Systematic Review Article

Extraction of primary canines for interceptive orthodontic treatment of palatally displaced permanent canines: *A systematic review*

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ABSTRACT

Objective: To determine whether the successful management of palatally displaced permanent canines (PDCs) can be achieved by the interceptive extraction of primary maxillary canines.

Materials and Methods: Digital databases (Medline, Scopus, Web of Science, and Cochrane) were searched to retrieve articles published from 1952 to April 2016. The university librarian developed search strategies for each database. Two calibrated reviewers independently reviewed potentially related titles and abstracts. Papers meeting the inclusion and exclusion criteria were read in full. The selected articles were evaluated and scored according to methodological quality criteria.

Results: Four randomized clinical trials (RCTs) were included in the systematic review. Compared with two older studies, two more recent RCTs were found to have better study designs, were better conducted, and involved better reporting of the results. The included studies compared intervention groups (children with PDCs undergoing extraction of primary canines) with controls (subjects with PDCs but no primary canine extractions). In three of the four studies, the interceptive extraction of primary canines facilitated eruption of PDCs in more than 65% of cases. Overall, the intervention groups had a markedly higher incidence of successful eruption of PDCs (50%–69%) compared with the control groups (36%–42%).

Conclusions: Based on the available evidence, it is reasonable to conclude that eruption of PDCs can be facilitated by extraction of primary canines. However, further high-quality, randomized clinical trials are warranted in other population groups. It is hoped that this study will help orthodontists make evidence-based decisions about clinically managing PDCs. (*Angle Orthod.* 2017;87:878–885.)

KEY WORDS: Palatally displaced canine; Interceptive orthodontics; Systematic review

INTRODUCTION

Permanent canines are the secondmost commonly impacted teeth after third molars, and almost 1%–3% of the population has been found to have impacted maxillary canines.[1,2] In about 85% of cases with impaction, maxillary canines are palatally displaced.[3] Genetic predisposition and several other factors are implicated in the etiology of palatally displaced maxillary canines (PDCs).[4] The management of these clinical problems may require interdisciplinary approaches in addition to substantial participation by orthodontists.[5] Complications resulting from PDCs include loss of space in the dental arch, displacement and resorption of adjacent roots, and formation of cysts in rare cases.[6] Moreover, patients may undergo traumatic surgical exposure of PDCs, followed by prolonged and costly fixed orthodontic treatment.[7,8]

The management of PDCs may require surgically exposing the canine and applying a fixed orthodontic appliance to guide it into appropriate occlusion or extracting the primary canine to provide space for its successor to eliminate or minimize developing malocclusion, an approach called "interceptive orthodontics."[9] Early interceptive treatment can lessen the degree of developing malocclusion and thus decrease the need for future orthodontic treatment of permanent

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Table 1. Search Strategy in Different Databases

Key Words	Databases	Number of Articles
(canine or cuspid) and (maxillary or palatal) and (impacted or unerupted or retained or ectopic or displaced) and (interceptive or extraction or removal)	Medline (Pubmed)	331
	Scopus	345
	Web of Science	190

teeth.[10] It can also minimize the time and cost of treatment in addition to improving self-esteem and patient satisfaction.[11]

Previously, Ericson and Kurol[12] reported that extraction of primary canines is the treatment of choice for impacted maxillary canines, as 78% of such cases resulted in normal occlusion. Several prospective studies[12–14] and a retrospective cohort study[10] have also shown that primary canine extraction facilitated the eruption of PDCs. Other studies have reported interceptive extraction of PDCs combined with orthodontic treatment (rapid maxillary expansion) or extraction of primary molars.[15–18] However, these studies varied considerably in their design, sample-size calculation, criteria for clinical examination, and outcomes.

Parkin et al.[19] conducted a systematic review in 2009 in which they were unable to provide reliable evidence to support the effectiveness of interceptive extraction of deciduous canines to manage PDCs. Later, Naoumova et al.[3] (2011) included two studies in their systematic review to determine whether extraction of primary canines helps prevent the impaction of permanent maxillary canines. However, robust evidence in favor of their hypothesis was limited. In 2012, Parkin et al.[20] considered two studies for their systematic review to determine whether complications of PDCs can be prevented via the extraction of primary canines. Due to the lack of reliable studies, the authors of these systematic reviews stressed the need for more clinical trials with high-quality methodology.[3,19,20] As a result, two recent randomized clinical trials reported the spontaneous correction of PDCs after the extraction of primary canines.[21,22]

The present systematic review summarized the relevant randomized clinical trials to provide reliable estimates of the efficacy of interceptive orthodontic intervention, specifically, to find out whether successful management of PDCs can be achieved by interceptive extraction of deciduous maxillary canines.

