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A systematic review of the interceptive treatment of palatally displaced maxillary canines

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SUMMARY The aim of this study was to assess whether interceptive treatment in the mixed dentition prevents impaction of palatally displaced canines (PDC) by systematically reviewing the literature.

A literature search of PubMed, the Cochrane Library electronic databases, and Scopus was performed covering the period from January 1966 to May 2009. The inclusion criteria were mixed dentition with unilateral or bilateral PDC, randomized controlled trials (RCT), prospective and retrospective studies with untreated controls, and clinical trials comparing at least two treatment strategies. Three reviewers selected and extracted the data independently and evaluated the quality of the studies. Inter-examiner reliability was measured using the intraclass correlation coefficient (ICC).

The search strategy resulted in 686 articles, of which two met the inclusion criteria. Because of the unequivocal results and heterogeneity in the study methods, the scientific evidence was too weak to fully evaluate the effect that interceptive treatment might have on PDC and which treatment modalities are most effective. The quality of the studies was rated as low because of inadequate sample selection and deficient description of sample size, confounding factors, uncertainty of randominization, and no blinding in measurements. The ICC value for total scores was >0.80, e.g. perfect agreement.

To obtain reliable scientific evidence as to whether interceptive treatment prevents impaction of PDC and which treatment modalities are the most effective, better controlled and well-designed RCTs are needed. Future studies should also include assessment of patient satisfaction and pain experience as well as analysis of the costs and side-effects of treatments.

Introduction

The maxillary canines usually emerge at the mean age of 10.5 years in girls and 11.5 years in boys, with individual variation of 3–4 years (Hägg and Taranger, 1986; Shapira and Kuftinec, 2001). In 2–3 per cent of the Caucasian population, these teeth fail to erupt and become impacted, which is defined as obstruction by hard or soft tissue structures and/or an ectopic eruption pattern (Thilander and Myrberg, 1973). Other definitions that are used in literature are: ectopic or displaced, meaning an abnormal position that may result in tooth impaction (Hitchin, 1956). The aetiology of the impacted canines is obscure and probably multifactorial (Thilander and Myrberg, 1973; Peck *et al.*, 1994; Pirinen *et al.*, 1996; Becker *et al.*, 1999).

Early preventive measures in the mixed dentition for palatal canine impaction are desirable, due to the risk of root resorption of the neighbouring permanent incisors. Such resorptions have been reported to occur in 47 per cent of subject in the age range of 10–13 years (Ericson and Kurol, 1987; 1988a,b; 2000).

Several studies have been carried out concerning interceptive treatment of palatally displaced canines (PDC; Ericson and Kurol, 1988a,b; Power and Short, 1993; Jacobs, 1996; Bruks and Lennartsson, 1999; Leonardi *et al.*, 2004; Ngan *et al.*, 2005; Baccetti *et al.*, 2008). However, a considerable variation in diagnostic tools, study designs, sample sizes, and research approach has produced results and conclusions that are sometimes conflicting and may be difficult to compare and interpret. Therefore, review articles are beneficial. Even if many reviews (Bishara, 1992; Kuftinec and Shapira, 1995; Rupp, 1997; Richardson and Russell, 2000) are well designed, they are often biased due to lack of formal methodology and inclusion criteria. In view of this and because evidence-based medicine has grown in importance (Evidence-Based Medicine Group, 1992), a systematic review of the present knowledge seems desirable. Recently, a systematic review was published reporting quantitative data on the outcome of the correction of PDC by extracting the primary canine (Parkin *et al.*, 2009). However, no previous systematic review has focused on the interceptive treatment of PDC, overall, without any restrictions on the therapy itself, and which treatment is the most effective.

Therefore, this systematic review was undertaken to answer the following questions: can interceptive treatment in the mixed dentition prevent impaction of PDC? Which

treatment modality is the most effective regarding total treatment time, side-effects, and cost? How do patients experience subjectively different treatment procedures and pain during treatment?

