

Rapid maxillary expansion for interceptive orthodontic treatment of palatally displaced canine: A systematic review



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Abstract

Aim The present systematic review aims to summarise the relevant randomised clinical trials and estimate the efficacy of interceptive orthodontic intervention, in particular if an interceptive treatment with rapid maxillary expansion could be successful in managing of palatally displaced canines (PDCs).

Materials and methods A search strategy was developed on electronic databases including Medline, Web of Science, Scopus and Cochrane Collaboration Trial from 1925 to 2019. Two reviewers independently reviewed the sources deciding for a full reading according to the inclusion and exclusion criteria. Methodological quality criteria were applied to the selected articles.

Results Three randomised clinical trials (RCTs) and one prospective longitudinal study were included in the systematic review. Generally, the intervention groups showed a higher incidence of successful eruption of PDCs (45.1% - 65.7%) compared with the control groups (13.1% - 13.6%).

Conclusions Based on the literature published, authors reached a reasonable conclusion that rapid maxillary expansion can facilitate the eruption of PDCs. Authors suggest to associate maxillary expansion with deciduous canine extraction or prevention of mesial movement of the upper first molars.

KEYWORDS Impacted canine; Palatal expansion; RPE; Interceptive treatment.

Introduction

Upper permanent canines are the most commonly impacted teeth excluding third molars [Ericson & Kurol, 1987; Kaczor-Urbanowicz et al., 2016]. The prevalence of this condition among the general population is approximately between 1% and 3%, with most of the cases presenting a palatal displacement [Bedoya & Park, 2009; Topkara & Sari, 2012]. The aetiology is multifactorial with a genetic predisposition, but also other factors are implicated such as missing laterals and dental-skeletal discrepancy [Becker & Chaushu, 2015a]. The treatment of palatally displaced canines often requires an interdisciplinary approach and coordination mainly between the orthodontist and the oral surgeon but sometimes also with periodontist and restorative dentist [Fabiani et al., 2017;

Garcovich et al., 2018]. The management of the treatment often requires firstly a fixed orthodontic appliance to create the appropriate space, the extraction of the deciduous tooth if present, surgical exposure and finally a careful traction from the appliance [Becker & Chaushu, 2015b]. Surgical exposure and consequent traction can be approached with two different techniques, open or closed, and the discussion on which one has the best outcome is still open [Becker & Chaushu, 2015b; Incerti-Parenti et al., 2016; Parkin et al., 2013]. The treatment can last several months more than a standard orthodontic therapy increasing the cost for the practice and the patient. It also has different complications including loss of space, displacement or root resorption (mainly upper laterals and first premolars), ankylosis and eruptive cysts [Kurol, 2006; Ucar et al., 2017].

Different interceptive treatments have been proposed to prevent the upper canine from impaction. The most common treatment was proposed by Ericson and Kurol [2010] and consisted in the strategic extraction of the deciduous canine. Different prospective studies and a systematic review confirmed the efficacy of this solution with an overall success rate ranging between 50%-69% compared with the 36%-42% of the control groups [Almasoud, 2017; Baccetti et al., 2008; Bazargani et al., 2014; Leonardi et al., 2004; Julia Naoumova et al., 2014]. Bonetti et al. [2011] in their study proposed the contemporary extraction of the deciduous canine and first molar stating that concomitant extractions proved to be more effective as a preventive approach to promote eruption of retained maxillary permanent canines positioned palatally or centrally [Alessandri Bonetti et al., 2011].

Other authors provided evidence of the combination of interceptive extraction with orthodontic treatments such as rapid maxillary expansion or extraoral traction [Burgueño Torres et al., 2015; Lanteri et al., 2018]. In particular rapid maxillary expansion is one of the most used orthodontic appliances worldwide in early mixed dentition to correct transverse discrepancy and enhance the upper arch development [Zuccati et al., 2013]. To date, there is no systematic review that evaluates the efficacy of rapid palatal expansion in preventing the impaction of upper canines.