MATERIALS AND METHODS

The preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines were followed for the present systematic review (www.prisma-statement.org).[23]

Information Sources

Search strategies were developed and electronic databases including Medline (PubMed), Scopus, Web of Science, and the Cochrane Collaboration Oral Health Group's Trials were searched with the help of an experienced librarian through the University of Dammam library resources. Clinical trials listed in clinicaltrials.gov and www.who.int/trialsearch/ were also searched. Studies published between 1952 and April 2016 were eligible for inclusion in the present systematic review. The electronic search was coupled with manual searching. The reference lists of retrieved studies, both original and review, were carefully reviewed. In addition, citation searching was carried out by searching the citations of relevant studies in Google Scholar to find more studies on similar topics.

Search Strategy

The search strategy made use of Boolean operators with different key words. The key words included "canine," "cuspid," "maxillary," "palatal," "impacted," "unerupted," "retained," "ectopic," "displaced," "interceptive," "orthodontics," "primary," "deciduous," "treatment," "management," "extraction," and "removal" (Table 1).

Eligibility Criteria

The inclusion and exclusion criteria were established based on populations, interventions, comparisons, outcomes, and study designs (PICOS). Details of inclusion and exclusion criteria are given in Table 2.

Study Selection and Methodological Quality Criteria

Calibration for interexaminer reproducibility was carried out for two reviewers (N.N.A. and M.A.N.). Both reviewers independently reviewed the titles and abstracts of the articles for inclusion in the present systematic review. Disagreements about the inclusion of certain articles were resolved by discussion and mutual consensus. The articles that met the inclusion and exclusion criteria were read fully and evaluated for their quality based on methodological quality criteria (Table 3) adapted from the CONSORT statement,[24] Jadad quality assessment scale,[25] and previous similar studies.[3,20]

Each reviewer independently scored the selected studies and discrepancies in the scoring of studies were resolved through discussion. Each study received a score out of 11 points (Table 4). The studies

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria	No. of Articles Excluded (n = 860)
Randomized clinical trials or cohort studies that evaluated eruption of PDCs after interceptive extraction of primary canines	Studies not related to the objective of the present systematic review: cross-sectional prevalence studies. Studies of interceptive treatment without a control group. Stuies of adults or participants with previous orthodontic treatment. Studies evaluating surgical exposure of PDCs. Studies involving children with primary dentition.	532
Interceptive orthodontic treatment provided to unilaterally or bilaterally displaced palatal canines during late mixed dentition stage	Review articles, discussions, and critical summaries.	49
Clinical examinations were performed using radiographs and or cast models	Case reports, research reports, and case series. Animal studies.	240 39

were classified as good (>9 points), moderate (7–9 points), or poor (<7 points) in quality based on the scoring of the methodological criteria.

RESULTS

Study Selection

The flow diagram in Figure 1 illustrates the PRISMA process that was used to identify, screen, and select studies for inclusion in the present review. Searching through Medline, Scopus, and Web of Science retrieved about 866 articles. Duplicate articles (repetitions) were removed. Titles of the articles were read and those found unrelated to the topic of research were excluded, which led to the exclusion of 791 articles. The remaining 75 articles were selected and their abstracts were thoroughly read. This resulted in selecting 33 articles for complete reading, and the inclusion and exclusion criteria were applied to these papers. Finally, four articles met the inclusion and exclusion criteria, to which were applied the methodological quality criteria.

Table 3. Methodological Quality Criteria[a]

Sr No.	Items	Scoring
A	Design of randomized clinical trial	1
B	Eligibility criteria for study participants	1
C	Sample size determination	1
D	Details about clinical diagnostic criteria	1
E	Ethical considerations	1
F	Method of blinding	1
G	Methods and type of randomization	1
H	Description of recruitment period and follow-up	1
I	Withdrawals and dropouts	1
J	Clearly defined outcomes	1
K	Appropriate statistical analyses	1
	Total score	11

[a] Methodological quality criteria adapted from the CONSORT statement (24), Jadad quality assessment scale (25), and previous similar studies (3,20).

Characteristics of the Included Studies

Table 4 summarizes the characteristics of the four selected studies. The recent study by Naoumova et al.[21] found the highest prevalence (69%) of successful eruption of PDCs. In three of the four studies, interceptive extraction of primary canines facilitated the eruption of PDCs in more than 65% of cases. Overall, the intervention groups in the selected studies had a significantly higher incidence of successful eruption of PDCs (ranging from 50% to 69%) compared with the control groups (36%–42%).

