

Two Interceptive Approaches to Palatally Displaced Canines: A Prospective Longitudinal Study

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Abstract: This study evaluated the effectiveness of two interceptive approaches to palatally displaced canines (PDCs), ie, extraction of the deciduous canines alone and in association with the use of a cervical pull headgear. The prospective longitudinal design of the investigation included 46 subjects with PDC (62 maxillary canines) who were randomly assigned to one of three groups (1) a group that underwent the extraction of the deciduous canine only, (2) a group that received in addition the use of a cervical pull headgear, and (3) an untreated control group. Panoramic radiographs were evaluated at initial observation (T1) and after an average period of 18 months (T2). Cervical vertebral maturation was assessed on lateral cephalograms at T1. Successful or unsuccessful canine eruption was assessed 48 months after T1. The between-group statistical comparisons were performed on the T1–T2 changes in the diagnostic parameters on panoramic radiographs, the prevalence rates of successful canine eruption, and the amount of time for canine eruption. The removal of the deciduous canine as an isolated measure to intercept palatal displacement of maxillary canines showed a prevalence rate of 50% success, which was not significantly greater than the success rate in untreated controls. The use of a headgear in addition to the extraction of the deciduous canine induced successful eruption in 80% of the cases, with a significant improvement in the measures for intraosseous canine position. There was no significant difference between the two interceptive approaches in the time required for canine eruption. (*Angle Orthod* 2004;74:581–586.)

Key Words: Palatally displaced canine; Impacted canines; Interceptive therapy; Deciduous canine; Headgear

INTRODUCTION

Palatal displacement of maxillary canines can be defined as the “developmental dislocation . . . to a palatal site often resulting in tooth impaction requiring surgical and orthodontic treatments.”¹ The prevalence of palatally displaced canines (PDCs) fluctuates between 0.8% and 5.2%.^{2–6} Archaeological discovery of ancient human skulls has shown

the presence of palatally impacted canines since the sixth century BC.⁷ The female to male ratio is 2:1.^{8,9} Racial variations in the prevalence of PDC has been observed among different populations.⁸

Two major theories have been delineated to explain the occurrence of PDC, ie, the “guidance” theory and the “genetic” theory.^{1,10–24} The guidance theory^{14–17} refers to excess of space in the apical region of the maxillary bone during the eruption pathway of the permanent canine, due to either hypoplasia or aplasia of the upper lateral incisors. The displaced canine lacks the “guide” represented by the roots of the neighboring teeth, thus suggesting the predominance of local reasons for the anomaly in the position of the tooth bud. Crowding may also play a role as an environmental cause of impaction, although arch length deficiency is associated primarily with buccal canine impaction.¹⁸ According to the genetic theory, PDCs are assigned to a complex of genetically determined tooth anomalies resulting from a developmental disturbance of the dental lamina.^{1,19–24} The associated dental features (aplasia and small size of lateral incisors included) allow for an early clinical diagnosis of the eruption disturbance.^{2,9,25–28} Familial recurrences of PDC have been reported as well.^{29,30}

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The most frequent consequence of PDC is the impaction of the canine. If orthodontic treatment is not started in PDC cases, some other possible sequelae may occur, such as resorption of the roots of the neighboring permanent teeth³¹⁻³⁴ and cysts.^{5,10,13} Several treatment procedures (or associations of them) have been proposed for impacted PDC, ie, surgical exposure of the crown of the canine, either performed alone or followed by orthodontic traction of the impacted tooth;^{13,35,36} extraction of the canine and replacement with implants;³⁷ and reimplantation of the displaced tooth.³⁸⁻⁴⁰

Despite extensive interest in both the etiology and the therapy of PDC, only a few studies in the past 20 years have focused attention on the preventive measures for canine palatal impaction.^{11,41-43} The clinical protocols proposed include the extraction of the corresponding deciduous canine, with or without orthodontic procedures to gain space at the upper arch (ie, distalization of buccal segments of the upper arch, maxillary expansion).^{43,44}

