Original Article

Effect of interceptive extraction of deciduous canine on palatally displaced maxillary canine:

A prospective randomized controlled study

Farhan Bazargani[a]; Anders Magnuson[b]; Bertil Lennartsson[c]

ABSTRACT

Objective: To evaluate the effect of the extraction of deciduous canines on palatally displaced canines (PDCs), to analyze the impact of the age of the patient on this interceptive treatment, and to assess the outcome of one-sided extraction of a maxillary primary canine on the midline of the maxilla.

Materials and Methods: This study included 48 PDCs in 24 consecutive patients with bilateral PDCs. The mean age of the patients at diagnosis was 11.6 years (standard deviation 1.2 years). After randomization, one deciduous canine of each patient was assigned to extraction, and the contralateral side served as control. The patients were then followed at 6-month intervals for 18 months with panoramic and intraoral occlusal radiographs.

Results: The rates of successful eruption of the PDCs at extraction and control sites were 67% and 42%, respectively, at 18 months. The difference between the sites was statistically significant, and the effect was significantly more pronounced in the younger participants. A significant decrease in arch perimeter occurred at extraction sites compared to control sites during the observation period. No midline shift toward the extraction side was observed in any patient.

Conclusions: The extraction of the deciduous canine is an effective measure in PDC cases, but it must be done in younger patients in combination with early diagnosis, at the age of 10–11 years. Maintenance of the perimeter of the upper arch is an important step during the observation period, and a palatal arch as a space-holding device is recommended. (*Angle Orthod.* 2014;84:3–10.)

KEY WORDS: Palatally displaced canines; Interceptive treatment; Randomized controlled trial

INTRODUCTION

The maxillary permanent canine is sometimes displaced toward the palatal side of the dental arch and does not erupt into the dental arch correctly. The palatally displaced canine (PDC) was described by Peck et al.[1,2] as a ''developmental dislocation'' with a genetic origin. While a genetic etiology 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 path of this tooth.[3]

The prevalence of PDC was reported to be about 2%–3% in a White population.[4,5] Palatal displacements are more common than labial displacements, and the ratio varies from 2:1 to 9:1.[6–8] The most frequent consequence of PDC is impaction of the canine, which increases the risk of resorption of the neighboring permanent teeth.[9–12]

The first step in preventing a PDC from becoming impacted is to extract the deciduous canine in the hope that the PDC improves its unfavorable position. Several clinical trials have demonstrated the effectiveness of this interceptive treatment.[3,13–15] Nevertheless, two systematic reviews published in 2009 and 2011[16,17] pointed out the lack of evidence to support the extraction of the deciduous maxillary canine to facilitate the eruption of the PDC because of the heterogeneity of the study methods and the low quality

[a] Senior Consultant, Department of Orthodontics, Postgraduate Dental Education Center, Orebro, Sweden.

[b] Statistician, Clinical Epidemiology and Biostatistic Unit, Orebro University Hospital, Orebro, Sweden.

[c] Associate Professor, Department of Orthodontics, Postgraduate Dental Education Center, Orebro, Sweden.

Corresponding author: Dr Farhan Bazargani, Senior Consultant, Postgraduate Dental Education Center, Department of Orthodontics, PO Box 1126, SE-701 11 Orebro, Sweden (e-mail: farhan.bazargani@orebroll.se)

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of scientific evidence of the reviewed studies. Thus, even if an extraction is carried out, the clinical rationale for extracting the deciduous canine in PDC cases is still disputed by many practitioners.

Early diagnosis of PDC and extraction of the deciduous canines were advocated by Ericson and Kurol,[13] but the lack of a control group complicated the interpretation of their results. Therefore, the impact of the age of the patient on the interceptive extraction of the deciduous canines also remains ambiguous.

The current randomized controlled trial (RCT) was therefore set up to (1) evaluate the efficacy of interceptive extraction of deciduous canines on PDCs, (2) analyze the impact of the age of the patient on the interceptive treatment, and (3) assess the effect of one-sided extraction of a maxillary primary canine on the midline of the upper arch.

