The clinical benefits of orthodontic treatment to pathologically migrated teeth: A systematic review

Gustavo H. Gameiro,[*] Michel Dalstra[†] and Paolo M. Cattaneo[†]
Department of Physiology, Federal University of Rio Grande do Sul, Porto Alegre-RS, Brazil[*] and Section of Orthodontics, Department of Dentistry, Faculty of Health Science, Aarhus University, Aarhus, Denmark[†]

Introduction: The present systematic review aimed to assess the evidence related to the periodontal benefits of orthodontic treatment of pathologically migrated teeth in combination with periodontal therapy with or without a regenerative procedure.
Methods: Electronic databases (PubMed, Embase and Cochrane) were searched up to March 21, 2019. Selection criteria included human studies in which pathologically migrated maxillary teeth were repositioned with orthodontic fixed appliances after periodontal therapy. Clinical trials not reporting a quantitative measurement of clinical attachment gain were excluded.
Results: The search strategy identified 90 relevant articles. After selection according to the inclusion/exclusion criteria, 15 articles qualified for the final analysis of which five were clinical trials and 10 were case series or reports. Five studies could be classified as providing a moderate level of evidence (33%), while 10 were classified as low levels of evidence (67%). None of the studies were classified as providing a high-level of evidence,
Conclusions: Based on the limited available evidence, orthodontic treatment had a fundamental role in the resolution of anterior pathologic tooth migration. Gains were seen in clinical attachment levels with accompanying improved aesthetic and functional final results. However, it was not possible to make any recommendations regarding the use of a specific regenerative procedure to improve the clinical results obtained by a combination of periodontal and orthodontic therapies. The most recurrent sources of bias were the absence of a control group and limited adequate examinations before and after treatment.
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Gustavo Hauber Gameiro: gustavo.gameiro@ufrgs.br; Michel Dalstra: michel.dalstra@dent.au.dk;
Paolo Maria Cattaneo: paolo.cattaneo@dent.au.dk

Introduction

Pathologic tooth migration (PTM) is defined as tooth displacement resulting from the disruption of forces that maintain teeth in a normal position with reference to the underlying skeleton.[1] The prevalence of PTM is high in periodontal patients, ranging from 30% to 56%.[2] Because of its significant negative impact with regard to a patient's self-esteem, a malocclusion generated from PTM is often the main motivation for adult patients to seek periodontal and orthodontic therapy.[2] Progressive spacing of the incisors is the most evident sign of a pathological change in the position of the teeth, and the minor spacing (< 1 mm) in the anterior teeth that sometimes occurs in the acute periodontal stages can be partially or completely reversed after conventional or surgical periodontal therapy.[3] However, moderate and severe cases require orthodontic intervention not only to correct, but also to prevent the aggravation of the PTM. It is well known that occlusal trauma and periodontitis can be mutually exacerbated in PTM, resulting in greater loss of attachment, extrusion, and mobility of the displaced teeth.[4]

The control of intrusion and torque during anterior tooth retraction and intrusion are the major concerns during orthodontic correction of PTM.[5,6] Although

these procedures are considered normal and not challenging when performed on teeth without severe alveolar bone loss, they can be a challenge when dealing with periodontally compromised dentitions.[6,7] A proper sequence of treatment planning when dealing with a periodontally compromised dentition should always be preceded by periodontal therapy, as the risk of periodontal breakdown when dental plaque control and periodontal health are not adequate is much higher.[6] Special attention should be given to the presence of angular bony defects, since these defects present a significantly higher risk of additional bone and tooth loss when compared with horizontal bone defects.[8]

The possible clinical benefits of orthodontic treatment in the management of infrabony defects are still a matter of debate. Although several clinical trials[5,9-16] and reviews[6,17,18] have been performed to investigate the effects of orthodontic treatment on periodontal defects, there are still unanswered questions related to the biomechanical aspects of moving a tooth with a reduced periodontium. In addition, the optimal timing of orthodontic treatment after periodontal therapy is unknown, as is the advantage of adding regenerative procedures during therapy.