The procedure of reducing the prevalence of impacted PDC by extracting the deciduous canine has been present in the dental literature since 1936.⁴⁵ The outcomes in several individual cases during the subsequent 50 years corroborated the clinical recommendation for this interceptive measure.¹¹ Finally, the prospective study by Ericson and Kurol in 1988⁴¹ analyzed the effects of extraction of the deciduous canine on PDC in terms of rate and time of "spontaneous" eruption. In 36 of 46 canines (78%), palatal eruption changed to normal, with duration of eruption ranging from six to 12 months. In a longitudinal two-year investigation in 1993, Power and Short⁴² described the achievement of a normal eruptive position of PDC in 62% of the cases after the extraction of the deciduous canines. These authors suggested combining the tooth extraction with procedures to increase arch length, such as distalization of the buccal segments of the upper arch. However, no study in the literature incorporated the use of control groups (CG) comprising subjects with PDC who did not undergo any interceptive measure.

The aims of the present study, which included an untreated CG, were:

- To establish the effectiveness of the extraction of the deciduous canine as interceptive procedure in PDC cases.
- To compare the outcomes of the extraction of the deciduous canine alone with the results of the extraction when combined with the use of a headgear, in terms of both success rate of interceptive therapy and improvement of the intraosseous position of the displaced canine.
- To compare the amount of time required for eruption of the PDC between the extraction-only group (EG) and extraction-headgear group (EHG).

MATERIALS AND METHODS

The examined sample consisted of the records of patients included in a prospective study at the Departments of Or-

thodontics of the University of Florence and University of Catania. To be enrolled in the study, the subjects had to be of Caucasian ancestry. None of the subjects had received any previous orthodontic treatment. Subjects with craniofacial syndromes; odontomas; cysts; cleft lip or palate (or both); sequelae of traumatic injuries to the face; or multiple or advanced caries (or both) were not considered eligible for the study.

A sample of 50 subjects with either unilateral or bilateral PDC was identified for the study, and an informed consent was obtained from them. PDC was diagnosed as intraosseous palatal position of the maxillary permanent canines from panoramic radiographs and periapical radiographs.

Several features were common to the PDC subjects: dental age at T1 older than eight years and younger than 13 years according to the method of Becker and Chaushu;⁴⁶ skeletal age at T1 showing active phases of skeletal growth according to the cervical vertebral maturation method (before CVMS IV);⁴⁷ absence of crowding at the upper arch; absence of aplasia or severe hypoplasia of the crown of upper lateral incisors.

The material collected from the PDC sample included panoramic radiographs and lateral cephalograms exposed immediately before the extraction of the deciduous canines (T1) and panoramic radiographs exposed after an average period of 18 months subsequent to T1 (T2). For all patients, the panoramic radiographs at T1 and at T2 were taken with the same radiology machine.

All PDC subjects were monitored clinically at bimonthly intervals for a 48-month period, and they were assigned randomly to one of the following three groups:

1. EG, where only extraction of the deciduous canine(s) corresponding to the PDC was performed.
2. EHG, where extraction of the deciduous canines corresponding to the PDC was followed by the use of a cervical pull headgear to maintain the length of the upper arch. The patients belonging this group started their headgear therapy during the six months after the extraction of the deciduous canine and were instructed to wear the headgear for 12-14 hours a day.
3. CG, where subjects did not receive any treatment between T1 and T2.

Seven subjects did not complete the clinical trial because they moved out or asked to be transferred to other clinicians. The remaining 46 subjects with 62 PDCs showed the following distribution—EG: 11 subjects; mean age at T1, 11.6 years; five boys and six girls, with 14 PDCs; EHG: 21 subjects; mean age at T1, 12.2 years; seven boys and 14 girls, with 32 PDCs; CG: 14 subjects; mean age at T1, 11.6 years; four boys and 10 girls, with 16 canines.