MATERIALS AND METHODS

The regional ethical review board in Uppsala, Sweden, which follows the guidelines of the Declaration of Helsinki, approved the study protocol. Twenty-four consecutive patients at the Postgraduate Dental Education Center, Department of Orthodontics, Orebro County Council, Sweden, who met the eligibility criteria, participated in this RCT between August 2007 and November 2010.

The following inclusion criteria had to be fulfilled by the participants enrolled in the study.

- Inability to locate the canines by digital palpation
- Bilateral PDCs identified on the panoramic and intraoral occlusal radiographs
- Age at diagnosis between 10 and 14 years, with dental stage in the late mixed dentition

Patients with previous or ongoing orthodontic treatment, aplasia of the upper lateral incisors, moderate to severe crowding in the upper arch (>3 mm), and/or craniofacial syndromes, odontomas, cysts, or cleft lip and/or palate were not considered eligible for inclusion in the study.

PDC was diagnosed by both a nonpalpable canine bulge in the alveolar process and criteria developed by Ericson and Kurol[13] using panoramic radiographs (Figure 1a,b). A canine within sectors 2–5, in an intraosseous position within the palate, and exceeding the long axis of the upper lateral incisors on an intraoral occlusal radiograph, was diagnosed as a PDC.

After informed consent was obtained, the patients' two deciduous canines were randomized into two sides: the extraction side (n = 24) and the control side (n = 24). The randomization procedure was as follows: A computer-generated randomization list was created

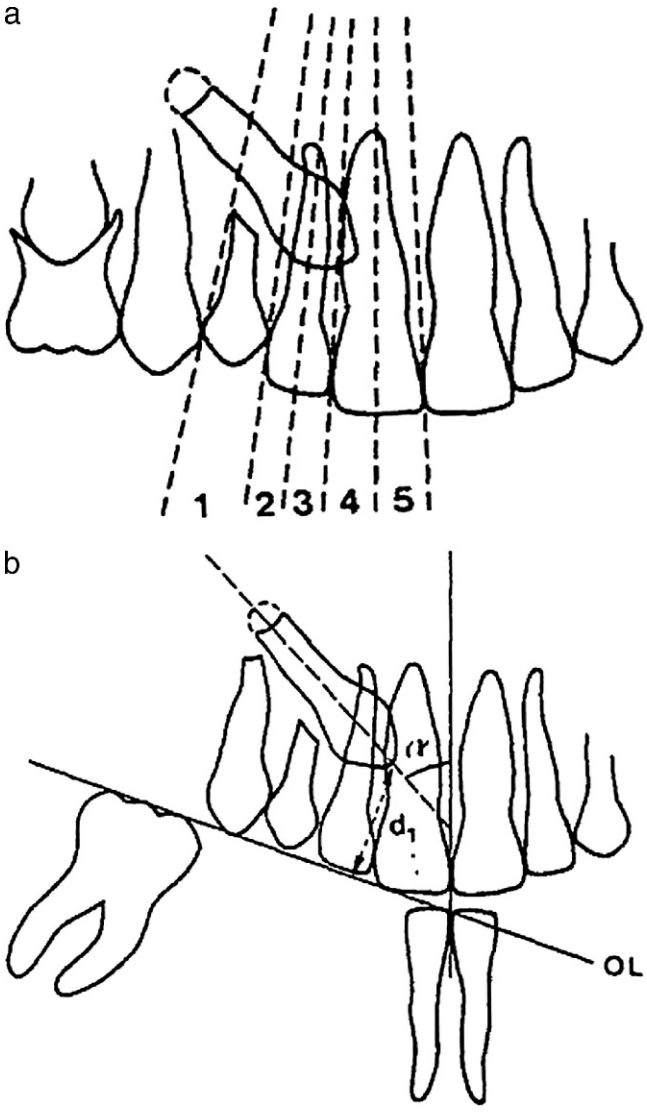

Figure 1a and 1b. Reference lines and linear and angular measurements. Canine inclination (α) to the midline, perpendicular distance (*d*) from the occlusal plane line (OL), and zone (1–5) of the displaced canine crown. (Adapted with permission from Kurol J.)

using SPSS software (version 15.0, SPSS, Chicago, Ill) and stored with a research secretary at the Postgraduate Dental Education Center. Each time a patient gave consent, the secretary was contacted by e-mail and gave the information about which deciduous canine was to be extracted. Consequently, 48 PDCs in eight boys and 16 girls with a mean age of 11.6 years (standard deviation [SD] 1.2 years) (Table 1) were randomized and followed at 6-month intervals for 18 months (Figure 2).