Objectives

The aim of the present systematic review was to evaluate the published scientific research on orthodontic movement to correct pathologic tooth migration by considering the clinical and radiographic findings, the biomechanical aspects, the methodologic quality, and the risk of bias. The focused question was: "What are the clinical benefits of orthodontic treatment in the correction of pathologically migrated teeth?" The possible advantage of adding a regenerative procedure during periodontal therapy was also investigated, as well as the optimal timing of orthodontic treatment after therapy. According to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2009 checklist, Table I better outlines the questions that will be addressed with reference to participants, interventions, comparisons, outcomes, and study designs (PICO) in this study.

Material and methods

Protocol and registration

This systematic review was prepared according to the Cochrane Oral Health Group's Handbook for Systematic Reviews of Interventions (http://ohg.cochrane.org) and was registered with the number CRD42015027068 in the PROSPERO database (http://www.crd.york.ac.uk/PROSPERO).

Eligibility criteria

Two reviewers independently screened titles and abstracts for eligible papers. Subsequently, full-text papers that fulfilled the eligibility criteria were identified and included for assessment. The inclusion criteria required the studies to be in English, conducted on humans, and evaluating orthodontic intrusion using fixed appliances to correct pathologic tooth migration of maxillary anterior teeth. The results should have been evaluated by clinical quantitative measurements and by radiographic exams before and after treatment. The exclusion criteria were reviews, studies on suprabony defects, studies on furcation defects, studies on posterior teeth and studies on implants or prosthetic treatment.

No study mentioned the term 'aggressive' in the case reports. Considering that aggressive periodontitis, in its local and generalised form, is usually associated with first molars and incisors, and normally occurs at the age of puberty, it was considered that the studies included in the present review described chronic periodontitis.

Table I. PICOS format.

Component	Description
Population	Clinical studies that involved patients with pathologic tooth migration
Intervention	Periodontal therapy followed by orthodontic intrusion with fixed appliances
Comparison	Variables of orthodontic (segmented arch or continuous arch technique, force magnitudes, timing and duration of treatment) and periodontal (with or without regenerative procedure) therapies
Outcome	Clinical attachment level
Study design	Clinical trials, case series and case reports

The primary outcome measure was the gain in clinical attachment level, because it is a highly sensitive diagnostic tool and it is the primary outcome variable used in studies of periodontal patients.[19] The secondary outcomes included changes in probing depth and in alveolar bone area.

Information sources, search strategy, and study selection

Computerised and manual searches were performed in three electronic databases: PubMed, Cochrane, and Embase. The databases were searched for studies conducted in the period up to and including March 21, 2019. The structured search strategy was designed to include any published paper that evaluated the clinical effects of orthodontic intrusion on patients with pathologic tooth migration and/or infra-bony defects. The electronic search strategy included the following terms and combinations:

(orthodontics OR orthodontic) AND ((Pathologic tooth migration) OR "angular defect" OR "angular defects" OR "Infrabony defect" OR "Infrabony defects" OR "Infra-bony defect" OR "Infra-bony defects" OR "Intrabony defect" OR "Intrabony defects" OR "Intra-bony defect" OR "Intra-bony defects" OR "Infraosseous defect" OR "Infraosseous defects" OR "Intraosseous defect" OR "Intraosseous defects").

Data items and collection

The reviewers extracted data independently, using specifically designed data-extraction forms. For each included study, qualitative and quantitative information was extracted, including the year of publication, the numbers and ages of patients, treatment types and durations, method of outcome assessment, the authors' conclusions, and all information needed for the methodologic quality evaluation. Any disagreement was discussed to reach a common final decision.

Considering the lack of randomised clinical trials and the small number of clinical trials evaluating the benefits of orthodontic treatment related to PTM, case series and case reports were also included in this review.

Risk of bias/quality assessment in individual studies

The methodologic scoring system was based on a previous systematic review[20] and on a methods guide for assessing the risk of bias of individual studies in systematic reviews,[21] which are described in Table II. The methodologic quality scores were reported as percentages of the maximum achievable score (19 points for clinical studies and 17 points for case reports or series). A mean score less than 60%

Table II. Methodologic Scoring System.