The present systematic review aims to summarize the relevant randomised clinical trials and estimate the efficacy of interceptive orthodontic intervention, in particular if an interceptive treatment with rapid maxillary expansion can be successful in managing of PDCs.

Key words	Databases	N. articles
(canine or cuspid) and (maxillary or palatal)	Medline	435
and (impacted or unerupted or retained or ectopic or displaced) and (interceptive or extraction or removal or rpe or rapid or erp or expansion or expander)	(PubMed)	468
	Scopus	289
	Web of Science	

TABLE 1 Search strategy in different databases.

Materials and methods

For the present systematic review the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines (www.prisma-statement.org) were followed [Moher et al., 2009].

Information sources

The authors conducted a search strategy on electronic databases including Medline, Web of Science, Scopus and Cochrane Collaboration Trial and also clinical trials listed in clinicaltrials.gov and World Health Organization website. The electronic search was combined with a manual one. The reference lists of original studies and reviews were also controlled. Furthermore, Google Scholar database was used to carry out a citation searching to find more articles to review on the topic. The systematic search was performed with the help of an experienced technician of the University medical library. Studies published between 1925 and January 2019 were eligible for inclusion in the present systematic review.

Search strategy

The search strategy was performed using Boolean operators combined with different key words. The key words selected included "canine", "cuspid", "maxillary", "palatal", "impacted", "unerupted", "retained", "ectopic", "displaced", "interceptive", "extraction", "removal", "rpe", "erp", "rapid", "expansion" and "expander" (Table 1).

Eligibility criteria

The inclusion and exclusion criteria were established based on populations, interventions, comparisons, outcomes, and study designs (PICOS guidelines) (Table 2).

Study selection and methodological quality criteria

Two authors independently and carefully reviewed the titles and abstracts of the articles that emerged from the search strategy for the inclusion in the present systematic review. A calibration for inter-examiner reproducibility was set: in case of disagreement regarding the inclusion the two authors resolved by discussion and mutual consensus. The articles that met the inclusion and exclusion criteria were considered for

Sr No.	Items	Scoring
A	Design of randomised 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 analysis	1
	Total score	11

TABLE 3 Methodological quality criteria.

full-text reading. Their quality was evaluated using methodological quality criteria (Table 3) adapted from the CONSORT statement, Jadad quality assessment scale [Jadad et al., 1996], and previous reviews [Almasoud, 2017; J. Naoumova et al., 2011]. The selected studies were independently scored by the two reviewers. In case of disagreement, the scoring was assigned through discussion. Each article received a score out of 11 points based on the methodological quality criteria and classified as good if higher than 9 points, moderate if between 7 and 9 points and poor if lower than 7 points.

Results

Study selection

The systematic research through PubMed, Cochrane, and Web of Science retrieved 1,184 articles. Duplicate articles and repetitions were removed. In the screening phase, a total of 1,134 articles were excluded; 605 articles were excluded through title reading because regarding unrelated topic of research, 412 articles were excluded because they were review articles, discussions, and critical summaries. Other 65 studies were excluded because they were case reports, research reports, case series, and animal studies. A total of 50 articles were considered eligible for complete full-text reading and evaluable according to the inclusion and exclusion criteria. In the end, four articles met the inclusion and exclusion criteria and underwent the methodological quality criteria.

The PRISMA selection process was used to identify, screen, and select studies for inclusion in the present review (Fig. 1).