Panoramic and intraoral occlusal radiographs and impressions for study casts were taken at baseline (just before extraction of the deciduous canine [T0]) and at 6 months (T1), 12 months (T2), and 18 months (T3) after extraction of the deciduous canine.

Table 1. Patient Characteristics

	Patients (n = 24)
Age	
Mean (SD)	11.6 (1.2)
Range	10–14
10–11 y, n (%)	15 (62)
12–14 y, n (%)	9 (38)
Sex	
Boys, n (%)	8 (33)
Girls, n (%)	16 (67)

The main outcome variables were distance from the occlusal plane to the canine crown (*d*), canine inclination to the midline (α), and sector of the canine crown position according to Ericson and Kurol,[13] in association with the potential effect of interceptive treatment. Other independent variables taken into account, because they might influence these associations, were sex and age (at time of diagnosis) of the patients.

All the panoramic and intraoral occlusal radiographs were taken at the Postgraduate Dental Education Center, Department of Oral Radiology, Orebro County Council, using a standardized technique with the same magnification (×1.3). A 20-mm-long, 0.019 × 0.025-inch stainless steel wire was placed parallel to the lower dental arch with the aid of a piece of wax before panoramic radiographs were obtained to facilitate the calibration of the radiographs later on. All the panoramic radiographs were calibrated and then traced in Facad software (version 3.0, Ilexis AB, Linköping, Sweden). Reference lines consisting of a horizontal occlusal line, the midline, and the zones of the PDCs, according to Ericson and Kurol,[13] were drawn in the FACAD software to calculate *d* and α. The zones were registered at the same time (Figure 3).

The study casts were assessed with regard to the midline of the upper dental arch. The midline of the upper central incisors was evaluated at T0 and T3 by relating it to both the midline of the palate (palatine raphe) and to the midline of the lower arch (Figure 4). Lines were drawn to mark palatine raphe and the midlines in the upper and lower arches on the casts to facilitate the comparison. Visual assessment was done on two separate occasions 3 months apart to compare the midline in the upper arch at T0 and T3.

Space measurements in the dental arch in the deciduous canine regions were conducted with a digital caliper (Digital 6, Mauser, Winterhur, Switzerland) at T0, T1, T2, and T3. The distance between the distal contact points of the deciduous canines and the distal contact points of the lateral incisors was measured at T0. After extraction of the deciduous canines, the measurements were conducted from the distal contact points of the lateral incisors to the mesial contact points of either the first deciduous molars or the first premolars. The space changes over time were recorded.

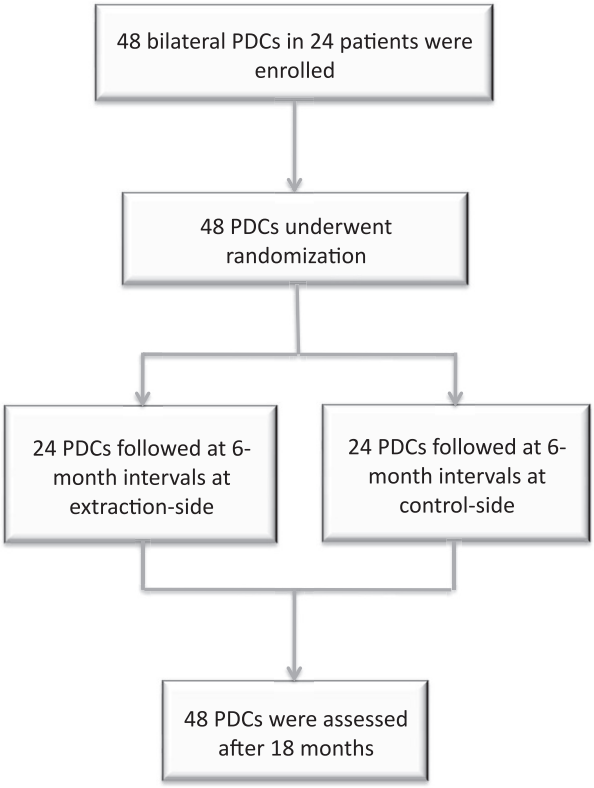

Figure 2. Flow chart.