Materials and methods

Search strategy

The strategy for undertaking this systematic review followed the guidelines from the National Health Service (NHS) Center for Reviews and Dissemination (2001). A computerized search was conducted using the Medline database (Entrez PubMed, www.ncbi.nlm.nih.gov), the Cochrane Collaboration Oral Health Group Database of Clinical Trials (www.cochrane.org), and Scopus (http://www.scopus.com). The search covered the period from January 1966 to May 2009. The terms used in the search were 'teeth*, tooth*, canine*, cuspid*, eyeteeth*, and eyetooth*' in various combinations with 'impact*, ectopic*, eruption abnormalities*, displace*, unerupt*, palatal*, and retain*.'

Furthermore, a quality analysis of the methodological soundness of the studies included in the review was performed.

Selection criteria

The inclusion and exclusion criteria are given in detail in Table 1. Interceptive treatment was defined as that between the ages of 10–13 years, allowing the maxillary PDC to resolve their unfavourable positions, to correct their path of active eruption, and to erupt spontaneously without further surgical intervention. All three authors, independently, assessed all article abstracts that appeared to meet the inclusion criteria, which were collected irrespective of the language in which they were published. The full article of the abstracts that met the inclusion criteria were ordered and read. In addition, the reference lists of the retrieved articles were checked for additional studies. Any inter-examiner conflicts were resolved by discussion to reach a consensus.

Data collection and analysis

The following data were collected: author, year of publication, study design, definition of PDC, materials, dropouts, measurements, treatment time, follow-up, success rate, side-effects, costs, patient satisfaction and pain experience, and author's conclusion. To document the methodological soundness of each article, a quality evaluation as well as external and internal validity were assessed independently for each study by the three authors. The studies were graded with a score of A–C according to pre-determined criteria (Table 2). Inter-examiner conflicts, regarding an article, were resolved by discussion to reach a consensus. Based on the evaluated studies, the final level of evidence for each conclusion was judged according to the protocol of the Swedish Council on Technology Assessment in Health Care (SBU) 2005 (Table 3), which is based on the criteria for assessing study quality from the Centre for Reviews and Disseminations in York (2001).

Table 1 Initial inclusion and exclusion criteria for the retrieved studies.

Inclusion criteria	Exclusion criteria
Interceptive treatment	Animal studies
Late mixed dentition with uni- or bilateral palatally displaced canine/s	Case reports and case series and preliminary reports
Randomized clinical trials or prospective, retrospective observational studies with concurrent untreated/normal controls	Treatment combined with extraction of permanent tooth/teeth or full-fixed appliances
Examination with radiographs and/or models	Treatment in the early mixed and permanent dentition: adults
Clinical trials comparing at least two treatment strategies without any untreated or normal control group involved	Reviews, discussions, and interviews
	Previous orthodontic treatment

Table 2 Criteria for grading of assessed studies.

Grade A—high value of evidence
All criteria should be met
Randomized clinical study or a prospective study with a well-defined control group
Defined diagnosis and endpoints*
Diagnostic reliability tests and reproducibility tests described
Blinded outcome assessment
Grade B—moderate value of evidence
All criteria should be met
Cohort study or retrospective case series with defined control or reference group
Defined diagnosis and endpoints
Diagnostic reliability tests and reproducibility tests described
Grade C—low value of evidence
One or more of the conditions below
Large attrition**
Unclear diagnosis and endpoints
Poorly defined patient material

*Outcome of treatment.
**Patients that are lost during the trial and not included in the analysis.

Table 3 Definitions of evidence level.

Level	Evidence	Definition
1	Strong	At least two studies assessed as level 'A'
2	Moderate	One study as level 'A' and at least two studies as level 'B'
3	Limited	At least two studies a level 'B'
4	Inconclusive	Fewer than two studies as level 'B'

Statistical analysis

Inter-examiner reliability was undertaken using the intraclass correlation coefficient (ICC), which is commonly used to measure agreement between two or more reviewers. Computed ICC values range from −1 (perfect disagreement) to +1, which occurs when assessments are in perfect agreement. In this study, the included articles were rated by three reviewers; therefore, a one-way random-effects model for ICC calculations was used. Ratings for ICC were <0.20 'slight agreement', 0.21–0.40 'fair agreement', 0.41–0.60 'moderate agreement', 0.61–0.80 'substantial agreement', and >0.80 'almost perfect agreement'.

Results

The search strategy in the Medline database resulted in 686 articles. After analysis according to the inclusion/exclusion criteria, two articles remained for inclusion. The reasons for exclusion and the number of excluded articles are listed in Table 4. Searching the Cochrane Collaboration Oral Health Group Database of Clinical Trials and Scopus or hand searching the reference lists did not result in additional articles other than those included from the Medline database. Therefore, only the articles from the Medline database are listed in Table 4.