Severity of canine displacement was similar in the three groups at T1, and it was not a discriminant factor for case assignment. Full eruption of the canine was assessed as the

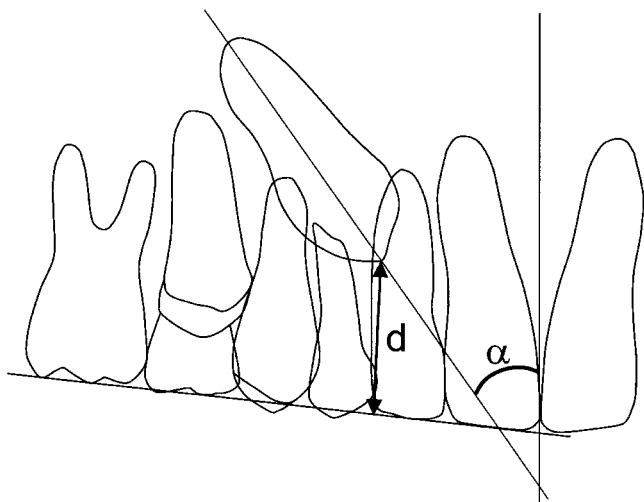


FIGURE 1. Inclination of the upper canine to the midline and distance to the upper occlusal plane.

time when the whole clinical crown of the tooth was visible.

Definition of successful outcome for PDC

The successful outcome for PDC was defined as the full eruption of the tooth, thus permitting bracket positioning for final arch alignment when needed. Unsuccessful outcome was represented by the lack of eruption of the permanent canine (impaction) at the completion of the clinical observation period (48 months after the initial observation).

Measurements on panoramic radiographs

The measurements proposed by Ericson and Kuroi⁴¹ were performed on the panoramic radiographs at T1 and T2, ie, the mesial inclination of the crown of the canine to the midline (α angle) (Figure 1); the distance of the cusp tip of the permanent canine from the occlusal line (d) (Figure 1); and the medial crown position in sectors 1–5 (s1–s5) (Figure 2).

Reproducibility of the diagnosis of PDC was assessed by reexamining the records of 100 subjects five months after the first examination. Reproducibility was 100%. Reproducibility of the measurements of α angle, d, and s1–s5 was estimated by repeating all those measurements and assessments on 16 patients after five months. Accuracy of measurements was tested using the Kappa test for s1–s5 and Dahlberg's formula⁴⁸ for α angle and d1. The result of the Kappa test for s1–s5 (0.94) showed a high rate of reproducibility. The method error was 1.2° for " α angle," and 0.5 mm for "d."

Statistical analysis

Effectiveness of the extraction of the deciduous canine alone and of the combined therapy including the extraction

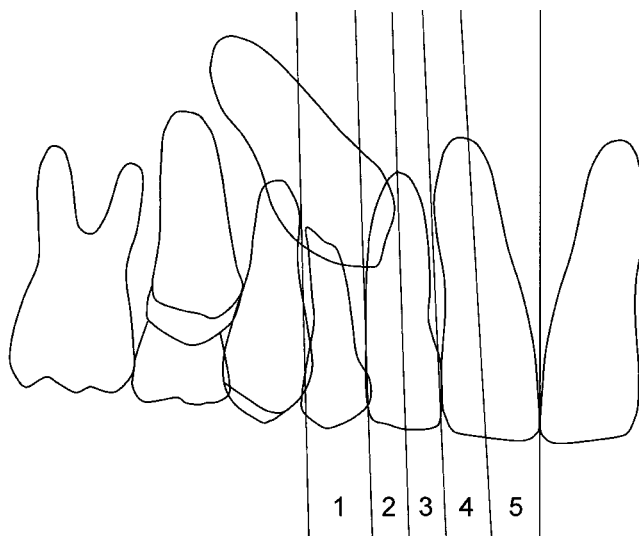


FIGURE 2. Sectors of medial crown position of the upper canine (modified from Ericson and Kuroi⁴¹).

of the deciduous canine followed by cervical-pull headgear as interceptive procedures in PDCs. The prevalences of successful cases and of unsuccessful cases in EG were compared with those in EHG and CG by means of chi-squared tests. The T2-T1 changes of α angle, d, and s1–s5 in EHG were in contrast to those in EG and in CG, as shown by Kruskal-Wallis test with Bonferroni correction for multiple comparisons ($P < .016$).

Comparison of time of canine eruption between the extraction-only and extraction-headgear groups. The duration of the eruption process of the canine in EG-successful cases was compared with the EHG-successful cases by means of Mann-Whitney test.

All statistical computations were carried out with the aid of a commercial statistical package (SPSS for Windows, release 10.0, SPSS Inc).