Characteristics of the included studies

The characteristics of the studies included in the final review are illustrated in Table 4. The most recent study is by Koutzoglou & Kostaki published in 2013 presenting a prospective longitudinal study. Two studies were published in 2011 by Armi

Inclusion Criteria	Exclusion Criteria	No. of Articles Excluded (total n. 1180)
Randomized clinical trials or cohort studies that evaluated eruption of PDCs after interceptive treatment with rapid maxillary expansion.	Studies not related to the objective of the present systematic review:	605
Interceptive orthodontic treatment provided to unilaterally or bilaterally displaced palatal canines during mixed dentition stage.	• cross-sectional prevalence studies. • Studies of interceptive treatment without a control group • Studies of adults or participants with previous orthodontic treatment. • Studies evaluating surgical exposure of PDCs. • Studies involving children with primary dentition.	
Clinical examinations were performed using radiographs and or cast models.	Review articles, discussions, protocol and critical summaries.	98
	Case reports, research reports, and case series.	412
	Animal studies.	65

TABLE 2 Inclusion and exclusion criteria.

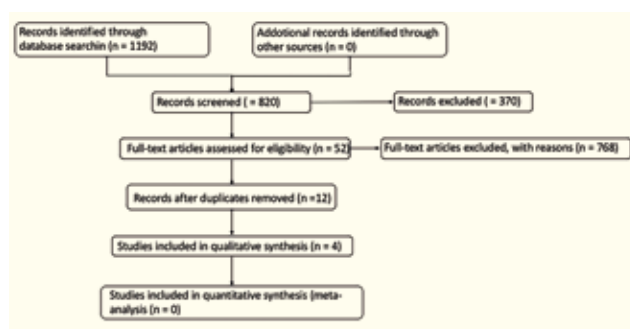


FIG. 1 Flow diagram of the search process.

et al. [2011] and Baccetti et al. [2011]. The oldest study was published in 2009 by Baccetti et al. [2009] These three studies are randomised controlled trials. In all the four studies, the intervention groups resulted more successful regarding the eruption of PDC (ranging from 45.1% to 85.7%) than the control groups (ranging from 13.1% to 36%).

Quality assessment of selected studies

Table 5 presents the evaluation of the methodological quality of the four studies included in the present systematic review.

Three studies were classified good [Armi et al., 2011; Baccetti et al., 2009, 2011] and one study was classified poor [Koutzoglou & Kostaki, 2013].

Risk of bias

The risk of bias was assessed in the four selected studies using PRISMA guidelines (Moher et al., 2009) (Table 6). Only the two studies from Baccetti et al. [2009, 2011] reported a blinding procedure for the investigators. For this reason, the risk of bias was considered generally high.

The data reported in these four studies are inconsistent, therefore it was considered as not possible to aggregate the results in a meta-analysis.

Discussion

Considering the huge amount of literature produced, only four studies passed the inclusion/exclusion criteria of this systematic review confirming a general lack of high-quality research. Based on the current evidence, authors reasonably conclude that rapid palatal expansion is an effective treatment in the prevention of PDCs (Fig. 2). All the studies evaluated the successful outcome of the canine eruption comparing it with

Authors	Study Design	Definitin of PDCs	Intervention	Participants' Gender and Age (y)
Baccetti et al., 2009	Randomised clinical trial	Not mentioned	Children with PDCs assigned to RME (Activation until a cusp to cusp relationship of the posterior teeth) or non-treatment group	Boys = 21 Girls = 39 60 children aged 7–9 y.
Baccetti et al., 2011	Randomised clinical trial	Not mentioned	Children with PDCs assigned to 4 groups: 1- RME + TPA + EC (7mm of active expansion) 2- TPA + EC 3- EC 4- control group	Boys = 48 Girls = 72 120 children aged 9.5–13 y
Armi et al., 2011	Randomised clinical study	Developmental dislocation of the upper canine [...] to a palat site often resulting in tooth impaction requiring surgical and orthodontic treatments	Children with PDCs assigned to 3 groups: 1- HP (12/14 h per day for 1 year) 2- RME + HP (7mm of active expansion + 6 months of retention + HP as group 1) 3- control group	Boys = 27 Girls = 33 60 children aged 11–12 y
Koutzoglou et al., 2013	Prospective Longitudinal study	The canines were considered impacted when their roots were fully developed but the teeth were still covered with bone or mucosa	157 PDCs, 150 in maxilla and 51 received treatment with RME	Boys = 46 Girls = 72 118 participants aged 11–46 y

TABLE 4 Summary of the characteristics of included study.

