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Effectiveness of various interceptive treatments of palatally displaced canines in children between 8 and 14 years old

Systematic review

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Dissertação 2o Ciclo de Estudos conducente ao Grau de Mestrado em Ortodontia

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Eficácia dos vários tratamentos interceptivos de caninos retidos por palatino em crianças entre 8 e 14 anos de idade.

Revisão sistemática

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Trabalho realizado sob a Orientação de Prof Rui Manual Simões Pinto

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I am very grateful to my classmates Helia, Gisele and Catarina. You are amazingly friendly.

Abstract

Introduction: Maxillary canines play a very important esthetic and functional role in permanent dentition. This set of teeth is the second most frequently impacted after the third molar and most commonly ectopically erupting amongst the others. Untreated displaced canines often result in impaction. Consequently, causing various complications such as follicular cyst, ankylosis, impacted cuspid root resorption as well as resorption of the roots of neighboring teeth (67% chance of resorption for lateral incisors root and 11.1 % for central incisors roots). Orthodontic treatment of impacted canine intraosseous malposition is very challenging, which requires surgical exposure followed by a long duration orthodontics traction, with possible complications or failure to erupt. Early diagnostic could enable interceptive treatment option to facilitate successful eruption of palatally displaced canines and avoid long and traumatic treatment time and pathological complications.

Objective: Systematic review on effectiveness of various interceptive treatments of palatally displaced canines, such as: extraction of deciduous canine, extraction of deciduous canine and first deciduous molar, Rapid Maxillary Expansion (RME), Transpalatal Arch (TPA) and cervical pull headgear as well as combination of these approaches in children between 8 - 14 years of age. Furthermore, to determine whether mentioned interceptive treatments will increase chance of successful eruption of palatally displaced permanent canines.

Methodology: Digital repository: PubMed, Web of Science, Cochrane Library, Clinical Trials. Selected articles were in English and French published between January 2000 – June 2023. Which included randomized controlled trials, non-randomized control trials (RCT) and longitudinal studies on palatally displaced canines in children between 8 and 14 years of age, that did not previously have orthodontics treatment nor envisaged surgically assisted one.

Result: Eight articles were selected amongst which; seven were Randomized Controlled Trials (RCT) and one – a Prospective Longitudinal Study. Qualitative assessment was done for all the eight studies. The following interceptive treatment protocols were experimented: single deciduous canine extraction, double extraction of deciduous canine and primary first molar, additional orthodontic appliances treatment (RME, TPA, Cervical Pull Headgear) in combination with or without deciduous canine extraction. The successful eruption result rages between 50% to 97.3%, depending on the method, in comparison to 25 % - 48% in control groups.

Conclusion. Even though various interceptive treatments of palatally displaced cuspids demonstrate diverse results of effectiveness, due to important difference in sample sizes and, in two RCT, lack of control group or non-randomized allocation of subjects to the control group, makes it difficult to draw a meaningful evidence-based conclusions in two of reviewed studies. Based on the published data, the most notable result with strong evidence was reported in the subjects treated with deciduous canine extraction in combination with Cervical Pull Headgear usage. It would appear that, additional application of orthodontic forces restricts physiological mesial movement of the first maxillary permanent molars. Consequently, ensuring the space maintenance and/or improvement of the upper arch permitter by preventing maxillary distal segment from anterior sagittal displacement. Therefore, preserving necessary space for palatally displaced canine to erupt. Despite demonstration of significant success rate of palatally displaced canine eruption, additional well designed RCT with proper randomization and larger sample sizes would provide more evidence-based data.

Key words: “palatally displaced canines”, “palatally impacted canines”, “interceptive”, “preventive”, “spontaneous eruption”, “extraction”, “RME”, “headgear”.

Resumo

Introdução: Caninos maxilares permanentes têm um papel importante não só na estética mas também funcional na dentição permanente.Este é o segundo conjunto de dentes mais impactado, a seguir ao terceiro molar, e o que mais erupção ectópica tem de toda a dentição. Caninos retidos sem tratamento geralmente resultam em impactação, muitos podem causar diversas complicações como cisto folicular, anquilose, reabsorção do cúspido impactado bem como dos seus dentes vizinhos (66.7% chance de absorção das raízes de um incisivo lateral, 11% das raízes de um incisivo central). O tratamento da malposição intraóssea desse canino é bastante complicado, o que requer exposição cirúrgica seguido de um tração ortodôntico de longa duração, com possíveis complicações ou falha de erupção. Um diagnóstico precoce permite uma opção de tratamento interceptivo, o que facilita uma erupção com sucesso dos caninos retidos por palatino e evitar um tratamento longo e traumático com complicações patológicas.