Reliability of the assessments

For the quality grades of the included articles, the ICC value for total scores was >0.80, between the reviewers in assessing the data extraction.

Summarized data of the included studies

Summarized data of the two studies are shown in Table 5. Both studies had a randomized controlled trials (RCT) design and the treatment modalities: extractions of the primary canines alone or in association with the use of cervical-pull headgear were compared with a control group (Leonardi *et al.*, 2004; Baccetti *et al.*, 2008). In one of the studies, ethical approval and informed consent were declared (Baccetti *et al.*, 2008).

In both studies, intraoral radiographs and a dental pantogram (DPT) were used to diagnose and measure the PDC, but none of the studies clarified how they defined a PDC, when including the patients in the trial. Lateral cephalograms were used in both studies but for different aims: in one to assess the sagittal position of the upper first molar and in the other to assess the skeletal age before extraction of the primary canine. The observation period for the groups was 18 months in both studies. In one of the studies, all groups were followed-up for an additional 30 months after which successful or unsuccessful canine eruption was assessed (Leonardi *et al.*, 2004).

A successful outcome was defined in both studies as a full eruption of the permanent canine. The success rate was reported to be between 50 and 65.2 per cent in the extraction group, while in the extraction group followed by headgear treatment, the success rate was between 80 and 87.5 per cent, compared with the control group of 25 and 50 per cent.

Neither of the two studies reported any side-effects nor was a cost analysis performed. Furthermore, neither included information regarding patient satisfaction and/or pain experience.

Quality of the studies

The research quality and methodological standard were assessed to have a low value of evidence (grade C) for both studies (Leonardi *et al.*, 2004; Baccetti *et al.*, 2008). Therefore, no evidence-based conclusions could be drawn. The most obvious shortcomings were small sample sizes, problems of bias and confounding variables, lack of selection description, and definition of a PDC. Only one of the studies had a power analysis (Baccetti *et al.*, 2008), but no explanation was given to the underlying assumptions that led to the number; therefore, the power of the sample in the study was questionable. The other study had insufficient sample sizes, implying low power with high risk, to achieve insignificant outcomes in spite of true differences (Leonardi *et al.*, 2004). Furthermore, neither study discussed the possibility of a type-II error occurring. The selection description was not adequate due to unclear inclusion/exclusion criteria and the absence of a definition of a PDC. Both studies were stated to have RCT design, but lacked information regarding the randomization procedure for the groups and how the unilateral and/or bilateral cases were randomized; thus, the study designs were assessed to be prospective and not RCT. Furthermore, the number of patients in each group was not equal, which also questions randomization. The number of dropouts was given in both studies (Table 5), but descriptive information regarding the dropouts was missing. In addition, there was a discrepancy regarding the number of patients in both of the studies after the dropouts. One of the studies reported the follow-up

Table 4 Distribution of excluded articles.

Exclusion criteria	No. of excluded articles
Studies not concerning the objectives of this review (analysis of surgical techniques, treatment in the primary or permanent dentition, aetiological studies, objectives that do not follow this review, interceptive treatment without controls, prevalence studies, diagnostic tools, predictions for impaction, and complications if treatment is not done)	424
Animal studies	32
Case reports, case series, and preliminary reports	189
Review articles, discussions, and interviews	39
Total	684

Table 5 Summarized published data of the two studies included in this review.