Methods/Measurement	Duration of Follow-up and Dropouts	Outcome
PDCs was diagnosed with panoramic and posteroanterior cephalograms	Follow-up: treatment group for 4.4 y and non-treatment group for 4.11 y Dropouts: 6 (3 for each group)	Eruption of PDCs in 65.7% of cases in treatment group Eruption of PDCs in 13.6% of cases in non-treatment group
PDCs was diagnosed with panoramic films	Total observation period: between 2 and 5 years Dropouts: 3	Eruption of PDCs in 80% of cases in RMA/TPA/EC group Eruption of PDCs in 79.2% of cases in TPA/EC group Eruption of PDCs in 62.5% of cases in EC group Eruption of PDCs in 27.6% of cases in control group
PDCs was diagnosed with panoramic and periapical radiographs	Follow-up: 18 months Total observation period: 18 months Dropouts: 4	Eruption of PDCs in 82.3% of cases in HG group Eruption of PDCs in 85.7% of cases in RME/HG group Eruption of PDCs in 36% of cases in control group
PDCs was diagnosed with panoramic film and CBCT	Follow-up: none Dropouts: none	Eruption of PDCs in 45.1% of cases in RMA group Eruption of PDCs in 13.1% cases in non-treatment group

TABLE 4 Extended

Authors	Items for Methodological Quality Criteria											Total score	Methodological Quality of the Study
	A	B	C	D	E	F	G	H	I	J	K		
Baccetti et al., 2009	1	1	0	1	1	0.5	1	1	1	1	1	9.5	GOOD (>9 points)
Baccetti et al., 2011	1	1	0.5	1	1	0.5	1	1	1	1	1	10	GOOD (>9 points)
Armi et al., 2011	1	1	0	1	1	0	1	1	1	1	1	9	GOOD (>9 points)
Koutzoglou & Kostaki, 2013	1	0	0	1	0	0	0	1	1	1	1	6	POOR (< 7 points)

TABLE 5
Methodological
Quality of Selected
Studies

Randomized clinical trial	Concealment of Randomisation	RTC stopped early	Blinding of patients	Blinding of caregivers	Blinding of data collectors	Blinding of Outcome assessors
Baccetti et al., 2009	Yes	No	No	No	No	Yes
Baccetti et al., 2011	Yes	No	No	No	No	Yes
Armi et al., 2011	Yes	No	No	No	No	No
Koutzoglou & Kostaki., 2013	No	No	No	No	No	No

TABLE 6 Assessment of bias risk.



FIG. 2 a) Orthopantomogram radiograph of a patient with palatally displaced canines; b) application of a rapid palatal expander; c) at the end of the interceptive treatment, the canines are in the dental arch and the patient undergoes a fixed appliance treatment.

a control group. In every study, the treatment group presents a success rate higher than the control one. In particular, in the study by Baccetti et al. [2009] the success rate of RPE group is 65.7% compared with 13.6% of the non-treatment group. In 2011 Baccetti et al. [2011] compared four groups: the highest success rate of 80% was obtained in the group treated with rapid maxillary expansion associated with transpalatal arch and deciduous canine preventive extraction, followed by 79.2% for the group treated with transpalatal arch and deciduous canine preventive extraction, compared with the 62.5% of deciduous canine preventive extraction only and the 27.6% of the non-treatment group. Armi et al. [2011] found similar data since the highest success rate was found in the rapid maxillary expansion in association with headgear 85.7%, compared with 82.3% of the headgear only and the 36% of the control group. These two studies suggest that the best outcome can be obtained when the rapid maxillary expansion is associated with an appliance that prevents the mesial movement of the first molar. The last study compared only the rapid maxillary expansion with a control group finding a success rate of the procedure of 45.1% compared with 13.1% of the control group.