Criteria assessed	Score
I. Study design (maximum score, 9 points)	
A. Type	Case report or series, 0 point; clinical studies, 2 points
B. Randomisation and control group	If present, 1 point
C. Sample size	Number of evaluated patients per group: <5, 0 point; 5 to ≤10, 1 point; >10 to ≤20, 2 points; >20 to ≤30, 3 points; >30, 4 points
D. Selection criteria	If the bone defects were clearly described, 1 point
E. Objective	If clearly formulated, 1 point
II. Methodologic soundness (maximum score, 7 points)	
A. Appliance type	If clearly described, 1 point
B. Force magnitude	If stated, 1 point; if controlled by a force measurement device, 2 points
C. Radiographic examination before and after treatment	Without a quantitative measurement, 0 point; With a quantitative measurement, 1 point
D. Measurement of clinical attachment level	If clearly described, 1 point
E. Timing of orthodontic treatment	If clearly described, 1 point
III. Data analysis (maximum score, 3 points)	
A. Statistical analysis	Appropriate for data, 1 point
B. Error of the method or repeated measures	If stated, 1 point
C. Data presentation	If any numerical measures stated, 1 point

indicated a low level of evidence; 60% to 70%, a moderate level of evidence; and more than 70%, a high level of evidence. The scoring system was adapted to include the evaluation of case series and case reports in a way that the scores were based on each study design. When some topics could not be reported due to an inherent limitation of that type of study (for example: the use of control group and statistical analysis in a case series or case report), that topic was marked as not applicable. This approach allowed a fair quality assessment when case reports are included in a Systematic Review.[21] The assessments for risk of bias were also performed, including an evaluation of the risk of selection, detection, attrition, and reporting biases for each study. As case reports were included in the present study, and as no RCTs were available, performance bias was not evaluated. Studies were categorised as having a low risk of bias if three or more domains were considered adequate, as having a moderate risk of bias if two domains were considered adequate, and as having a high risk of bias if only one domain was considered adequate.