Statistical Analysis

The sample size was calculated as a within-patient design and based on a significance level of 5% and a power of 90% to detect a 50% improvement (mean, 22 to 11 degrees) in α of the PDCs between treated and untreated sides at follow-up, based on data from Ericson and Kurol.[13] With a paired *t*-test and an assumption of SD = 15.7 for the differences, we determined that a sample of 24 patients (48 PDCs) would be sufficient to detect a significant difference between treated and untreated sides.

To evaluate the repeatability of measuring α, *d*, and space, the coefficient of variation (COV) was estimated by one-way analysis of variance from 10 duplicated, randomly selected panoramic radiographs, with 3 months between measurement sessions. One operator performed all measurements.

A mixed model for repeated measurements with unstructured covariance matrix was used to analyze side differences (extraction vs control side), as well as extraction side and control side separately for α, between time points T0 and T3. We also tested for

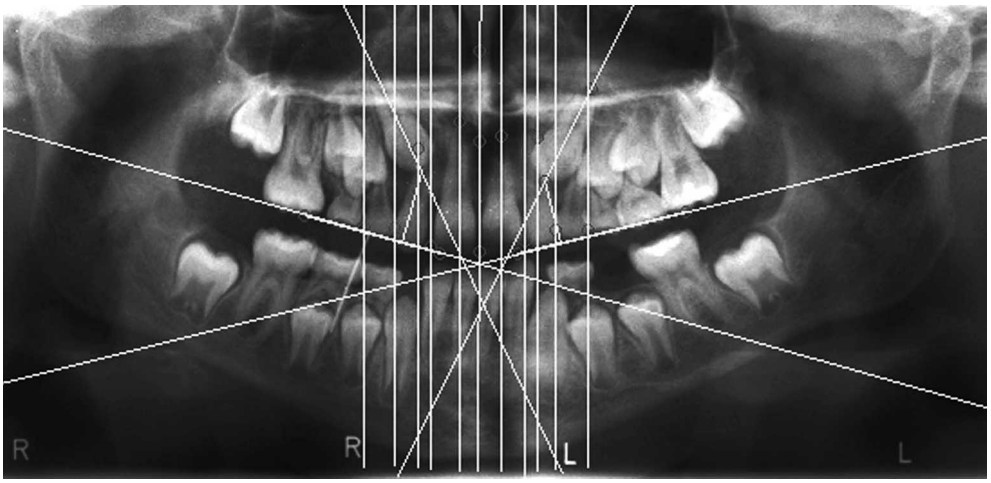

Figure 3. Reference lines and linear and angular measurements derived using Facad software.

statistical interactions by patient age, categorized as 10–11 years vs 12–14 years. The same mixed-model analysis was performed for *d* and space changes within the dental arch. The Wilcoxon paired rank sum test was used to evaluate changes in zone, between sides and between time points, for either extraction side or control side. Because multiple comparisons were being made at different time points, Bonferroni correction was performed for mixed-model analysis; otherwise, the Bonferroni-Holm method was applied. All analyses were conducted with the SPSS statistical package (version 17.0, SPSS).