Article	Study design	Definition of PDC	Material: size, gender, age (years), and dropouts	Methods/measurements	Observation time/ follow-up time	Success rate of canine/s erupted	Side-effects/cost/ patient satisfaction	Outcome/author's conclusion
Baccetti *et al.* (2008)	Prospective controlled clinical trial	Not declared	Σ 75 subjects Five dropouts EG**:** 23 (8 boys,15 girls) with 25 PDC Age: mean 11.7	Extraction of primary canine versus extraction of primary canine followed by cervical-pull headgear versus non-extraction	Observation: 18 months	Assessed after 18 months EG: 65.2%	Not declared	Extractions resulted in more than twice as successful eruption of PDC compared with CG. EHG was almost three times more effective than CG
			EHG: 24 (10 boys,14 girls) with 35 PDC Age: mean 11.9	DPT (Ericson and Kurol, 1988a,b) Periapical radiographs (double determination)	Follow-up: not declared	EHG: 87.5%		
			CG: 22 (9 boys,13 girls) with 26 PDC Age: mean 11.6	Lateral cephalograms (Björk and Skieller, 1983)		CG: 36.0%		
Leonardi *et al.* (2004)	Prospective controlled clinical trial	Not declared	Σ 50 subjects Seven dropouts	Extraction of primary canine versus extraction of primary canine followed by cervical-pull headgear versus non-extraction	Observation: 18 months	Assessed after 48 months	Not declared	No significant difference between EG and CG
			EG: 11 (5 boys, 6 girls) with 14 PDC Age: mean 11.6	DPT (Ericson and Kurol, 1988a,b)		EG: 50%		Significant difference between EG and EHG
			EHG: 21 (7 boys, 14 girls) with 35 PDC Age: mean 12.2	Periapical radiographs	Follow-up: 48 months from start, i.e. 30 months after the observation period	EHG: 80%		No significant differences between EG and EHG for time required for canine eruption
			CG: 14 (4 boys, 10 girls) with 26 PDC Age: mean 11.6	Lateral cephalograms (Baccetti *et al.*, 2002)		CG: unequivocal results (25% and/ or 50%??)		

EG, extraction group; EHG, extraction/headgear group; CG, control group; PDC, palatal displaced canine; and DPT, dental pantogram.

period (48 months) with information concerning the average time for complete eruption of the canine, which was 20 months (Leonardi *et al.*, 2004), while in the other study an unsuccessful outcome was assessed after 18 months of treatment (Baccetti *et al.*, 2008). The methods used to detect and analyse the treatment effects are well-known (Ericson and Kurol, 1988a,b). Both studies included a method error analysis and used appropriate statistical analysis, but the choice of statistical methods was not explained concerning the clustering of patients with bilateral PDC. None of the studies used blinding in the measurements.

Discussion

The aim of this systematic review was to answer questions on whether interceptive treatment in the mixed dentition prevents impaction of PDC, which treatment modality is most effective, and patient satisfaction and pain experience during these treatments. Besides covering randomized and controlled clinical trials, which is the scope of the Cochrane report (Parkin *et al.*, 2009), the present review also included prospective and retrospective observational studies with concurrent controls, as well as observational studies comparing different treatment modalities, which should not be ignored when assessing the scientific literature (Ioannidis *et al.*, 2001). To answer the aims of this trial, an exhaustive literature search was performed. However, no evidence-based conclusions could be drawn due to the few studies found and their unequivocal results. Moreover, the included studies had problems with insufficient or lack of sample selection description, no discussion of confounding factors, lack of blinding in measurements, and large differences between the groups at baseline.

Numerous methods and scales to incorporate quality into systematic reviews have been published and have been widely applied to various RCTs in medicine (Colditz *et al.*, 1989; Jadad *et al.*, 1996). However, many of the items suggested were clearly not applicable to this systematic review. Instead, the quality of the articles included in this trial was graded as low, moderate, or high, according to the protocol of SBU (2005; Table 3), which is based on criteria for assessing study quality from the Centre for Reviews and Disseminations in York (2001). Moreover, previous studies have reported the importance of using numerous databases when searching and selecting literature for systematic reviews (Chalmers and Altman, 1995; Suarez-Almazor *et al.*, 2000; Flores-Mir *et al.*, 2006). Therefore, more than one database was used to search and identify the articles for this trial. The search strategy resulted in 686 articles, but after analysis, according to the inclusion/exclusion criteria (Table 1), only two articles remained that qualified for the analysis. In both studies, the methods to detect and analyse the treatment effects are well-known. However, two-dimensional radiographs were used, and it remains to be evaluated whether this is a reliable method in determining the palatal position and severity of canine displacement. It is remarkable that neither study made any comment on this point, which could have affected the results. Moreover, precise information of the time when the DPTs were taken in both trials was lacking, which is useful when evaluating the results and must therefore be considered as a confounding variable.