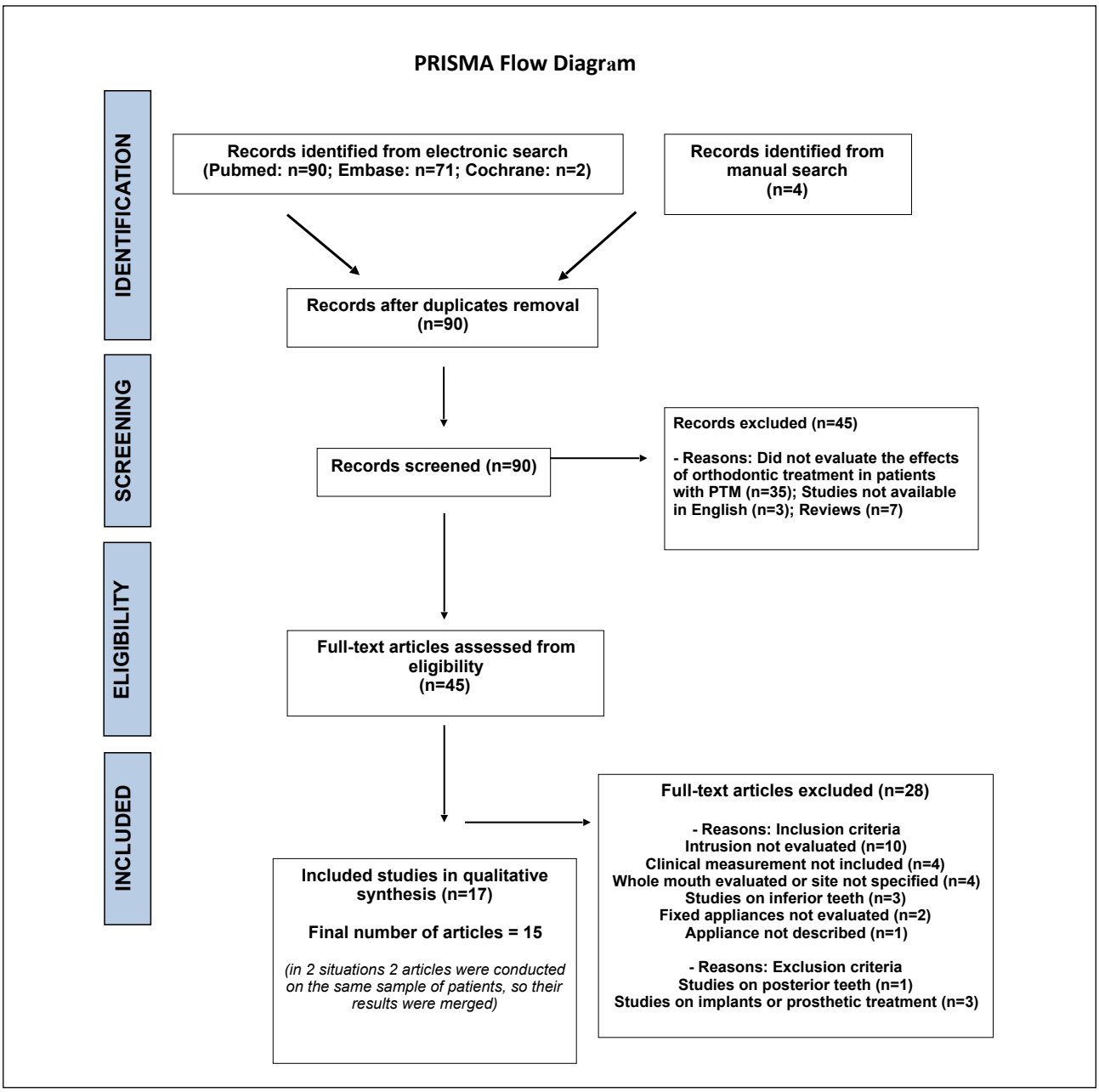

Figure 1. Flow diagram of the article selection process.

Results

A total of 90 articles were identified by the electronic and manual search. The PRISMA flow diagram[22] reports the overview of the article's selection process (Figure 1). In the first step of the screening process, 45 articles were excluded because they were determined to be irrelevant based on their titles and/or abstracts. The remaining 45 full-text articles were re-assessed, of which 24 articles were excluded because of failure to meet the inclusion criteria, and four articles were excluded after the application of the exclusion criteria. After the selection process, 17 full-text articles were included. By careful reading and comparison of the authors' name and the sample studied, it was found that the same sample of patients was repeated in two articles. This was confirmed by an email from the authors of these studies. Therefore, in both cases the two articles were treated as one article and consequently the results were combined. The final number of studies included in this review was 15 (Figure 1).

A summary of the main findings and data of the selected studies is reported in Table III (studies on orthodontic treatment and periodontal therapy without a regenerative procedure) and Table IV (studies on orthodontic treatment and periodontal therapy with a regenerative procedure). Detailed assessments of the methodologic quality and the risk of bias are reported in Tables V through VIII.

Discussion

The present discussion is divided into two main topics, describing firstly the mechanical and temporal aspects of orthodontic treatment and, secondly, the benefits of regenerative procedures during periodontal therapy.

The intrusion and retraction of the incisors is usually the logical solution to correct anterior pathologically migrated teeth, in relation to causative, aesthetic, and functional perspectives.[5,6] However, orthodontists need to be aware of the altered biomechanical conditions when dealing with periodontally compromised dentitions. Firstly, the centre of resistance in periodontally reduced teeth moves to a more apical position as progressive alveolar bone loss occurs. This requires specific adjustments in the torque–force ratio in order to avoid a larger moment and an uncontrolled tooth displacement during force application.[7] Secondly, the reduced bone levels and the smaller periodontal ligament volumes will cause the orthodontic forces to be distributed over a smaller surface area.[23] The increased loads could, therefore, give rise to greater bone loss. Thirdly, the increased loads may also cause or accelerate root resorption. Considering that excessive forces represent one of the main treatment-related aetiologic factors of root resorption,[20] the control of force levels has clinical significance in patients with alveolar bone loss. The present review has focused on a study of orthodontic intrusion, because this movement is usually associated with an increased risk of root resorption, independently of the orthodontic technique applied.[24] This is an obvious biomechanical consequence of incisor root shape. Given the tapered, essentially cone-shaped structure of the roots, pressure from the axial component of orthodontic forces will be maximised at the root apex.[25]

Twelve of the 15 studies included in the present review applied a segmented technique to intrude the pathologically migrated teeth,[5,9,10,13-16,26-30] and three used a continuous straight-wire appliance.[11,12,31] Six studies did not report the force values applied, and in the remaining nine studies, the forces ranged from 10 to 20 g per tooth. Although there is no evidence identifying the optimal force level in orthodontics, a recent study using a finite element method suggested a force reduction of approximately 30% in periodontally reduced teeth.[7] This reduction would avoid loads exceeding the levels that normally develop in a healthy periodontium. Three articles reported a lack of significant root resorption after orthodontic treatment, but the remaining articles did not evaluate this problem.