Quality Assessment of Selected Studies

Table 5 presents the evaluation of the methodological quality of the four studies included in the present systematic review. The two recent studies[21,22] scored higher than did the two older studies.[26,27]

Risk of Bias

The risk of bias was assessed in the four selected studies using PRISMA guidelines.[28] Most studies were found to have a high risk of bias (Table 6).

The measures of effect size of published studies such as odds ratio, relative risk, and standardized mean differences are calculated in meta-analysis to report the strength of the relationship between intervention and control groups (two variables) and thus the effect of intervention.[29] Hence, due to the nature and inconsistencies of the data reported in the selected studies, it was not possible to perform a meta-analysis.

DISCUSSION

It was encouraging to find two recent studies[21,22] with better methodological rigor than previous studies[26,27] that were also included in similar systematic re-

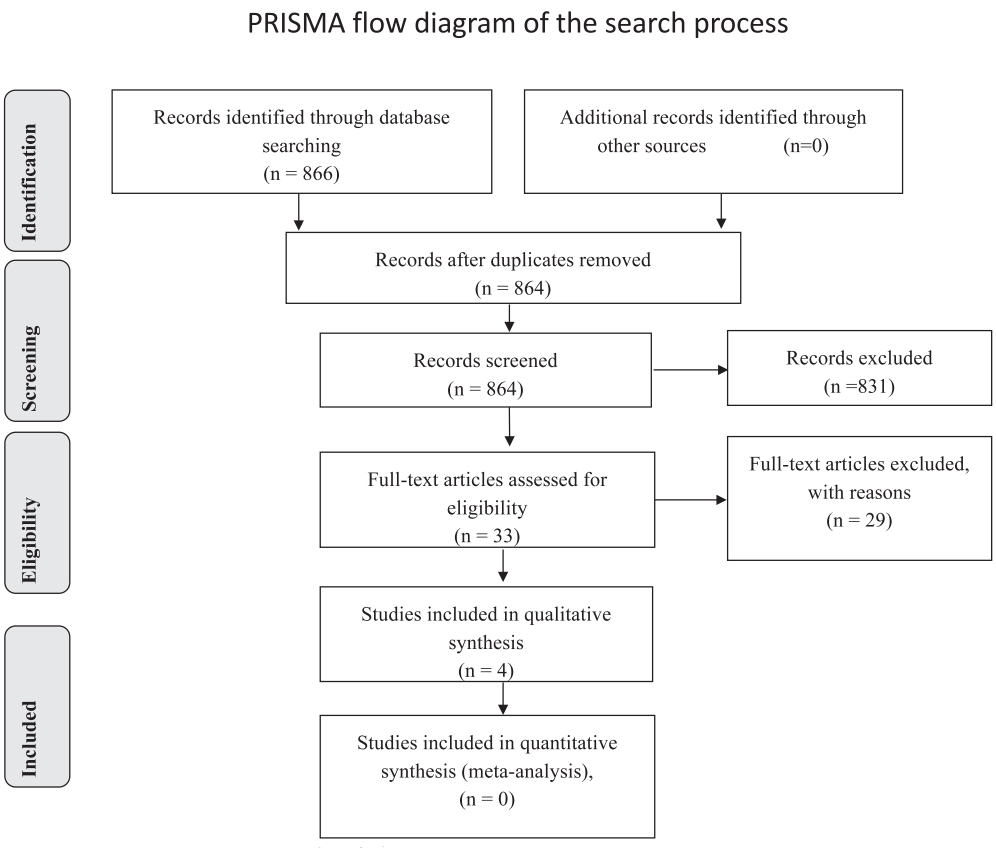

Figure 1. PRISMA flow diagram of the search process.

views.[3,20] Although a large body of high quality research is still lacking in the literature, it was reasonable to conclude, based on the available evidence, that the interceptive extraction of primary maxillary canines can be employed as an acceptable approach to facilitate the eruption of PDCs.

All studies included in the present systematic review compared the percentage of success or improvement between the intervention and control groups. Naoumova et al.[21] found that 69% of cases in the extraction group had spontaneous eruption of the permanent maxillary canines compared with 39% of the control group. Bazargani et al.[18] reported a success rate of 67% at the extraction sites and 42% at the control sites. Similarly, Baccetti et al.[26] found a significantly higher success rate of 65.2% in the treatment group, compared with 36% in untreated controls. Leonardi et al.[27] demonstrated that the 50% success rate in the extraction group was not significantly different from that in the control group.