RESULTS

Effectiveness of the two interceptive procedures

Tables 1 and 2 show the effectiveness of the two interceptive procedures. No statistically significant difference was found for the prevalence of successful cases ($\chi^2 = 2.01$, $P = .15$) between EG and CG. The prevalence of cases 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 deciduous canine was significantly greater than both the CG ($\chi^2 = 14.9$, $P < .000$) and the extraction-only group ($\chi^2 = 4.69$, $P < .05$). The variable α angle exhibited statistically significant changes between T1 and T2 in EHG when compared with both EG and CG. The variable d showed significant changes in EHG when compared with CG. The variable s1–s5 did not show significant differences in T1-T2 changes. The measurements α angle, d, and s1–s5 did not show statisti-

TABLE 1. Descriptive Statistics at T1 and at T2

	EG ^a (n = 14)				EHG (n = 32)				CG (n = 16)			
	Median	Range	Minimum	Maximum	Median	Range	Minimum	Maximum	Median	Range	Minimum	Maximum
Measures at T1												
α Angle	37.5	25.5	23.5	49.0	33.3	52.5	12.5	65.0	23.3	52.0	14.0	66.0
d	19.0	13.0	10.5	23.5	15.3	15.0	9.0	24.0	16.0	27.0	1.0	28.0
s1-5	3.0	3.0	2.0	5.0	2.0	3.0	1.0	4.0	3.0	3.0	2.0	5.0
Measures at T2												
α Angle	32.0	56.0	0.0	56.0	10.5	65.0	0.0	65.0	28.5	73.0	0.0	73.0
d	12.0	22.0	0.0	22.0	7.5	25.0	0.0	25.0	14.0	28.0	0.0	28.0
s1-5	3.0	3.0	1.0	4.0	1.0	3.0	1.0	4.0	4.0	4.0	1.0	5.0

^a EG indicates extraction group; EHG, extraction-headgear group; and CG, control group.

TABLE 2. Comparison of Change T2-T1

	EG ^a (n = 14)				EHG (n = 32)				CG (n = 16)				Significance		
	Median	Range	Minimum	Maximum	Median	Range	Minimum	Maximum	Median	Range	Minimum	Maximum	EG-EHG	EG-CG	EHG-CG
Measures at T1															
α Angle	-7.5	46.5	-30.5	16.0	-19.0	56.0	-46.0	10.0	-2.0	58.0	-21.0	37.0	*	NS	*
d	-3.5	18.5	-18.0	0.5	-7.3	20.5	-17.0	3.5	-1.5	17.0	-13.0	4.0	NS	NS	*
s1-5	0.0	4.0	-3.0	1.0	-1.0	5.0	-3.0	2.0	0.0	4.0	-2.0	2.0	NS	NS	NS

^a EG indicates extraction group; EHG, extraction-headgear group; CG, control group; and NS, not significant.

* $P < .16$.

cally significant changes between the panoramic radiographs at T1 and T2 in EG when compared with CG.

Comparison of time of canine eruption between the extraction-only and extraction-headgear groups

No significant difference was found between successful cases in EG and EHG regarding the duration of the eruption process ($Z = -0.59$, $P = .55$). The average time for complete eruption of the canine was one year and eight months, with durations ranging from five to 38 months.

DISCUSSION

This prospective randomized longitudinal study on the effectiveness of two interceptive procedures in subjects with palatally displaced maxillary canines presented with several peculiar methodological characteristics.

1. The evaluation of a group of subjects with PDC who were left untreated throughout the observation period: these subjects comprised the CG that was used to test the effectiveness of interceptive approaches to PDC.
2. None of the examined subjects in either treated groups received any additional orthodontic or surgical therapy beyond the extraction of the deciduous canine (EG) and a cervical pull headgear (EHG) throughout the observation period.
3. In cases of unsuccessful outcome, a diagnosis of canine impaction was made at the time of the second obser-

vation (T2) on the basis of both dental and skeletal ages of individual patients, developmental stage of the canine, and the full eruption of the contralateral canine in subjects showing unilateral canine displacement.

4. The observation period for canine eruption was during the developmental phases of active skeletal growth, as assessed by a reliable biological indicator of individual skeletal maturity (CVMS).