Relative to the optimal timing of orthodontic treatment after a pre-orthodontic phase of periodontal therapy, most studies preferred to initiate orthodontic treatment shortly after therapy. The orthodontic movement was initiated seven to 14 days after the periodontal surgery in seven studies[5,9,10,15,26,32,33] and after one month in one study.[30] Two articles (both related to a regenerative procedure) reported a delayed orthodontic start of one year after surgery.[28,31] The other articles did not report the time it took to initiate the orthodontic treatment after periodontal therapy. Given the heterogeneous methodologies applied in the studies, a direct comparison of the results was not possible, and therefore there was an inability to

Table III. Results of studies on orthodontic treatment and periodontal therapy without a regenerative procedure.

Study	Study design	Participants/tooth involved	Type of defect/ Pocket probing depth	Periodontal treatment	Orthodontic appliance/Force system	Timing of orthodontic treatment after periodontal therapy	Main findings
Melsen et al., 1989[5]	CT	30 patients aged 22 to 56y requiring intrusion (upper incisors)	3-wall/NA	SRP (a modified Widman flap operation was necessary in 15 patients)	4 types of appliances/ 10-20 g per tooth with Burstone appliance	1 week after surgery	Area of bony alveolus ↑ 6.8% Clinical crown length ↓ 0.5 to 1.0 mm
Steffensen & Storey, 1993[16]	CR	1 patient aged 46y (central incisor)	NA/ PPD 3 to 7 mm	SRP	Resin splint, elastics and utility arch/ 70 g for distal retraction	NA	Gain in bone coverage of 15% Gain in clinical attachment ≅ 4 mm
Rabie et al., 1998[13]	CS	2 patients aged 36 and 27y (upper incisors)	NA/ PPD 3 to 7 mm	SRP	Intrusion arch/10-15 g per tooth	NA	PPD ↓ to 3 mm Clinical crown length ↓ 0.5 to 1.0 mm
Re at al., 2000[15]	CT	267 patients aged 29 to 66y (204 in maxilla)	NA / NA	129 patients had surgical periodontal treatment with a modified Widman flap, and 128 patients had nonsurgical treatment	Segmented arch/ 10-15 g per tooth	1 week after	PPD ↓ ≅ 3 mm No differences between surgical and nonsurgical periodontal therapies
Cardaropoli et al., 2001[10] and Corrente et al., 2003[32]	CT	10 patients aged 33 to 53y (central incisor)	NA/ PPD≥ 6 mm at the osseous defect	Open-flap surgery to eliminate deep debris and granulation tissue.	Base arch or cantilevers/ 10-15 g per tooth	7 to 10 days after	Gain in marginal bone level of 2 mm PPD ↓ 4.35 mm Clinical crown length ↓ 1.05 mm
Re at al., 2002[29]	CR	1 patient aged 44y (central incisor)	NA/ PPD = 9 mm on mesial surface	Surgical treatment with a Widman modified flap to eliminate the deep periodontal infection	Cantilevers/ 10g for intrusion and distal retraction	1 week after	Gain in bone area of 4.8 mm^2 Gain in clinical attachment of 4.7 mm
Cardaropoli et al., 2004[9] and Re et al., 2004[33]	CT	28 patients aged 29 to 60y (central incisor)	NA/ PPD≥ 6 mm at the osseous defect	Open-flap surgery to eliminate deep debris and granulation tissue.	Base arch or cantilevers/ 10-15 g per tooth	7 to 10 days after	PPD ↓ 4.35 mm Gain in clinical attachment of 5.93 mm
Cirelli et al., 2006[11]	CR	1 patient aged 36y (central incisors)	NA/ PPD 3 to 7 mm	SRP	Straigth-wire/ forces NA	NA	PPD ↓ ≅ 2 mm Gain in clinical attachment ≅ 3 mm
Modoni et al., 2009[12]	CR	1 patient aged 47y (upper incisors)	NA/ PPD 4 to 10 mm	SRP	Lingual straigth-wire/ forces NA	NA	PPD ↓ to 4 mm Gain in clinical attachment ≅ 8 mm