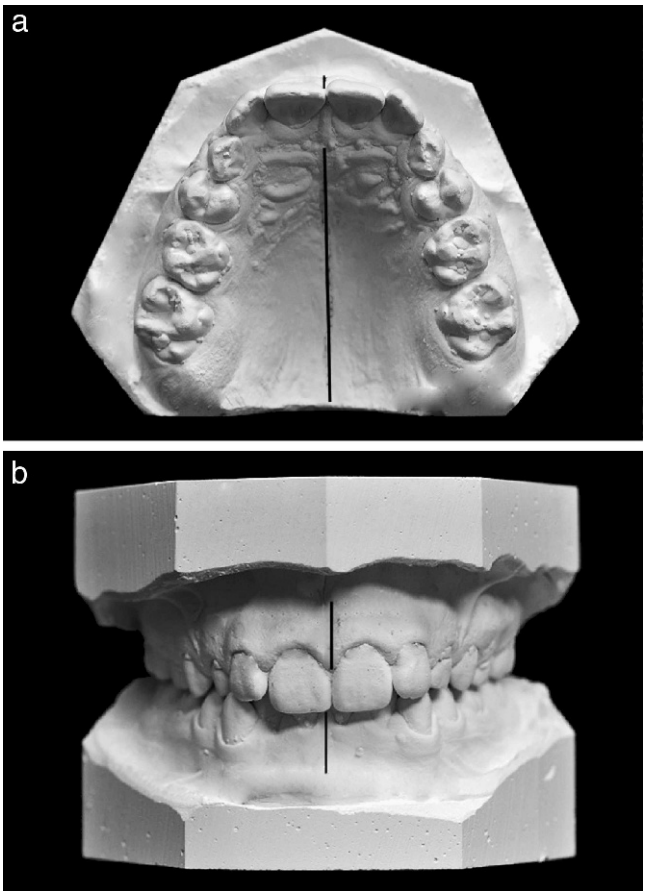

Figure 4a and 4b. Evaluation of the midline of the upper central incisors in relation to both the midline of the palate and the midline of the lower arch.

RESULTS

In the analysis of all 48 PDCs, α at T0 was a mean of 23.2 (SD 7.9) degrees on the extraction side and was similar on the control side (Table 2). The repeatability of measurements of α and *d* was COV = 2.3% and 1.9%, respectively, on the extraction side and COV = 2.9% and 1.4%, respectively, on the control side. The repeatability of space measurement was COV = 2.1%.

At T1, α on the extraction side decreased by a statistically significant amount from T0 through T3, but no changes were found on the untreated control side. The same pattern was observed for the side differences except at T3, although no mean differences were detectable between T2 (−7.9 degrees) and T3 (−7.9 degrees) (Table 2).

However, there was a statistically significant interaction by age ($P = .016$). After the subjects were stratified into a younger group (10–11 y) and an older group (12–14 y), the latter showed no major decrease in α at T1, T2, or T3. On the other hand, analysis of the younger group (10–11 y) showed a statistically significant decrease at T1 and T2 for the extraction side and for the side differences compared to T0 but not at T3, although no major mean difference was detectable between T2 (−13 degrees) and T3 (−12.5 degrees) (Table 2). No statistically significant interaction was found with regard to sex ($P = .47$). The same pattern of associations was observed for *d* (Table 2).

Table 2. Results from Mixed-Model Analysis of α and *d:* Changes from T0 to T1–T3 on Extraction and Control Sides and Differences Between Sides for All 24 Patients and Stratified by Age*

	T0			T0 to T1		
	Extraction	Control	Difference	Extraction	Control	Difference
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD) *P* Value[c]	Mean (SD) *P* Value[c]	Mean[d] (95% CI)[3] *P* Value[c]
α						
All[a]	23.2 (7.9)	23.1 (8.3)	0.0 (8.2)	18.3 (12.7) $P = .022$	23.3 (10.2) $P = 1.000$	−5.0 (−9.0 to −0.9) $P = .014$
10–11 y	22.1 (5.8)	20.2 (4.2)	2.0 (8.1)	14.9 (9.1) $P = .004$	20.6 (5.4) $P = 1.000$	−7.7 (−13.0 to −2.3) $P = .005$
12–14 y	24.9 (10.8)	28.1 (11.0)	−3.2 (7.7)	24.1 (16.2) $P = 1.000$	27.7 (14.7) $P = 1.000$	−0.4 (−6.0 to 5.2) $P = 1.000$
d						
All[b]	11.7 (1.8)	11.6 (2.0)	0.1 (1.9)	9.3 (3.0) $P < .001$	10.5 (1.9) $P < .001$	−1.3 (−2.3 to −0.4) $P = .005$
10–11 y	11.5 (1.9)	11.3 (1.8)	0.2 (1.7)	8.4 (2.9) $P < .001$	10.4 (1.8) $P = .004$	−2.2 (−3.4 to −1.0) $P = .001$
12–14 y	12.2 (1.6)	12.2 (2.3)	−0.1 (2.3)	10.8 (2.6) $P = .177$	10.8 (2.2) $P = .086$	0.1 (−0.9 to 1.0) $P = 1.000$