This study showed that the removal of the deciduous canine as an isolated measure to intercept palatal displacement of maxillary canines is not effective. The results of this investigation do not support the procedure of reducing the prevalence of canine impaction by extracting the deciduous canine alone, as described by many case reports in the literature since 1936.^{45,49-52} The prevalence rate of 50% success after extraction of the deciduous canine that we found in this study is considerably lower than the data of previous longitudinal studies (78% according to Ericson and Kuroi, 62% according to Power and Short). Moreover, the prevalence rate of successful outcomes in subjects in whom the deciduous canines were extracted did not differ significantly from the prevalence rate for spontaneous eruption of the maxillary canines in the untreated CG.

The extraction of the deciduous canine as an interceptive measure to prevent impaction of a palatally displaced permanent canine had been proposed originally^{11,45} on the basis of the assumption that the persistence of the deciduous tooth would represent a mechanical obstacle for the emergence of the permanent tooth. To our knowledge, this hy-

pothesis has not received any scientific validation so far.¹¹ The findings of this study, which included an untreated CG, provided evidence that the removal of the deciduous canine per se is not a decisive factor of success for eruption of malposed canines. It should also be emphasized that one of four PDCs achieved spontaneous eruption in the absence of any interceptive intervention.

The addition of cervical pull headgear to the treatment regimen of subjects with PDC who underwent extraction of the deciduous canine proved to be a more effective therapeutic option. The prevalence rate of successful eruption of the canine in cases treated using this protocol was 80%, a rate which is more than three times greater than the percentage of spontaneous eruption of the canine in untreated subjects. These data confirm the previous results of a study by Olive,⁴³ who found that 75% of the canines emerged after orthodontic treatment with fixed appliances to create space in the upper arch after extraction of the deciduous canine. Kettle⁵¹ and Jacobs⁵³ also reported that the success rate of canine eruption was increased by combining the extraction of the deciduous canine with the manipulation of the space conditions at the upper arch by distal movement of the buccal segments or by localized permanent tooth extractions. Further, in the present study, the radiographic evaluation after approximately 1.5 years subsequent to the initial observation revealed that PDCs treated with extraction of the deciduous tooth in association with the headgear exhibited a significant improvement in the mesial inclination of the canine and in the distance of the tooth from the occlusal plane.

It has been shown that PDC is mainly the consequence of a genetic disorder affecting the position of the tooth bud or the eruption pathway of the canine (or both).^{1,8,20–24,29,30} The lack of space in the upper arch is not a recognized factor for the palatal impaction of the maxillary canine.¹⁸ However, it appears that, from a clinical point of view, the maintenance and increase of upper arch length after extraction of the deciduous canine may play a favorable role for the eruption of the permanent canine without surgical intervention. On the other hand, this study does not provide additional information for answering the question whether orthodontic-orthopedic procedures, such as maxillary expansion,⁴⁴ are able to improve the rate of success in PDC cases in the absence of extraction of the deciduous canines.

As for the duration for full eruption of the palatally displaced maxillary canine after interceptive treatment, eruption of the canine in successful cases occurred on average 20 months after the initial observation. The possible range in duration of eruption was much broader than in the investigation by Ericson and Kurol.⁴¹ No statistical difference was recorded in successful patients between those treated with the extraction of the deciduous canine only and those who also received the headgear. Therefore, it is demonstrated that the use of a headgear in combination with the extraction of the deciduous canine is able to augment the rate

of success for canine eruption but does not result in earlier eruption of canines when compared with the isolated procedure of extraction of the deciduous canine.

CONCLUSIONS

The findings of this study can be summarized as follows:

- The extraction of the deciduous canine alone is not an effective procedure to increase the rate of normal eruption of palatally displaced maxillary canines, whereas the use of cervical pull headgear in addition to the extraction of the deciduous canine is able to induce successful eruption of the permanent canine in 80% of the cases.
- The additional use of the headgear does not influence the time of eruption of the palatally displaced maxillary canine.