CT: clinical trial; CS: case series; CR: case report; PPD: pocket probing depth; NA: not available; SRP: Scaling and root planning

determine which of the two strategies produced the best outcome. However, several experimental studies have shown the advantages of early orthodontic tooth movement after periodontal therapy, such as the favourable effects on the restraint of epithelial apical down-growth, a decrease pocket depth and an enhancement in healing of bony defects.[34,35]

The clinical and radiological findings of the studies present significant positive effects of the orthodontic treatment on the gain of clinical attachment. Ten studies (four clinical trials,[5,9,10,15] five case reports[11,12,16,29,30] and one case series[13]) evaluated the effects of orthodontic treatment after a course of traditional periodontal therapy, with or without surgery (Table III), and six studies[14,26-28,30,31] evaluated the effects of orthodontic treatment after periodontal therapy following a regenerative procedure (Table IV). The review of the studies varied from the time needed to perform the orthodontic treatment to up to 12 years post-treatment. In the studies reporting

Table IV. Results of studies on orthodontic treatment and periodontal therapy with a regenerative procedure.

Study	Study design	Participants/ tooth involved	Type of defect/ Pocket probing depth	Presurgical phase/ Regenerative material	Orthodontic appliance/Force system	Timing of orthodontic treatment after periodontal therapy	Main findings
Re et al., 2002[14]	CR	1 patient aged 57y (central incisors)	NA/ PPD≥ 6 mm	SRP/Bovine bone mineral and fibrin sealer	Intrusive arch and cantilevers or utility arch/ 10 gr	10 days after surgery	PPD ↓ ≅2.8 mm Gain in clinical attachment of ≅6 mm
Cardaropoli et al., 2006[26]	CS	3 patients (central incisors)	NA/ PPD≥ 6 mm at the osseous defect	SRP/Collagen bovine bone material	Intrusive arch and cantilevers or utility arch/ NA	14 days after surgery	PPD ↓ 3.7 mm Gain in clinical attachment of 4.7 mm Gain in vertical bone level of 3.2 mm Gain in horizontal bone level of 2 mm
Ghezzi et al., 2008[31]	CT	14 patients, age of at least 21y (NA)	1,2,3-wall/ PPD≥ 6 mm	SRP/EMD for 3-wall defect SRP/Collagen membrane + bone graft for 1,2-wall defects	Straigth-wire/ NA	1 year after surgery	PPD ↓ 5.6 mm Gain in clinical attachment of 5.9 mm
Fung et al., 2012[27]	CR	1 patient aged 68y (central incisor)	3-wall/ PPD ≥ 6 mm	SRP/EMD+ bone substitute	Rigid archwire+NiTi overlay wire/ 40 gr	1 week after surgery	PPD ↓ 5 mm Gain in clinical attachment of 6 mm
Jepsen et al., 2015[28]	CR	1 patient aged 52y (central incisor)	2,3-wall/ PPD≥ 9 mm	SRP/Tissues grafts+EMD	Segmented technique combining steel and NiTi wires/NA	1 year after surgery	PPD ↓ 6 mm Gain in clinical attachment of 2 mm
Jang et al., 2019[30]	CR	1 patient aged 52y (central and lateral incisors)	NA/ PPD≥ 6 mm at the osseous defect	SRP/ EMD+synthetic bone	Rigid archwire+NiTi overlay wire/ NA	1 month after surgery	PPD ↓ 3 mm Gain in clinical attachment of 3 to 5 mm

CR: case report; PPD: pocket probing depth; NA: not available; EMD: enamel matrix derivatives; NiTi: nickel-titanium; SRP: Scaling and root planning

Table V. Study design (maximum score, 10 points).