Three studies[21,22,26] received ethical approval from the respective institutional review boards/committees, and these studies also specified that verbal or written consent was obtained from the subjects or their parents/guardians. Leonardi et al.[27] did not obtain ethical approval from an institutional review board; however, the authors received informed consent from the study participants or parents.

Sample size calculations were performed appropriately in two of the four studies.[21,22] The clinical diagnostic procedures used in the selected studies involved clinical and radiographic examinations at baseline and during and after the follow-up period. Bazargani et al.[22] also took impressions for study casts and included a single examiner who assessed the reproducibility of measurements performed every 3 months during the observation period. Similarly, Baccetti et al.[26] and Leonardi et al.[27] reported a high rate of reproducibility of measurements in their studies. Two calibrated examiners independently performed all the measurements in the study performed by Naoumova et al.[21]

The inclusion of a control group was adequately reported in three studies.[21,26,27] Bazargani et al.[22] recruited a sample of 24 consecutive patients with bilateral PDCs; one side of the maxilla served as the extraction site (treatment group), while the contralateral side as the nonextraction site (control group). Details of the randomization process were discussed in all four selected studies. Naoumova et al.[21] employed a block randomization method and concealment of allocation. Bazargani et al.[11] generated a computerized random-

Table 4. Summary of the Characteristics of Included Studies

Authors	Study Design	Definition of PDCs	Intervention	Participants' Gender & Age (y)
Naoumova et al., 2015 (21)	Randomized clinical trial	Not mentioned	Children with PDCs assigned to extraction & nonextraction groups	Boys = 8; girls = 16. 67 children aged 10–13 y.
Bazargani et al., 2014 (22)	Randomized clinical trial	Not mentioned	One side of maxilla with PDCs served as extraction site, while contralateral side was control site	Boys = 27; girls = 40. 24 children, aged 10–14 y
Baccetti et al., 2008 (26)	Randomized clinical trial	Not mentioned	Children with PDCs assigned to 3 groups: (1) extraction group, (2) extraction with headgear, & (3) control	Boys = 27; girls = 42. 69 children, mean age, 11.7 y
Leonardi et al., 2004 (27)	Randomized clinical trial	Not mentioned	Children with PDCs assigned to 3 groups: (1) extraction group, (2) extraction with headgear, & (3) control	Boys = 16; girls = 30. 46 children mean age, 11.6–12.2 y

ization list and briefly described the process of randomization. On the other hand, in the two older studies,[16,17] the methods of randomization were not adequately discussed and an unequal number of cases were allocated to the intervention and control groups.

Discrepancies in the reporting of information were found in the study by Leonardi et al.[27] The authors mentioned that there were 50 participants at the start of study and that 7 of them dropped out. However, they also stated that 46 participants were divided into three groups. Similarly, Baccetti et al.[26] reported that 75 participants were enrolled and 70 individuals completed the trial, as 5 subjects left the study. Later, they described the allocation of 69 participants into three groups. No such data inaccuracies were found in the two recent trials.[21,22]

The follow-up period varied among the four studies. Naoumova et al.[21] reported a follow-up period of 12 months, after which surgical exposure of the canine and orthodontic treatment were performed on those subjects who did not exhibit spontaneous canine eruption; thus, the total observation period was 24 months. The remaining three studies had an average follow-up period of 18 months, but the total observation period in the study by Leonardi et al.[27] was 48 months. Regarding dropouts, Baccetti et al.[26] and Leonardi et al.[27] mentioned five and seven dropouts, respectively, in their studies. However, neither the reasons for dropout nor their effects on the overall results were discussed. Naoumova et al. (2015)[21] investigated the effect on the resorption of adjacent teeth, but found no differences in control or intervention groups. Similarly, Bazargani et al., (2014)[22] observed no midline shift after unilateral extraction of the primary maxillary canine. Two previous studies did not report any side effects of intervention.[26,27]

Table 5. Methodological Quality of Selected Studies

Authors	Items for Methodological Quality Criteria											Total Score	Methodological Quality of the Study
	A	B	C	D	E	F	G	H	I	J	K		
Naoumova et al., 2015 (21)	1	1	1	1	1	0.5	1	1	1	1	0.5	10	Good
Bazargani et al., 2014 (22)	1	1	1	1	1	0	0.5	1	1	1	1	9.50	Good
Baccetti et al., 2008 (26)	1	1	0	1	1	0	0	0.5	0	1	1	6.5	Poor
Leonardi et al., 2004 (27)	1	1	0	0.5	0	0	0	0.5	0	1	1	5	Poor