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REFERENCES

1. Peck S, Peck L, Kataja M. Site-specificity of tooth maxillary agenesis in subjects with canine malpositions. *Angle Orthod.* 1996;66:473–476.
2. Baccetti T. A controlled study of associated dental anomalies. *Angle Orthod.* 1998;68:267–274.
3. Brin I, Becker A, Shalhav M. Position of the permanent canine in relation to anomalous or missing lateral incisors: a population study. *Eur J Orthod.* 1986;8:12–16.
4. Chu FC, Li TK, Lui VK, Newsome PR, Chow RL, Cheung LK. Prevalence of impacted teeth and associated pathologies—a radiographic study of the Hong Kong Chinese population. *Hong Kong Med J.* 2003;9:158–163.
5. Ericson S, Kurol J. Radiographic examination of ectopically erupting maxillary canines. *Am J Orthod Dentofacial Orthop.* 1987;91:483–492.
6. Thilander B, Jakobsson SO. Local factors in impaction of maxillary canines. *Acta Odontol Scand.* 1968;26:145–168.
7. Baccetti T, Franchi L, Moggi Cecchi J, Pacciani E. Associated dental anomalies in an Etruscan adolescent. *Angle Orthod.* 1995; 65:75–80.
8. Peck S, Peck L, Kataja M. The palatally displaced canine as a dental anomaly of genetic origin. *Angle Orthod.* 1994;64:249–256.
9. Leifert S, Jonas IE. Dental anomalies as microsymptom of palatal canine displacement. *J Orofac Orthop.* 2003;64:108–120.
10. Bishara SE. Impacted maxillary canines: a review. *Am J Orthod Dentofacial Orthop.* 1992;101:159–171.
11. Jacobs SG. Reducing the incidence of unerupted palatally displaced canines by extraction of deciduous canines. The history and application of this procedure with some case reports. *Aust Dent J.* 1998;43:20–27.
12. Jacoby H. The etiology of maxillary canine impactions. *Am J Orthod Dentofacial Orthop.* 1983;84:125–132.
13. McSherry PF. The ectopic maxillary canine: a review. *Br J Orthod.* 1998;25:209–216.