Article	Type	Randomisation and control group*	Sample size	Selection criteria	Objective	Score
Melsen et al., 1989	2	0	3	1	1	7
Steffensen & Storey, 1993	0	NA	0	1	1	2
Rabie et al., 1998	0	NA	0	1	1	2
Re at al., 2000	2	0	4	0	0	6
Cardaropoli et al., 2001 and Corrente et al., 2003	2	0	1	1	1	5
Re at al., 2002	0	NA	0	1	1	2
Cardaropoli et al., 2004 and Re et al., 2004	2	0	3	1	1	7
Cirelli et al., 2006	0	NA	0	1	0	1
Modoni et al., 2009	0	NA	0	1	0	1
Re et al., 2002b	0	NA	0	1	0	1
Cardaropoli et al., 2006	0	NA	0	1	0	1
Ghezzi et al., 2008	2	0	2	1	1	6
Fung et al., 2012	0	NA	0	1	0	1
Jepsen et al., 2015	0	NA	0	1	0	1
Jang et al., 2019	0	NA	0	1	0	1

*merged because none of the studies was a randomised or controlled clinical study; NA: not applicable

Table VI. Methodological soundness (maximum score, 7 points).

Article	Appliance type	Force magnitudes	Radiographic exams	Clinical measurement of CAL	Timing of orthodontic treatment	Score
Melsen et al., 1989	1	1	1	1	1	5
Steffensen & Storey, 1993	1	1	1	1	0	4
Rabie et al., 1998	1	1	0	1	0	3
Re at al., 2000	1	1	0	1	1	4
Cardaropoli et al., 2001 and Corrente et al., 2003	1	1	1	1	1	5
Re at al., 2002	1	1	1	1	1	5
Cardaropoli et al., 2004 and Re et al., 2004	1	1	0	1	1	4
Cirelli et al., 2006	1	1	0	1	0	3
Modoni et al., 2009	1	1	0	1	0	3
Re et al., 2002b	1	1	0	1	1	4
Cardaropoli et al., 2006	1	1	1	1	1	5
Ghezzi et al., 2008	1	1	0	1	1	4
Fung et al., 2012	1	0	0	1	1	3
Jepsen et al., 2015	1	0	0	1	1	3
Jang et al., 2019	1	0	1	1	1	4

no regenerative procedure, the gain in clinical attachment obtained after orthodontic treatment ranged from 3 to 8 mm, with a reduction in probing depth values ranging between 2 to 4.4 mm. The results reported by the studies that applied a regenerative procedure during periodontal therapy were similar. The increase in clinical attachment levels varied from 2 to 6 mm, with a reduction in probing depths values ranging from 2.8 to 6 mm. Although a direct comparison of these results cannot be performed, it appears that the addition of a periodontal regenerative procedure during the periodontal therapy did not provide additional clinical benefits to the orthodontic treatment in relation to clinical attachment gain. However, recent systematic reviews have provided evidence that the use of a regenerative procedure can result in additional clinical improvements in tissue attachment and probing depth compared with those obtained by periodontal therapy that applied only open flap debridement.[36,37] The former procedure seems to have a higher potential to heal via the formation of new cementum, new periodontal ligament, and new alveolar bone, while the latter usually leads to minimal or no bone infill and the formation of a long junctional epithelium in the treatment of infra-bony defects. Considering that the attachment between the newly regenerated tissue and the root surface cannot be examined without a biopsy of the treated teeth, further controlled clinical trials are required to clarify this topic.

In reference to the methodologic quality assessment, the scores ranged from 29% to 68%, with a mean score of 45%, which corresponds to a low evidence level. Interestingly, if only the clinical trials are considered, the mean methodologic quality score is 65%, which corresponds to a moderate evidence level. Considering the lack of randomised clinical trials and the small number of clinical trials evaluating the benefits of orthodontic treatment to PTM, case series and case reports were also included in the present review. Despite their limitations, case series and case reports comprise a large part of the evidence base in health sciences and are generally accepted as clinical guidelines by clinicians when dealing with complex cases. Moreover, the inclusion of these reports assists to strengthen the credibility of the present review.

No study achieved a high evidence level, and almost all were considered to have a moderate risk of bias. Some reasons for these results are obvious. For example, the orthodontists who performed the treatments could not be blinded. The blinding of outcome assessment was also not possible because none of the studies included in the present review evaluated a control

Table VII. Data analysis (maximum score, 3 points).