Objetivos: Revisão Sistemática sobre a eficácia de diferentes tratamentos de caninos retidos por palatino, tais como: Extração do canino decíduo e primeiro molar decíduo, Expansão Maxilar Rápida (RME), Arco Transpalatal (TPA) e aparelho extrabucal com tração baixa, tal como qualquer combinação destes procedimentos, em crianças entre os 8 e 14 anos de idade. Para além disso, determinar se os estes tratamentos interceptivos aumentam as chances de erupção espontânea de cúspides permanentes retidos por palatino.

Metodologia: Repositório digital: PubMed, Web of Science, Cochrane Library, Clinical Trials. Os artigos selecionados encontram-se em inglês e francês, publicados entre janeiro 2000 e junho 2023. Estes incluem ensaios clínicos randomizados, ensaios clínicos não-randomizados (RCT) e estudos longitudinais em caninos retidos por palatino em crianças entre 8 e 14 anos de idade, que não tiveram tratamento ortodôntico anterior nem é previsto ser assistido cirurgicamente.

Resultado: Foram selecionados oito artigos, dentro dos quais, sete eram ensaios controlados randomizados (RCT) e um estudo prospectivo longitudinal. A análise qualitativa foi feita para todos os oito estudos. Os seguintes protocolos de tratamento interceptativo foram estudados: extração única de canino decíduo, extração dupla de canino decíduo e primeiro molar decíduo, tratamento com aparelhos ortodônticos adicionais (RME, TPA, Cervical Pull Headgear) em combinação com ou sem extração de canino decíduo. O resultado da erupção com sucesso varia entre 50% a 97,3%, dependendo do método, – em comparação, com 25% - 48% nos grupos de controle.

Conclusão: Mesmo que vários tratamentos interceptativos de cúspides retidos palatinamente demonstrem resultados diversos de eficácia, devido à importante diferença nos tamanhos das amostras e, em dois RCT, falta de grupo de controlo ou alocação não randomizada de indivíduos para o grupo de controlo, torna-se difícil traçar conclusões significativas baseadas em evidência em dois dos estudos revisados. Com base nos dados publicados, o resultado mais notável baseado em evidências foi relatado em indivíduos tratados com extração de caninos decíduos em combinação com o uso de aparelho extrabucal com tração baixa. Parece que a aplicação adicional de forças ortodônticas restringe o movimento mesial fisiológico dos primeiros molares superiores permanentes. Consequentemente, garantir a manutenção do espaço e/ou melhoria do arco superior permite evitar que o segmento distal da maxila tenha deslocamento sagital anterior. Portanto, preservando o espaço necessário para a erupção do canino retido por palatino. Apesar da demonstração de taxa de sucesso significativa de erupção canina deslocada palatinamente, um RCT adicional bem desenhado com amostras aleatórias adequadas e tamanhos amostrais maiores, forneceriam mais dados baseados em evidências.

Palavras-chave: “caninos retidos por palatino”, “caninos impactados por palatino”, “interceptivo”, “preventivo”, “erupção espontânea”, “extração”, “RME”, “headgear”.

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LIST OF ABREVIATIONS

PDC: palatally displaced canine

PIC: palatally impacted canine

BDC: buccally displaced canine

RME: rapid maxillary expansion

TPA: transpalatal arch

EG: extraction group

SEG: single extraction group

DEG: double extraction group

EHG: extraction and cervical pull headgear

CG: control group

1. INTRODUCTION

Displaced tooth is characterized by intraosseous developmental dislocation that often results in tooth impaction (1), (2). "Impacted tooth is a tooth that remains in intraosseous position and whose root is developed in excess of two- thirds of its expected final length, but which is not anticipated to erupt in a reasonable time" (3), (4).