Table 2. Continued.

	T0 to T2			T0 to T3		
	Extraction	Control	Difference	Extraction	Control	Difference
	Mean (SD) *P* Value[c]	Mean (SD) *P* Value[c]	Mean[d] (95% CI)[c] *P* Value[3]	Mean (SD) *P* Value[c]	Mean (SD) *P* Value[3]	Mean[d] (95% CI)[c] *P* Value[c]
α						
All[a]	14.5 (16.5) $P = .010$	22.4 (13.3) $P = 1.000$	−7.9 (−14.4 to −1.4) $P = .014$	11.7 (18.5) $P = .004$	19.6 (17.8) $P = .659$	−7.9 (−16.2 to 0.5) $P = .069$
10–11 y	8.1 (10.8) $P < .001$	19.1 (9.8) $P = 1.000$	−13.0 (−21.6 to −4.3) $P = .004$	4.6 (11.9) $P < .001$	15.1 (15.3) $P = .654$	−12.5 (−25.3 to 0.3) $P = .057$
12–14 y	25.1 (19.5) $P = 1.000$	27.8 (16.9) $P = 1.000$	0.5 (−6.2 to 7.2) $P = 1.000$	23.7 (22.0) $P = 1.000$	27.1 (20.1) $P = 1.000$	−0.2 (−6.1 to 5.6) $P = 1.000$
d						
All[b]	7.6 (4.8) $P < .001$	9.8 (2.8) $P = .003$	−2.3 (−4.0 to −0.6) $P = .005$	6.0 (5.5) $P < .001$	8.0 (4.8) $P = .002$	−2.2 (−4.4 to 0.6) $P = .059$
10–11 y	5.7 (4.1) $P < .001$	9.3 (2.8) $P = .023$	−3.8 (−5.8 to −1.8) $P < .001$	3.7 (4.3) $P < .001$	7.0 (5.1) $P = .012$	−3.6 (−6.9 to −0.2) $P = .035$
12–14 y	10.7 (4.4) $P = .883$	10.6 (2.8) $P = .248$	0.2 (−1.8 to 2.1) $P = 1.000$	9.8 (5.2) $P = .448$	9.7 (4.1) $P = .204$	0.1 (−1.7 to 2.1) $P = 1.000$

[a] Statistically significant interaction of α (side differences) between age and time points ($P = .016$).
[b] Statistically significant interaction of *d* (side difference) between age and time points ($P = .011$).
[c] Corrected for multiple comparison by Bonferroni method; CI indicates confidence interval.
[d] Adjusted for side difference at T0.
* $P < .05$ is considered statistically significant.

The mean amount of space in the dental arch in the primary canine region was 7.4 mm (SD 0.5 mm) at T0. This decreased by a statistically significant amount on the extracted side at T1, with similar decreases at T2 and T3 compared to T0 (Table 3). The decrease in spacing was more pronounced in the older patients (12–14 y).

Table 4 shows the distribution of zone positions on the extraction and control sides. A change in zone distribution occurred, and more PDCs with lower zones were seen on the extraction side, when compared to T0. There was also a statistically significant difference in zone position when comparing the extraction side with the control side at T1, T2, and T3, with lower zones on the extraction side.

The prevalence rates for successful eruption of the PDC (ie, above the gingival margin in an esthetically acceptable location in the dental arch at the extraction site and the untreated control site after 18 months) were 67% and 42%, respectively ($P = .037$).