Table 4. Extended

Methods/Measurement	Duration of Follow-up & Dropouts	Outcome
PDC was diagnosed as a canine without labial bulge on palpation but diagnosed radiographically when crown was palatally placed	Follow-up: 12 mo. Total observation period: 24 mo. Dropouts: none	Eruption of PDCs in 69% of cases in extraction group. Eruption of PDCs in 39% of cases in control group
PDC was diagnosed as a nonpalpable canine bulge & by using panoramic radiograph	Follow up: 18 mo. Dropouts: none	Eruption of PDCs at extraction sites was 67%. Eruption of PDCs at control sites was 42%
PDC was diagnosed through panoramic & periapical radiographs as palatally placed permanent canine in maxilla	Follow-up: 18 mo. Dropouts: 5	Successful eruption of PDCs in 65.2% of cases in extraction group. Successful eruption of PDCs in 36% of cases in control group. Successful eruption of PDCs in 87.5% of cases in extraction group with headgear.
Intraosseous palatal position of permanent canines was diagnosed as PDCs using panoramic & periapical radiographs	Follow-up: 18 mo. Total observation period: 48 mo. Dropouts: 7	Eruption of PDCs in 50% of cases in extraction group; not significantly different than controls. Successful eruption of PDCs in 80% of cases in extraction group with headgear

All the studies in the present systematic review had more than single outcomes. Naoumova et al. (2015) investigated whether extraction of the primary canine facilitated the eruption of the palatally displaced canine and also evaluated the root resorption of teeth adjacent to PDCs.[21] Two outcomes were evaluated in two studies conducted by Baccetti et al. (2008) and Leonardi et al. (2004).[26,27] Authors of both these studies observed two interceptive methods for managing PDCs, that is, extraction of the deciduous canine alone and extraction of the deciduous canine along with using cervical pull headgear. Bazargani et al., (2014) analyzed three main outcomes in their randomized clinical trial.[22] They evaluated the (1) effect of extraction of the primary canine on the successful eruption of PDCs, (2) age of patients appropriate for interceptive treatment, and (3) impact of unilateral extraction of the primary canine on midline shift. In addition, included studies did not report confounding factors that could affect the results.

Some studies were not included in the present systematic review because they did not fulfil the inclusion and exclusion criteria. However, those studies reported that most cases of PDCs achieved a normal eruptive position after extraction of deciduous maxillary canines.[12,13,30,31] It is hoped that the present systematic review will help clinicians and orthodontists make informed decisions about the management of PDCs by interceptively extracting primary canines, preferably in children aged 10–11 years, as reported by Bazargani et al.[22]

Limitations

The main limitation of this review was the inclusion of two older studies[26,27] that were of insufficient quality due to a lack of methodological rigor, including inadequate information about the selection of participants and sample size calculation, heterogeneity in study designs, and inconsistency in outcome definitions. These two studies[26,27] were performed in Italy

Table 6. Assessment of Bias Risk

Randomized Clinical Trial[a]	Concealment of Randomization	RCT Stopped Early	Blinding of Patients	Blinding of Caregivers	Blinding of Data Collectors	Blinding of Outcome Assessors
Naoumova et al., 2015 (21)	Yes	No	No	No	No	Yes
Bazargani et al., 2014 (22)	No	No	No	No	No	No
Baccetti et al., 2008 (26)	No	No	No	No	No	No
Leonardi et al., 2004 (27)	No	No	No	No	No	No

whereas the two more recent trials[21,22] were conducted in Sweden, and all four studies recruited subjects of Caucasian ancestry. This might limit the generalizability of our findings to individuals from different regions of the world. Therefore, high-quality randomized clinical trials to investigate the efficacy of interceptive extraction of the deciduous canine for PDCs involving different population groups are necessary. Moreover, an evaluation of the complications of the interceptive method, patient satisfaction about this treatment modality, and its associated financial expenses should also be carried out.

CONCLUSIONS

- Based on the currently available body of research, it is reasonable to conclude that the eruption of PDCs can be facilitated by the extraction of primary canines.
- Although evidence about the efficacy of extracting deciduous canines for the successful management of PDCs is mounting, there is still a need to conduct further high-quality, randomized, clinical trials recruiting different population groups.
- It is also important to evaluate the side effects and a cost analysis of this procedure.

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