Permanent maxillary cuspids present the highest incidence of impaction after the third molar (5). In addition, maxillary cuspids are the most frequently ectopically erupting teeth (6) (7). Considered to be cornerstone of the dental arches, permanent maxillary cusps play a very important in stomatognathic system. From functional standpoint this set of teeth perform ripping and tearing food as well as providing guidance during functional mandibular excursion by enhancing canine-guided occlusion. Where the vertical and horizontal overlap of the canine teeth causes disengagement of the posterior teeth in the lateral movement of the mandible (8). From esthetic standpoint maxillary cuspid crowns make up a part of a "golden proportion" in a smile, while their long roots with an average length of 27,31 mm (9) create canine eminence on the alveolar bone to provide support to the upper lip and nose alae.

According to various reports, prevalence of maxillary canine impaction ranges between 1,7 – 5,9% (10). However, the anomaly has unequal distribution amongst different ethnic groups. with 5,9% for Caucasians and 1,7% for Asians (11). In Caucasian population localization of maxillary canine in relation to the adjacent root of lateral incisor is buccal or distobuccal in 39% of cases, while 50 % is lingual or distolingual and 11% apical or between the lateral and central incisor roots (12). In contrast, amongst Asians, buccal displacement of the canine appears to be almost three times more prevalent than palatal (B:P = 140:46) (13).

Taking into consideration PICs only, prevalence in Japanese population is 0.27 % and 2,4% in Italian. Females to male's ratio 3:1 (11). Unilateral impaction is predominant, where the revealed to be more frequently affected (14).

Permanent maxillary cuspids are mesially angulated and buccally inclined. Located at the furthers distance from occlusal plane then other teeth, therefore, have the longest and the most torturous path of eruption until reaching their dedicated space in full occlusion (15). Calcification starts at the age of four month after birth lateral to apertura pirimormis. The trajectory of canine development has been calculated where it has been shown that the tooth overcomes a path in an average of 21,99 mm^2. With movement that occur at different stages of development in three planes with an average posterior movement of 11, 48mm, lateral of 2, 67mm and vertical 18, 56 of (16). Several different interferences of genetic, environmental, or local factors can occur during this long and torturous path of eruption which can result in displacement and often in further impaction of maxillary cusps. If palatially displaced maxillary canine is diagnosed before the age of chronological eruption, interceptive treatment can facilitate spontaneous eruption depending on their intraosseous localization taking into consideration: α-angle between the impacted canine and inter-incisor median line, perpendicular distance between the occlusal plane line and the tooth, and zone (1-5) of the displaced canine crown in relation to lateral and central incisors. (17). After the chronological age of eruption palatally displaced cuspid is considered to be impacted. In this case the only treatment option available would-be surgical exposure followed by orthodontic traction. In cases of impaction with favorable prognostics the treatment duration averages 17 months for canines displaced in zone 1 or 2, 20 months for those in zone 3, and 27 months for canines displaced in zone 4 or 5. Tooth position in a less favorable zone increases treatment duration (18). Therefore, early diagnosis and interceptive treatment can be beneficial in cases of displaced maxillary canines to facilitate spontaneous eruption before the displaced tooth becomes impacted and avoid long and traumatic treatment as well as potential pathological complications such as follicular cyst, ankylosis, root resorption or resorption of the roots of neighboring teeth (67% chance of resorption for lateral incisors root and 11.1 % for central incisors roots) (19).

2. MATERIALS AND METHODS

PRISMA protocol was followed for this systematic review. Inclusion criteria for selecting studies were the following: articles published between January 2000 until May 2023, randomized clinical trials, non-randomized clinical trials, longitudinal studies. Boolean operators combined with following key words were performed in the search: “maxillary canine”, “palatally displaced canines”, “palatally impacted canines”, “interceptive treatment”, “rapid maxillary expansion”, “headgear”, “extraction”.

Exclusion criteria; literature using animal studies, thesis, reviews, dissertations, and case studies, studies with children under 8 years old, studies with teenagers over 14 years old and adult participants, studies with surgical interventions, studies involving conventional orthodontics appliance, studies of participants with lip or/and palatal cleft, studies with tooth transposition, studies that did not differentiate between buccal and palatal canines in outcome, studies than included buccal canines.

Eligibility criteria:

PICO guidelines were followed for this systematic review.