14. Becker A, Sharabi S, Chaushu S. Maxillary tooth size variation in dentitions with palatal canine displacement. *Eur J Orthod.* 2002;24:313–318.
15. Becker A. Ectopic eruption of maxillary canines. *Eur J Orthod.* 1993;15:425.
16. Becker A. In defense of the guidance theory of palatal canine displacement. *Angle Orthod.* 1995;65:95–98.
17. Becker A. Etiology of maxillary canine impaction. Letters to the editor. *Am J Orthod Dentofacial Orthop.* 1984;86:437–438.
18. Langberg BJ, Peck S. Adequacy of maxillary dental arch width in patients with palatally displaced canines. *Am J Orthod Dentofacial Orthop.* 2000;118:220–223.
19. Baccetti T. A clinical and statistical study of etiologic aspects related to associated tooth anomalies in number, size, and position. *Minerva Stomatol.* 1998;47:655–663.
20. Peck S, Peck L, Kataja M. Sense and nonsense regarding palatal canines. *Angle Orthod.* 1995;65:99–102.
21. Peck S, Peck L, Kataja M. Concomitant occurrence of canine malposition and tooth agenesis: evidence of orofacial genetic fields. *Am J Orthod Dentofacial Orthop.* 2002;122:657–660.
22. Pirinen S, Arte S, Apajalahti S. Palatal displacement of canine is genetic and related to congenital absence of teeth. *J Dent Res.* 1996;75:1742–1746.
23. Vastardis H. The genetics of human tooth agenesis. New discoveries for understanding dental anomalies. *Am J Orthod Dentofacial Orthop.* 2000;117:650–656.
24. Leonardi R, Peck S, Caltabiano M, Barbato E. Palatally displaced canine anomaly in monozygotic twins. *Angle Orthod.* 2003;73:466–470.
25. Brenchley Z, Oliver RG. Morphology of anterior teeth associated with displaced canines. *Br J Orthod.* 1997;24:41–45.
26. Mossey PA, Campbell HM, Luffingham JK. The palatal canine and the adjacent lateral incisor: a study of a west of Scotland population. *Br J Orthod.* 1994;21:169–174.
27. Oliver RG, Mannion JE, Robinson JM. Morphology of the maxillary lateral incisor in cases of unilateral impaction of the maxillary canine. *Br J Orthod.* 1989;16:9–16.
28. Stahl F, Grabowski R. Maxillary canine displacement and genetically determined predisposition to disturbed development of the dentition. *J Orofac Orthop.* 2003;64:167–177.
29. Svinhufvud E, Myllarniemi S, Norio R. Dominant inheritance of tooth malpositions and their association to hypodontia. *Clin Genet.* 1988;34:373–381.
30. Zilberman Y, Cohen B, Becker A. Familial trends in palatal canines, anomalous lateral incisors, and related phenomena. *Eur J Orthod.* 1990;12:135–139.
31. Ericson S, Bjerklind K, Falahat B. Does the canine dental follicle cause resorption of permanent incisor roots? A computed tomographic study of erupting maxillary canines. *Angle Orthod.* 2002;72:95–104.
32. Ericson S, Kurol J. Resorption of incisors after ectopic eruption of maxillary canines. A CT study. *Angle Orthod.* 2000;70:415–423.
33. Ericson S, Kurol J. Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. A clinical and radiographic analysis of predisposing factors. *Am J Orthod Dentofacial Orthop.* 1988;94:503–513.
34. Rimes RJ, Mitchell CNT, Willmot DR. Maxillary incisor root resorption in relation to the ectopic canine: a review of 26 patients. *Eur J Orthod.* 1997;19:79–84.
35. Burden DJ, Mullally BH, Robinson SN. Palatally ectopic canines: closed eruption versus open eruption. *Am J Orthod Dentofacial Orthop.* 1999;115:640–644.
36. Usiskin LA. Management of the palatal ectopic and unerupted maxillary canine. *Br J Orthod.* 1991;18:339–346.
37. Mazor Z, Peleg M, Redlich M. Immediate placement of implants in extraction sites of maxillary impacted canines. *J Am Dent Assoc.* 1999;130:1767–1770.
38. Berglund L, Kurol J, Kvint S. Orthodontic pre-treatment for autotransplantation of palatally impacted maxillary canines. Case reports on a new approach. *Eur J Orthod.* 1996;18:449–456.
39. Sagne S, Lennartsson B, Thilander B. Transalveolar transplantation of maxillary canines. An alternative to orthodontic treatment in adult patients. *Am J Orthod Dentofacial Orthop.* 1986;90:149–157.
40. Moss JP. Autogenous transplantation of maxillary canines. *J Oral Surg.* 1968;26:775–783.
41. Ericson S, Kurol J. Early treatment of palatally erupting maxillary canines by extraction of the primary canines. *Eur J Orthod.* 1988;10:283–295.
42. Power SM, Short MB. An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. *Br J Orthod.* 1993;20:215–223.
43. Olive RJ. Orthodontic treatment of palatally impacted maxillary canines. *Aust Orthod J.* 2002;18:64–70.
44. McConnell TL, Hoffmann DL, Forbes DP, Janzen EK, Weintraub NH. Maxillary canine impaction in patients with transverse maxillary deficiency. *ASDC J Dent Child.* 1996;63:190–195.
45. Buchner HJ. Root resorption caused by ectopic eruption of maxillary cuspid. *Int J Orthod.* 1936;22:1236–1237.
46. Becker A, Chaushu S. Dental age in maxillary canine ectopia. *Am J Orthod Dentofacial Orthop.* 2000;117:657–662.
47. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the Cervical Vertebral Maturation (CVM) Method for the assessment of mandibular growth. *Angle Orthod.* 2002;72:316–323.
48. Dahlberg AG. *Statistical Methods for Medical and Biological Students.* London, UK: Bradford and Dickens; 1940.
49. Leivesley W. Minimizing the problem of impacted and ectopic canines. *J Dent Child.* 1984;51:367–370.
50. Williams BH. Diagnosis and prevention of maxillary cuspid impaction. *Angle Orthod.* 1981;51:20–30.
51. Kettle MA. Treatment of the unerupted maxillary canine. *Dent Pract.* 1958;8:245–255.
52. Lappin MM. Practical management of the impacted maxillary cuspid. *Am J Orthod.* 1951;37:769–778.
53. Jacobs SG. Palatally impacted canines: aetiology of impaction and scope for impaction. Report of cases outside the guidelines of interception. *Aust Dent J.* 1994;39:206–211.