Table 3. Results of Mixed-Model Analyses of Space Changes from T0 to T1–T3 for All 24 Patients and Stratified by Age*

	T0	T0 to T1		T0 to T2		T0 to T3	
	Mean (SD)	Mean (SD)	Change (95% CI)[b]; *P* value[b]	Mean (SD)	Change (95% CI)[b]; *P* value[b]	Mean (SD)	Change (95% CI)[b]; *P* value[b]
Space							
All[a]	7.4 (0.5)	6.4 (1.2)	−1.1 (−1.6 to −0.5); $P < .001$	6.5 (1.5)	−0.9 (−1.6 to −0.2); $P = .009$	6.4 (1.8)	−1.0 (−1.9 to −0.2); $P = .010$
10–11 y	7.6 (0.5)	6.9 (1.1)	−0.7 (−1.5 to 0.1); $P = .098$	7.3 (1.4)	−0.3 (−1.2 to 0.6); $P = 1.000$	7.2 (1.5)	−0.4 (−1.4 to 0.6); $P = .997$
12–14 y	7.2 (0.5)	5.5 (0.7)	−1.6 (−2.3 to −1.0); $P < .001$	5.3 (1.0)	−1.8 (−2.6 to −1.1); $P < .001$	5.0 (1.3)	−2.2 (−3.4 to −1.1); $P = .001$

[a] Statistically significant overall time effect for space from mixed model ($P < .001$) and interaction between age and time ($P = .014$).
[b] Corrected for multiple comparison by Bonferroni method; CI indicates confidence interval.
* $P < .05$ is considered statistically significant.

Table 5 shows the observed tendency for a weaker response of the PDCs in the higher zones (4 and 5) compared to the PDCs in the lower zones (2 and 3). No midline shift toward the extraction side was observed in any case.

DISCUSSION

This prospective longitudinal trial investigated the effectiveness of extraction of the deciduous canine on PDC with a RCT design in which the patients served as both cases and matched controls; thus, the same genetic background prevailed in all subjects. The duration of the observation period (18 months) was chosen to match previous studies.[3,13,18–20]

The α measurement of the PDCs in this study between the extraction and control sides at baseline (T0) was very similar and therefore gave rise to an adequate comparison between the sides, but 14 PDCs on the extraction site were in zone 2, compared to 10 PDCs on the control side at baseline, which may have affected the result in some way. This uneven distribution of PDCs between the sides was an unfortunate consequence of the randomization procedure. Furthermore, the repeatability of all measurements regarding α, *d*, and arch perimeters showed a high rate of reproducibility.

The results of this study show that extraction of the deciduous canine, as an interceptive measure to improve the position of the PDC, is an effective treatment, but the effect was significantly more pronounced in the younger patients (10–11 y) than in the older patients (12–14 y). This is in accordance with the results of earlier studies and confirms their findings.[13,21] Notably, the deviation of α was greater in the older subjects, which may be a consequence of the longer eruption time. Hence, early diagnosis is a very important factor if interceptive treatment is to be successful. With late diagnosis, crowding, resorption, or a very horizontal path of eruption, alternative modes of treatment should be considered. Surgical exposure with subsequent orthodontic appliance treatment will be the main choice in such cases.[13]

Table 4. Zone of PDC Positions from T0 to T3 for All 24 Patients and Stratified by Age*

	T0		T1		T2		T3	
	Extraction	Control	Extraction	Control	Extraction	Control	Extraction	Control
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Zone								
1	0 (0)	0 (0)	11 (46)	4 (17)	14 (58)	7 (29)	16 (67)	10 (42)
2	14 (58)	10 (42)	5 (67)	8 (50)	2 (67)	5 (50)	2 (75)	1 (46)
3	5 (79)	10 (83)	4 (83)	8 (83)	3 (79)	6 (75)	4 (92)	6 (71)
4	5 (100)	3 (96)	4 (100)	2 (92)	4 (96)	4 (92)	2 (100)	5 (92)
5	0	1 (100)	0	2 (100)	1 (100)	2 (100)	0	2 (100)
Test between time points[a] (compared to T0)			$P < .001$	$P = .540$	$P = .008$	NS*	$P = .017$	NS*
Test between sides[a] (extraction vs control)			$P = .015$		$P = .018$		$P = .037$	

[a] Wilcoxon paired rank sum test corrected for multiple comparison with Bonferroni Holm method.
[b] Percentages are cumulative.
* $P < .05$ is considered statistically significant; NS indicates not significant.