Problem	Palatally displaced canine (PDC)
Interventions	Interceptive treatments; extraction of deciduous canine, simultaneous extraction of deciduous canine and first deciduous molar, RME, TPA, cervical pull headgear and combination of these approaches
Comparison	Efficacy of different interceptive treatment measures, combination of several interceptive treatments and control group that received no treatment
Outcome	Successful eruption of PDC

Table 1. PICO considerations

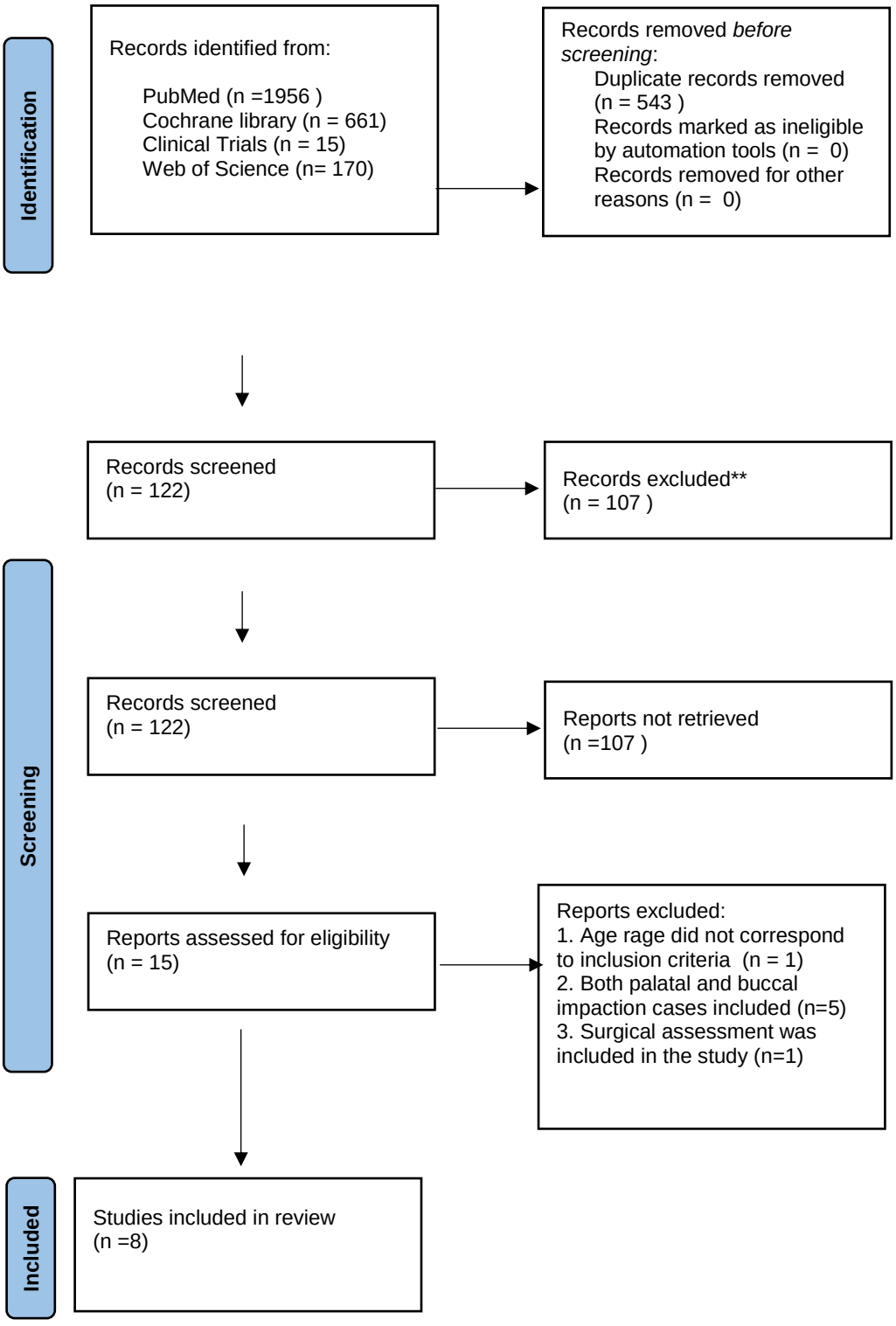

Figure 1. Flow diagram PRISMA

3. Results

During the search through PubMed, Cochrane Library, Clinical Trials, and Web of Science two thousand two hundred and fifty-nine (2259) records were identified, fifteen were eligible, amongst which: seven RCTs and 1 longitudinal study were chosen. The number of articles excluded after reading the title was two thousand hundred and thirty-eight (2138) because they were irrelevant to the subject. One hundred and twenty-two articles were screened (122), one hundred and seven (107) articles were excluded because they were reviews, case reports, case series, four were excluded because only abstract was available without the full article, 15 were eligible, however 7 were excluded for the following reasons: participant's age did not correspond to inclusion criteria, there was no differentiation between palatal and buccal displacement in the outcome. Afterall seven RCT and 1 longitudinal study corresponded to inclusion and exclusion criteria.