Article	Statistical analysis	Error of the method or repeated measures	Data presentation	Score
Melsen et al., 1989	0	0	1	1
Steffensen & Storey, 1993	NA	0	1	1
Rabie et al., 1998	NA	0	1	1
Re at al., 2000	1	0	1	2
Cardaropoli et al., 2001 and Corrente et al., 2003	1	0	1	2
Re at al., 2002	NA	0	1	1
Cardaropoli et al., 2004 and Re et al., 2004	1	0	1	2
Cirelli et al., 2006	NA	0	1	1
Modoni et al., 2009	NA	0	1	1
Re et al., 2002b	NA	0	1	1
Cardaropoli et al., 2006	NA	0	1	1
Ghezzi et al., 2008	1	0	1	2
Fung et al., 2012	NA	0	1	1
Jepsen et al., 2015	NA	0	1	1
Jang et al., 2019	NA	0	1	1

NA: not applicable

Table VIII. Evidence level and risk of bias classification.

Article	Total score and percent	Evidence level	Selection bias	Detection bias	Attrition bias	Reporting bias	Risk of bias
Melsen et al., 1989	13 (68%)	Moderate	Yes	Yes	No	No	Moderate
Steffensen & Storey, 1993	7 (41%)	Low	Yes	Yes	No	No	Moderate
Rabie et al., 1998	6 (35%)	Low	Yes	Yes	No	No	Moderate
Re at al., 2000	12 (63%)	Moderate	Yes	Yes	No	Yes	High
Cardaropoli et al., 2001 and Corrente et al., 2003	12 (63%)	Moderate	Yes	Yes	No	No	Moderate
Re at al., 2002	8 (47%)	Low	Yes	Yes	No	No	Moderate
Cardaropoli et al., 2004 and Re et al., 2004	13 (68%)	Moderate	Yes	Yes	No	No	Moderate
Cirelli et al., 2006	5 (29%)	Low	Yes	Yes	No	No	Moderate
Modoni et al., 2009	5 (29%)	Low	Yes	Yes	No	No	Moderate
Re et al., 2002b	6 (35%)	Low	Yes	Yes	No	No	Moderate
Cardaropoli et al., 2006	7 (41%)	Low	Yes	Yes	No	No	Moderate
Ghezzi et al., 2008	12 (63%)	Moderate	Yes	Yes	No	No	Moderate
Fung et al., 2012	5 (29%)	Low	Yes	Yes	No	No	Moderate
Jepsen et al., 2015	5 (29%)	Low	Yes	Yes	No	No	Moderate
Jang et al., 2019	6 (35%)	Low	Yes	Yes	No	No	Moderate

group without orthodontic treatment. This would be the only way to quantify the possible additional benefits of correcting the malpositioned teeth after the control of the periodontal disease.

It is important to emphasise that the orthodontic correction of pathologically migrated teeth may not only increase tissue attachment levels, but also improve the aesthetic and functional aspects of the occlusion. The orthodontic treatment in these cases has a profound impact on patient appearance, which also indirectly increases the patient´s motivation. Moreover, the repositioning of teeth can improve access for cleaning, re-establishes incisal guidance, improves lip-seal and reduces non-axial loading which can act as an important co-factor, along with a dental biofilm, to accelerate periodontal destruction.[38,39]

Conclusions

1. Considering that PTM is rarely solely managed by periodontal treatment, orthodontists have an important role in the aesthetic and functional re-establishment of occlusion in affected cases.
2. In order to avoid excessive force application to the periodontal tissues, clinicians need to understand the altered biomechanical aspects of a periodontally reduced dentition. A segmented orthodontic approach applied early after periodontal therapy appears to be the best option.
3. Although consistent findings were shown for the benefits of orthodontic treatment on PTM, the level of evidence is still low and the risk of bias of the studies is considered moderate.
4. There is insufficient evidence to make any current recommendations on the application of a specific regenerative procedure to improve the results achieved by interdisciplinary treatment of PTM.

Corresponding author

Prof. Dr. Gustavo Hauber Gameiro
Department of Physiology
Federal University of Rio Grande do Sul – UFRGS
Rua Sarmento Leite 500
CEP 90050-170
Porto Alegre-RS
Brazil

email: gustavo.gameiro@ufrgs.br

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