Table 5. PDCs Stratified by Zone*

	T1	T2	T3
	Extraction	Extraction	Extraction
	n (%)	n (%)	n (%)
Zone[a]			
2–3, n = 19			
Better zone than T0	12 (63)	14 (74)	15 (79)
Equal zone as T0	7 (37)	3 (16)	2 (10)
Worse zone as T0	0 (0)	2 (10)	2 (10)
Test between times (compared to T0)[a]	$P = .003$	$P = .006$	$P = .007$
4–5, n = 5			
Better zone than T0	1 (20)	1 (20)	1 (20)
Equal zone as T0	4 (80)	3 (60)	2 (40)
Worse zone as T0	0 (0)	1 (20)	2 (40)
Test between times (compared to T0)[a]	$P = .951$	NS	NS

[a] Wilcoxon paired ranked sum test corrected for multiple comparison with Bonferroni-Holm method.
* $P < .05$ is considered statistically significant; NS indicates not significant.

Data from the current study indicated a tendency toward a weaker response of the PDCs in the higher zones (4 and 5) to interceptive extraction of the deciduous canine. This tendency could be a result of the fact that the PDCs in the higher zones were further away from the extraction site and therefore somehow responded more poorly to the interceptive treatment.

The prevalence rate for successful eruption of the PDCs on the extraction site after 18 months was 67%, which is somewhat lower than the 78% reported by Ericson and Kurol[13] but is more or less in agreement with the results of the previous studies of Power and Short[14] (62%) and Baccetti et al.[3] (65.2%). The prevalence rate for successful outcome at extraction sites (67%) differed significantly from the prevalence rate for the spontaneous eruption of the PDC at untreated control sites (42%).

The space in the dental arch at the extraction site showed a continued decrease during the observation period and indicated a more pronounced reduction in perimeter of the upper arch in the older patients. Baccetti et al.[3] demonstrated that a significant mesial movement of the upper first molars occurs in all cases and therefore recommended space maintenance by space-holding devices. One could argue that this mesial movement of the upper first molars is indeed accentuated by eruption of the upper second molars, which occurred in the majority of the patients in the older group (12–14 y) in the current study.

No midline shift toward the extraction side was observed in any case. It appears that as long as the lateral incisors are in place, the extraction of a deciduous canine does not have an impact on the midline of the upper arch. This finding has clinical importance, ie, symmetrical extraction of the deciduous canines is not required for the purpose of keeping the midline at place.

Clinical Implications

If interceptive treatment outcomes after the extraction of deciduous canines in PDC cases are unsuccessful, whether because of the patient's age (older than 11 years) based on missed early diagnosis, an unfavorable position of the PDC in the palate, or resorption, surgical exposure with subsequent orthodontic appliance treatment should be considered. A previous study[22] estimated the average cost of surgical exposure with subsequent orthodontic appliance treatment of PDC at $4300 per case. This indicates a very high cost for society or for patients for the treatment of PDCs that do not respond to interceptive extraction of deciduous canines. Moreover, the patient's discomfort with surgery and subsequent long treatment with orthodontic appliances must be taken into consideration. This emphasizes the importance of both early diagnosis and early onset of interceptive treatment by extraction of the deciduous canine, not only to minimize cost but also to improve the odds of successful treatment outcomes.

CONCLUSIONS

- The extraction of the deciduous canine is an effective measure in PDC cases, but it must be done in younger patients in combination with early diagnosis, at the age of 10–11 years.
- Maintenance of the perimeter of the upper arch is an important step during the observation period, and the palatal arch as a space-holding device is recommended.

- No midline shift toward the extraction side was observed in any patient.

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