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Table 2. Date collected from the selected studies

Title/ Author/Date	Type of study	Purpose	Intervention /groups	Participants	Result
"Double vs single primary tooth extraction in interceptive treatment of palatally displaced canine" Sigud Hadler-Olsen et al., 2020	RCT	To compare the impact of primary canine and primary molar extraction with extraction of the primary canine only in cases of PDCs	Children with PDCs assigned to ONE of the following groups: 1)Double extraction (deciduous canine + deciduous molar) group (DEG) = 25 PDCs 2)Single extraction (deciduous canine) group (SEG)= 23 PDCs	32 Children / 48 PDCs Boys = 14 Girls = 18 Age = 9.5 – 13.5 y.o.	Successful eruption 1)DEG=64% 2)SEG=78%

Title/Author/Date	Type of study	Purpose	Intervention /groups	Participants	Result
"An RCT on treatment of palatally displaced canines with RME and/or a transpalatal arch" Tiziano Baccetti et al., 2010	RCT	To investigate the effect of RME and/or TPA therapy in combination with deciduous canine extraction on the eruption of PDCs	Children with PDCs assigned to ONE of the following groups: 1) RME + TPA + extraction (RME/TPA/EC) treated with bonded RME appliance with 0 ,25 mm /day until 7 mm expansion and 4–5-month retention period, after removal of RME appliance TPA was placed followed by extraction of primary canines= 40 participant/66PDCs 2) TPA + extraction (TPA/EC) = 24participants/36 PDCs 3) Extraction only (EC)=24 participants/34 PDCs 4) Control group (CG)=29 participants/42 PDCs	Children 117/178 PDCs Boys = 46 Girls = 71 Age = 9.5 – 13.0 y.o	Successful eruption 1) RME/TPA/EC= 80% 2) TPA/EC= 79.2% 3) EG =62.5% 4) CG= 27.6%

Title/Authors/Date	Type of study	Purpose	Intervention /groups	Participants	Result
"A randomized clinical study of two interceptive approaches to palatally displaced canines" Tiziano Baccetti et al., 2008	RCT	To evaluate the effectiveness of two interceptive approaches to palatally displaced canines; extraction of the primary canines alone or association of with the use of cervical pull headgear.	Children with PDCs assigned to ONE of the following groups: 1)Extraction of deciduous canine (EG)= 23 subjects/25PDCs 2)Extraction + cervical pull headgear (EHG) HG – started 3 months after the extraction =24 subjects/35 PDCs 3)Control group (CG)= 22subjects/26 PDC	Children = 69/86 PDCs Boys = 27 Girls = 42 Age = 8 – 13 y.o.	Successful eruption 1)EG= 65.2% 2)EHG =87.5% 3)CG=36%

Title/Authors/Date	Type of study	Purpose	Intervention /groups	Participants	Result
"Effect of interceptive treatment of deciduous canine on palatally displaced maxillary canine" Farhan Bazargani et al., 2013	RCT	To evaluate the effect of the extraction of the deciduous canines on PDCs.	Children whose maxilla was randomized into 2 sides: 1)Extraction side 2)Control side	Children = 24/48 PDCs Boys = 8 Girls = 16 Age =10 – 14 years old	Successful eruption 1)Extraction site=67% 2)Control side= 42%

Title/Authors/Date	Type of study	Purpose	Intervention /groups	Participants	Result
"Effect of RME and headgear treatment on the eruption of palatally displaced canines" Pamela Armi et al., 2010	RCT	To determine The effectiveness of orthodontics treatment finalized on the maintenance/ Improvement the upper arch perimeter to assist in the successful eruption of PDCs	Children with PDCs assigned to ONE of the following groups: 1)Cervical pull headgear (HG) used for 1 year, 12-14 hours per day = 17 subjects/25 PDCs 2)RME and cervical pull headgear (RME/HG) - Banded expander. 7 mm expansion with 6-month retention followed by use of cervical pull headgear = 21 subjects/30 PDCs 3)Control group (CG) = 22 subjects/26 PDCs	Children = 60/81 PDCs Boys = 27 Girls =33 Average age given = 11.1- 11.6 y.o.	Successful eruption 1)HG=82.3% 2)RME/HG=85.7% 3)CG=36%

