4.0	NS	*	*
*s*1–*s*5	0.0	4.0	−3.0	1.0	−2.0	5.0	−3.0	2.0	0.0	4.0	−2.0	2.0	NS	NS	*

*$P < 0.016$; NS, not significant.

1. The subjects in the CG with a PDC who were left untreated during the observation period were used to evaluate the effectiveness of interceptive approaches to PDC.
2. None of the examined subjects in either treated groups received any additional orthodontic/surgical therapy beyond the extraction of the primary canine (EG) and a cervical-pull headgear (EHG) throughout the observation time.
3. The duration of the observation period for canine eruption (18 months) was appropriate (Ericson and Kurol, 1988).
4. A superimposition study was performed to assess changes in upper molar position concurrent with alternative interceptive approaches to PDC.

The results of the current study showed that removal of the primary canine as an isolated measure to intercept palatal displacement of maxillary canines is effective. These findings did not confirm the outcome of a preliminary report on a smaller groups of subjects with PDC (Leonardi *et al.*, 2004), thus indicating the importance of an adequate power study in clinical trials. On the other hand, the prevalence rate of successful eruption of the permanent canine following extraction of the corresponding primary tooth reported (65.2 per cent) is in agreement with the data of previous longitudinal studies: 78 per cent (Ericson and Kurol, 1988) and 62 per cent (Power and Short, 1993). The prevalence rate of successful outcomes in the subjects where the primary canines were extracted also differed significantly from the prevalence rate for spontaneous eruption of the maxillary canines in the untreated CG (36 per cent).

The addition of a cervical-pull headgear in the treatment regimen of subjects with PDC who underwent extraction of the primary canine proved to be a more effective therapeutic option. The prevalence rate of successful eruption of the canine in subjects treated with this protocol was 87.5 per cent. This rate is slightly more favourable than that reported by Olive (2002), who found that 75 per cent of the canines emerged after orthodontic treatment with fixed appliances to create space in the upper arch following extraction of the primary canine.

In the present study, radiographic evaluation at T2 revealed that PDC treated with extraction of the primary tooth either alone or in association with headgear exhibited a significant improvement in the mesial inclination of the canine and of the distance of the tooth from the occlusal plane. However, a significant improvement in the sector was achieved only when a headgear was added to the treatment protocol. It should be noted that, despite the median value for sector change in the extraction-only group (zero), two of the 23 subjects in this group exhibited an improvement by three sectors and 10 subjects an improvement by one sector.

Interestingly, the superimposition study (Figure 3) showed that a significant mesial movement of the upper first molars (about 2.5 mm) occurred both in untreated PDC subjects and in PDC patients who underwent extraction only of the primary canine. On the contrary, headgear wear resulted in a significant reduction in the amount of mesial displacement of the upper molar, which exhibited an actual lack of mesial movement (0.24 mm). The addition of part-time wear of the cervical-pull headgear to the interceptive treatment of PDC apparently restrained the distal segment

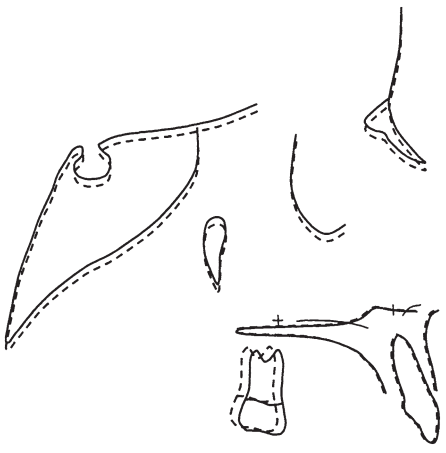

Figure 3 Superimposition on maxillary stable structures. Dotted line: average tracing for the untreated control group (CG) at T1; continuous line: average tracing for the untreated CG at T2. Note the 2.5 mm mesial advancement of the upper first molar.

of the upper dental arch from moving mesially, thus maintaining the space available for canine eruption. It is legitimate to speculate that the goal of avoiding mesial movement of the upper posterior teeth in conjunction with the extraction of the primary canine might be achieved by means of less compliance-dependent appliances than headgear, such as transpalatal arches, or space-holding devices in addition to a palatal Nance button.