The oldest three studies [Armi et al., 2011; Baccetti et al., 2009, 2011] obtained the approval from an ethical committee and a specific consent from the patients, while the study by Koutzoglou & Kostaki [2013] did not mention any of them. Furthermore, Koutzoglou & Kostaki [2013] did not apply specific inclusion/exclusion criteria since "all the patients who agreed to undergo therapy were included", increasing the risk of bias. Sample size calculation was partially reported only in the article by Baccetti et al. of 2011 [2011] in the calculation of the power analysis estimating a range between 25 and 40 subjects.

The diagnosis of PDCs in the four selected studies involved

a clinical and radiographic evaluation. All the four studies used a panoramic film, Baccetti et al. in 2009 used also a posteroanterior film, Armi et al. [2011] added a periapical film and Koutzoglou & Kostaki [2013] is the only study in which a cone beam computed tomography is used. Three studies also used dental casts for the evaluation of dentition [Armi et al., 2011; Baccetti et al., 2009, 2011]. The observation period was different in the four studies: Baccetti et al. in 2009 [2009] reported a follow-up of 4.4 years for the treatment group, Baccetti et al. in 2011 [2011] reported a total observation period ranging from 2 and 5 years, Armi et al. [2011] reported a follow-up of 18 months while Koutzoglou & Kostaki [2013] considered the observation period concluded with a complete maturation of the canine root.

Two studies recruited 60 children allocated in the different groups [Armi et al., 2011; Baccetti et al., 2009], while the other two recruited a larger sample of respectively 120 children and 118 patients [Koutzoglou & Kostaki, 2013]. Koutzoglou & Kostaki [2013] reported 150 maxillary PDCs and 51 of them received a treatment phase with RME. The first three studies reported some dropouts; 6 in the study by Baccetti et al. [2009], 3 in study by Baccetti et al. [2011] and 4 in the study by Armi et al. [2011], while no dropouts were observed by Koutzoglou & Kostaki [2013]. The reason for the dropouts was the same in all the studies because the patients moved to a different city or asked to be transferred to other orthodontists. Different outcomes were also considered: Baccetti et al. in 2009 [2009] and Baccetti et al. in 2011 [2011] considered only the eruption of PDCs in the dental arch, Armi et al. [2011] considered the eruption but also the changing in the sagittal position of the upper first molars on the superimposed tracing and finally Koutzoglou & Kostaki [2013] considered other than the eruption

the ankylosis event and the need of extraction.

Since rapid maxillary expansion is one of the most common and evidence-based interceptive treatment of maxillary transverse discrepancy [Mason et al., 2018a, 2018b; Spolaor et al., 2020], authors aimed to summarise its efficacy also in preventing upper canine inclusions. From this review it emerged that the rapid maxillary expansion alone is quite effective in preventing canine inclusion (45.1% - 65.7% of eruption versus 13.1% - 13.6% of the control groups), but it is even more powerful when associated with extraction of the primary canines or with other appliances (headgear of transpalatal arch) that prevent the mesial movement of upper first molars. In these cases, the successful outcome can reach and exceed 80%. Authors hope that the present systematic review can help orthodontists taking a proper decision to prevent maxillary canine impaction.

Limitations

The main limitation of this review is the heterogeneity of the study designs included. Furthermore, most of the studies associated rapid maxillary expansion to other procedures and only two studies considered it without other treatments. Moreover, there is a lack of data regarding the possible complications of these treatments, patient perspective and cost analysis.

Conclusions

Based on the literature, authors retain a reasonable conclusion that rapid maxillary expansion can facilitate the eruption of PDCs. Interceptive treatment of this condition reaches the best outcome when maxillary expansion is associated with deciduous canine extraction or prevention of mesial movement of the upper first molars. Authors also highlight the need to conduct further high-quality, randomised, clinical trials.

Competing interests

Authors declare that there is no competing interest

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