Title/Authors/Date	Type of study	Purpose	Intervention /groups	Participants	Result
"Two interceptive approaches to palatally displaced canines: A Prospective Longitudinal Study" Maria Leonardi et al., 2004	Prospective Longitudinal Study	Evaluate effectiveness of two interceptive approaches to PDCs; extraction of deciduous canine alone and extraction followed by use of cervical pull headgear, who started the therapy during 6 months after the extraction and wore the headgear 12-14 hours per day. Untreated control group	Children with PDCs assigned to ONE of the following groups: 1)Extraction of deciduous canine (EG)=11 patients/14 PDC 2)Extraction of deciduous canine and cervical pull headgear (EHG)=21 patients/32 PDC 3)Control group (CG)= 14patients/ 16 PDC	Children = 43/62 PDCs Boys = 19 Girls =34 Average age = 11.1-11.6 y.o.	Successful eruption 1)EG=50% 2)EHG=80% 3)CG= 25%

Title/Authors/Date	Type of study	Purpose	Intervention /groups	Participants	Result
Extraction of the deciduous canine as an interceptive treat- ment in children with palatal displaced canines - part I: shall we extract the deciduous canine or not? Naoumova J et al., 2015	RCT	To analyse whether extraction of the deciduous canines facilitates eruption of the palatal displaced canines (PDCs), and to analyse root resorption in adjacent teeth caused by the PDCs.	Children with PDCs assigned to ONE of the following groups: 1)Extraction group (EG)= 45 patients/45PDCs 2)Control group =44 patients/ 44PDCs	Children=67/ 89/ PDCs Boys=27 Girls=40 Average age= 11.4±1.0 y.o.	Successful eruption 1)EG=69% 2)CG=39%

Title/Authors/Date	Type of study	Purpose	Intervention /groups	Participants	Result
Preventive treatment of ectopically erupting maxillary permanent canines by extraction of deciduous canines and first molars: A randomized clinical trial Giulio Alessandri Bonetti et al., 2009	RCT	To compare the effectiveness of single deciduous canine extraction and double deciduous canine extraction and first molar extractions in subjects with retained maxillary permanent canines positioned palatally or centrally in the alveolar crest.	Children with PDCs assigned to ONE of the following groups: 1)Single extraction (deciduous canine) (ECG) =17patients/ 28 PDCs 2)Double extraction (deciduous canine and deciduous first molar (ECMG)=20patientes/37 PDCs 3)Control group (CG)= 31 patient/53 PDCs	Children=68/ 118 PDCs Boys=34 Girls=34 Age 8-13 y.o.	Successful eruption 1)ECG=78.6% 2)ECMG=97.3%

4. Discussion

The possibility of interceptive treatment of PDC has been a popular debate subject amongst maxillofacial surgeons and orthodontists for many decades. For the first time, in 1988 S. Ericson and J. Kurol (23) reported that interceptive extraction of deciduous maxillary canines in children aged 10 – 13 years old resulted in 78% of successful eruption and normalization of the path of eruption (23). Both outcomes were combined, making it impossible to know the exact percentage of successful eruption. Also, absence of control group makes it difficult to draw a meaningful conclusion from the RCT. Nevertheless, the extraction protocol has been adopted by many clinicians throughout the world and inspired further investigations into the proposed measure, as well as experimenting with new strategies, such as simultaneous double extraction of deciduous canine and primary first molar, rapid maxillary expansion, transpalatal arch and cervical pull headgear treatment.)

Amongst different RCT aiming to treat PDCs preventively, the highest success rate ever reported is 97.3% was revealed by G.Bonetti et al. (2009) in double extraction (deciduous canine and primary first molar(ECMG)) group. This outcome was approximately 1.2 times higher than the single canine removal group (CEG) which proved to be 78.62%, demonstrating that single extraction is less efficient. In the beginning of the trial during clinical and radiographic evaluation stage, subjects who presented at least one of the following risks factors; palatally palpable canine bulge or absence of bulge, abnormal inclination, rotation of lateral incisor crown or α angle >25°, were randomly allocated to CEG or ECMG. Risk free patients were non randomly assigned to CG. Consequently, due to limitations of non-randomized CG, authors decided to use this group only to evaluate PDC intraosseous position changes in comparison to CEG and ECMG. Exact outcome percentage of successful eruption was not revealed in CG (24).