Conclusions

The findings of the present randomized clinical study of two interceptive treatment approaches to PDC can be summarized as follows:

1. Extraction of the primary canine only is an effective procedure to increase the rate of normal eruption of maxillary PDC (was more twice than as that in the untreated controls); the use of cervical-pull headgear in addition to the extraction of the primary canine is able to significantly increase the rate of successful eruption of the permanent canine (almost three times more than that in the untreated controls).
2. In PDC subjects treated with the additional use of headgear, physiological mesial movement of the upper first molars (2.5 mm) is prevented.

Address for correspondence

Tiziano Baccetti
Department of Orthodontics
Università degli Studi di Firenze
Via del Ponte di Mezzo 46-48
50127 Firenze
Italy
E-mail: t.baccetti@odonto.unifi.it

Acknowledgements

The authors wish to thank Drs Jüri Kurol and Sheldon Peck for their valuable advice.

References

Baccetti T 1998 A controlled study of associated dental anomalies. The Angle Orthodontist 68: 267–274

Baccetti T, Franchi L, McNamara J A 2005 The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Seminars in Orthodontics 11: 119–129

Becker A, Chaushu S 2000 Dental age in maxillary canine ectopia. American Journal of Orthodontics and Dentofacial Orthopedics 117: 657–662

Bishara S E 1992 Impacted maxillary canines: a review. American Journal of Orthodontics and Dentofacial Orthopedics 101: 159–171

Björk A, Skieller V 1983 Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. European Journal of Orthodontics 5: 1–46

Brin I, Becker A, Shalhav M 1986 Position of the permanent canine in relation to anomalous or missing lateral incisors: a population study. European Journal of Orthodontics 8: 12–16

Buchner H J 1936 Root resorption caused by ectopic eruption of maxillary cuspid. International Journal of Orthodontics 22: 1236–1237

Chu F C, Li T K, Lui V K, Newsome P R, Chow R L, Cheung L K 2003 Prevalence of impacted teeth and associated pathologies-a radiographic study of the Hong Kong Chinese population. Hong Kong Medical Journal 9: 158–163

Dahlberg A G 1940 Statistical methods for medical and biological students. Interscience Publications, New York

Ericson S, Kurol J 1987 Radiographic examination of ectopically erupting maxillary canines. American Journal of Orthodontics and Dentofacial Orthopedics 91: 483–492

Ericson S, Kurol J 1988 Early treatment of palatally erupting maxillary canines by extraction of the primary canines. European Journal of Orthodontics 10: 283–295

Ericson S, Kurol J 2000 Resorption of incisors after ectopic eruption of maxillary canines. A CT study. The Angle Orthodontist 70: 415–423

Ericson S, Bjerklin K, Falahat B 2002 Does the canine dental follicle cause resorption of permanent incisor roots? A computed tomographic study of erupting maxillary canines. The Angle Orthodontist 72: 95–104

Jacobs S G 1998 Reducing the incidence of unerupted palatally displaced canines by extraction of primary canines. The history and application of this procedure with some case reports. Australian Dental Journal 43: 20–27

Leonardi M, Armi P, Franchi L, Baccetti T 2004 Two interceptive approaches to palatally displaced canines: a prospective longitudinal study. The Angle Orthodontist 75: 581–586

McConnell T L, Hoffmann D L, Forbes D P, Janzen E K, Weintraub N H 1996 Maxillary canine impaction in patients with transverse maxillary deficiency. ASDC Journal of Dentistry for Children 63: 190–195

McSherry P F 1998 The ectopic maxillary canine: a review. British Journal of Orthodontics 25: 209–216

Olive R J 2002 Orthodontic treatment of palatally impacted maxillary canines. Australian Orthodontic Journal 18: 64–70

Peck S, Peck L, Kataja M 1996 Site-specificity of tooth maxillary agenesis in subjects with canine malpositions. The Angle Orthodontist 66: 473–476

Power S M, Short M B 1993 An investigation into the response of palatally displaced canines to the removal of primary canines and an assessment of factors contributing to favourable eruption. British Journal of Orthodontics 20: 215–223

Rimes R J, Mitchell C N T, Willmot D R 1997 Maxillary incisor root resorption in relation to the ectopic canine: a review of 26 patients. European Journal of Orthodontics 19: 79–84

Thilander B, Jakobsson S O 1968 Local factors in impaction of maxillary canines. Acta Odontologica Scandinavica 26: 145–168