The outcome or authors' conclusions differed between the two articles concerning interceptive treatment with extraction of a primary canine, while extraction of a primary canine followed by treatment with headgear, resulted in more successful eruption of the PDC. In one of the studies, it was not clear if the percentage of successful eruption in the control group was 25 or 50 per cent as different figures were given in different places in the article (Leonardi *et al.*, 2004). Therefore, it is not clear whether there were any significant differences between the extraction and control group in that study (Leonardi *et al.*, 2004). One reason for these conflicting results could be the disparity of the sample size. A sample size calculation, required to make the observed differences statistically significant, was stated in only one of the studies, but did not explain the underlying assumptions that led to the number (Baccetti *et al.*, 2008). Furthermore, the patients included in both studies were at dental age 8–13 years, which can lead to false diagnose of PDC, because between 5 and 9 years of age the canines tend to move palatally, with substantial movement in a buccal direction between 10 and 12 years (McSherry and Richardson, 1999).

The number of dropouts were reported in both studies, with a discrepancy regarding the number of enrolled patients after the dropouts. Descriptive information and the severity of canine displacement for the dropouts were not presented, nor were the results presented with or without the dropouts in the analysis. The selection description was inadequate in both studies with some unclear inclusion/exclusion criteria, e.g. how a PDC was defined when including patients in the trial was not mentioned. The authors did not explain why patients with multiple and/or advanced caries or aplasia were excluded, even though previous aetiological studies have shown that there is an association between aplasia and PDC (Thilander and Jakobson, 1968; Peck *et al.*, 1994; Pirinen *et al.*, 1996; Becker *et al.*, 1999). Neither of the studies had information regarding the malocclusion and crowding, except that crowding was an exclusion criteria in one of the studies (Baccetti *et al.*, 2008) and an inclusion criteria in the other (Leonardi *et al.*, 2004). In addition, it was not reported how crowding was measured and defined and the hypothesis behind using headgear in patients with a PDC was not stated. Patients were instructed to start using headgear after 3 (Baccetti *et al.*, 2008) and 6 (Leonardi *et al.*, 2004) months after extraction of the primary canine. Why the patients had to wait for the headgear therapy or if the results were judged from the start of the extraction or from the start of headgear wear was not described. Furthermore, neither of the studies reported the

method for randomization for the groups or how the unilateral and/or bilateral cases were randomized. Even though the studies were reported to have a RCT-design with randomized material, the number of patients and PDC in each group differed, which questions the study design. The severity of canine displacement in the three groups studied was stated to be similar, but the results show that inclination of the upper canine to the midline, the vertical distance from the occlusal plane, and the distance from the midline differed between the three group, before treatment, which could have influenced the outcome. Descriptive data on the measurements at the start and end of the trial were not presented in the study of Baccetti *et al.* (2008). Only comparisons of changes were included.

In one of the studies, the duration of the observation period was ambiguous; the follow-up period was reported to be either 18 or 48 months (Leonardi *et al.*, 2004). As the complete eruption of the canine varied widely, it would have been favourable to assess the treatment outcome for a longer than 18 months, as in the study of Baccetti *et al.* (2008).

Neither of the studies reported the use of blinding in measurement or analysis. Such studies are more likely to show the advantage an improvement has over a standard treatment method (Ioannidis *et al.*, 2001). It is difficult to use blind assessment in this type of study, but, for example, the extracted tooth and the bands in the headgear-treated group could have been concealed on the radiographs when the outcome of treatment was measured. The results of this quality analysis were somewhat disappointing and similar shortcomings of the study results have also been presented in another systematic review (Parkin *et al.*, 2009). Systematic reviews have become the cornerstone of evidence-based health care and are our most powerful tool in evaluating therapy, and the quality of the trial significantly affects the validity of the inferences. The results from this systematic review have highlighted valuable guidelines for future studies and show that there is a need for conducting well-controlled RCTs regarding the effectiveness of different treatment strategies and for assessing which treatment is most effective in the case of a PDC in the mixed dentition.

Conclusions

No evidence-based conclusions could be drawn due to the few studies identified, the heterogeneity in study design, and the unequivocal results. To obtain reliable scientific evidence, better controlled RCTs with sufficient sample sizes are needed to determine which treatment is the most effective for treating PDC in the mixed dentition. Future studies should also include analysis of cost and side-effects of the interventions as well as evaluation of patient satisfaction and pain experience during treatment.

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