Similar treatment protocol of single extraction vs double extraction was performed in a RCT by S. Hadler-Olsen et al., (2020), where authors reported 64% of successful eruption for double extraction group and 78% for single extraction group. Consequently, isolated extraction of deciduous canine revealed to be 1.2 times more efficient, which contradicts G.Bonetti et al. (2009) outcome. Possibly it could be explained by a difference in sample size or duration of observational period. G.Bonetti et al. (2009) involved 68 patients/118 PDC, which were observed during 48 months till the end of the research. In contrast S. Hadler-Olsen et al., (2020), trial sample consisted of 32 patients/48 PDCs, amongst which 12 patients/ 14 PDCs were gradually eliminated during observational period at 6, 12, 18, 24 month clinical and radiographic follow-up, due to worsening of intraosseous position (increase in sector or angle) of PDCs. Alternative orthodontic treatment options were suggested to eliminated participants. (25)

Non randomized allocation of participants, who are not consider to be at risk by G.Bonetti et al. (2009) and absence of CG Hadler-Olsen et al., (2020), makes it difficult to determine the true evidence on the effectiveness of single extraction and double extraction as an interceptive measure. Result comparison between mentioned above two approaches show contradictive results.

Non randomized allocation of participants, who are not consider to be at risk by G.Bonetti et al. (2009) and absence of CG Hadler-Olsen et al., (2020), makes it difficult to determine the true evidence on the effectiveness of single extraction and double extraction as an interceptive measure. Result comparison between mentioned above two approaches show contradictive results.

J. Naumova, J Kurol et al. (2015) investigated isolated extraction protocol, in which they have reported 69% successful eruption rate in experimental group in comparison to 39% in control group. This outcome can be compared to the report of T. Baccetti et al. (2008) with 65.2% in EG vs 36% in CG and Baccetti et al. (2010) with 62.5% in EG vs 27.6 % on CG. F.Bazargani

et al. (2013), who included only subjects with bilateral displacement and used extraction side as an experimental and non-extraction as control; reported 67 % of success on the extraction side vs 48% on control one. The positive outcome of J. Naumova, J Kurol et al. (2015), Baccetti et al. (2008), Baccetti et al. (2010), F.Bazargani et al. (2013) ranges between 69% - 62.5%. However, M.Leonardi et al. (2004), regardless long (48 months) observational period, revealed only 50% of eruption, in EG in contrast with 25% in CG (26).

P.Armi et al.(2010), M. Leonardi et al.(2004), T. Baccetti et al.(2008),T. Baccetti et al.(2010); experimented using RME, TPA or cervical pull headgear treatment in combination with or without removal of deciduous canine. The highest success was achieved by T. Baccetti et al. (2008) in the experimental group with extraction followed by cervical pull headgear treatment (EHG), achieving 87.5% of successful result in comparison to isolated extraction (EG) with 65.2% and CG with 36% of eruption. Lateral cephalograms were used in the superimposition study according with the method of Björk and Skieller (1983) to evaluate the mesial movement of the upper molar. It was determined that cervical pull headgear prevented sagittal displacement of upper molar (0.24 mm mesial movement within 18 months period), therefore restrained distal segment form moving mesially maintaining thus preserving the space for PDCs. (27) On the contrary, subjects in EG and CG exhibited an average of 2.5mm in mesial displacement of upper permanent molars. This remarkable outcome exceeded 80% of success, in extraction combined with headgear (EHG), by M. Leonardi et al. (2004).

Baccetti et al. (2010) tried to evaluate the impact of RME, TPA and removal of primary canine. (RME/TPA /EC) experimental group was compared to TPA and extraction group (TPA/EG), EG and to CG. RME/TPA/EC and TPA/EG presented significantly high outcome of 80% (RME/TPA/EC) and 79.2 %(TPA/EG) in comparison 62.5 % in EG and 27.6% in CG. These results are comparable with 80% in cervical pull headgear group in Leonardi et al. (2004) and insignificantly lower than 85.7 % for RME/HG and 82.3% RME/HG in P.Armi et al.(2010) study. Primary goal of maxillary expansion was to relieve crowding and improve arch perimeter, because patients with PDCs do not exhibit maxillary constriction (28). Similar findings in correlation between increased upper arch perimeter and successful eruption were

reported by Hadler-Olsen et al., (2020). This confirms F.Bazargani et al. (2013) observations in the continued space decrease in the upper arch on the extraction side causing reduction in perimeter in older children group (12-14 y.o.). Authors hypothesized that it could occurred due to second molars eruption.

P.Armi et al. (2010) in RME/HG of 85.7 % compared to 82.3% in HG and 36% in the CG(29). Patients in RME/HG group were treated with banded rapid maxillary expanders to achieve 7 mm of expansion with 6-month retention period, after which they have used cervical pull headgear for one year 12-14 hours a day. The HG group, in which participants were using only this extraoral appliance for one year 12-14 hours a day. The purpose of this study was to maintain or improve the upper arch perimeter without deciduous canine extraction. Based upon the importance of keeping upper primary canines in situ, in case of unsuccessful outcome so that potential surgical intervention would allow to perform the tunnel technic, to which authors refer as a treatment of choice for an optimal long term periodontal success of concerned permanent canine (29). The distance of upper molar mesial movement was investigated by superimposing inicial and final lateral cephalograms, according to the method of Björk and Skieller (30). It was reported that an average amount of upper molar mesial displacement was 0.2 mm only, compared to 2.32mm in CG. Consequently, usage of HG was effective in restraining maxillary distal segment from mesial movement and maintained available space for PDCs.

The diagnosis of PDCs in reviewed studies was based upon clinical and radiographical evaluation. Clinical examination of canine bulge palpation, inclination, or rotation of the adjacent lateral incisor crowns. Radiographical analysis (panoramic radiographs) was performed in accordance with S. Ecicson and J. Kurol method (23) with three variables: α angle - between long axis of PDC and maxillary median line, d – perpendicular line distance from the tip of PDC crown to the occlusal plane, sector - positional relation to adjacent lateral and central incisors. Additionally, G.Bonetti et al. (2009) evaluated 2 stages of displaced cuspid root development with the method of S. Ecicson and J. Kurol; in the first stage the root was longer than the canine crown, in the second stage the root was shorter than the canine crown.

T. Baccetti et al. (2008) and P. Armi et al. (2010) added lateral cephalometric superimposition evaluation in accordance with A. Björk and A. Skieller method (30) to measure upper molar mesial movement. F. Bazargani et al. (2013) were the only authors, who assessed study casts to monitor changes of the maxillary midline as well as distance between distal contact point of deciduous canine and distal contact point of lateral incisor.

Baccetti et al. (2010) also analyzed lateral cephalograms for cervical vertebral maturation stage, according to Baccetti et al. (2005) (31) and root development according to the Nolla's method (1960). Which revealed that the 62% of subjects, whose canines failed to erupt were in pubertal stages CS3 or CS4 of CVM; also, those, whose canine roots were in stage 9 or above i.e.., with closed root apex (according to Nolla) appeared five times more with unsuccessful outcome. This data confirms F. Bazargani et al. (2013) findings, where group older patients (12-14 y.o) exhibited worse response to interceptive extraction than younger patients. Hadler-Olsen et al. (2020) used periapical radiographs applying Same Lingual Opposite Buccal (SLOB) rule and Lindauer et al., sectoral classification for impacted canines (32) and occlusal photographs on the upper arch to classify patients according to the dental arch space conditions amongst crowded, aligned and spaced, where subjects with excess space demonstrated higher prevalence of successful eruption.

5. Conclusion

Based on the results of accurately designed RCT with proper subject randomization and CG the most effective interceptive treatment has been proven to be the protocol of deciduous canine removal in combination with cervical pull head gear (87.5%). Non- extraction approach with the use of headgear on its own or together with RME have proven to be almost as efficient, with negligible (1.8% - 5.2%) difference in the outcome. While isolated extraction measures exhibit lower outcome that ranges between 69% - 62.5%. The usage of orthodontics appliance in experimental groups demonstrated:

- Improvement in upper arch perimeter
- Prevented upper arch distal segment from physiological mesial movement, which was estimated average of 2.5mm in EG and CG
- Maintained sufficient space for the PDC

As to simultaneous deciduous canine and primary first molar extraction protocol, even though the result in one study was remarkably high (97.3%), due the absence of proper randomization the risk of bias was increased, making it impossible to draw a clear evidence- based conclusion.

Further studies with larger sample size, proper randomization and inclusion of the CG are needed to provide better evidence in PDCs interceptive efficiency.

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