Mestrado Integrado em Medicina Dentária

Faculdade de Medicina da Universidade de Coimbra

Applications of orthodontics in hopeless teeth for implant site development: A systematic review

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Coimbra, 2022

Integrated Master in Dentistry

Faculty of Medicine, University of Coimbra

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Coimbra, 2022

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ABSTRACT

Introduction: Tooth loss negatively impacts quality of life, especially when appearance and ability to eat are compromised, and is followed by bone and soft tissue resorption. To treat these patients, different treatment options are available, such as implant-supported restorations. The long term prognosis of implants depends on the quality and quantity of hard and soft issues. Slow orthodontic extrusion, which consists of the application of a light orthodontic force that moves teeth and surrounding tissues coronally, is the only available non-surgical option for implant-site development in hopeless teeth.

Aim: To evaluate the effectiveness ofsSlow orthodontic extrusion in hopeless teeth for hard and soft tissue gain for implant placement.

Materials and methods: This review followed the PRISMA framework to answer the focused question: “How efficient is orthodontic extrusion in hopeless teeth for hard and soft tissue gain?”. A systematic search of four databases was done and 5 articles were sellected, all clinical studies.

Results: A total of 80 teeth in 38 patients were orthodontically extruded for implant site development. Most of the extruded teeth were anterior maxillary teeth, with periodontal disease being the major cause of tooth loss. The studies varied greatly in the amount of parameters evaluated and in the evaluation method of said parmeters. Despite these differences, most studies showed positive outcomes for bone and soft tissue augmentation for implant site development, even though there was also evidence of the contrary, with slow orthodontic extrusion significantly reducing buccal bone height, hindering implant placement. The studies that reported follow-ups after implant placement showed survival rates of 96% to 100%, although follow-up periods varied greatly.

Conclusion: Despite the variability of outcomes shown, clinicians should keep orthodontic implant site development in mind as a valid treatment option for their patiens, alongside other treatments such as surgical grafting.

Keywords: Orthodontic extrusion, implant site development, tooth loss, dental implant, alveolar bone

RESUMO

Introdução: A perda dentária afeta negativamente a qualidade de vida das pessoas, especialmente se comprometer a sua aparência e capacidade de alimentação. Após perda dentária, o osso alveolar sofre um processo de reabsorção, seguido pelos tecidos moles. Para reabilitar estes doentes existem, entre outros tratamentos, os implantes dentários, cujo sucesso depende da qualidade e quantidade de osso envolvente e de tecido gengival. A extrusão ortodôntica lenta, que consiste na aplicação de forças ortodônticas que extruem o dente e os tecidos envolventes, é, atualmente, a única abordagem não cirúrgica para o desenvolvimento de leito implantar em dentes irrecuperáveis.

Objetivo: Avaliar a eficácia da extrusão ortodôntica lenta em dentes irrecuperáveis para o desenvolvimento de tecido ósseo e tecido gengival.

Materiais e métodos: A presente revisão foi realizada segundo o protocolo PRISMA para responder à questão: “Quão eficaz é a extrusão ortodôntica em dentes irrecuperáveis para aumento ósseo e gengival?”. Realizou-se uma pesquisa sistematizada em quatro bases de dados, da qual 5 estudos clínicos foram selecionados.

Resultados: Em 38 doentes, foram ortodonticamente extruídos 80 dentes para desenvolvimento de leito implantar, a maioria dos quais apresentava doença periodontal como motivo da indicação para extração. Os estudos selecionados apresentam grande variabilade nos parâmetros avaliados e nos meios usados para avaliação. Apesar destas diferenças, a maioria dos estudos mostrou melhorias a nível tos tecidos moles e duros, apesar de também ter havido evidência em contrário, com redução significativa da tábua óssea vestibular causada pela extrusão ortodôntica lenta, impossibilitando a colocação de implantes. Apesar da grande variabilidade nos períodos de follow-up após colocação dos implantes, observaram-se taxas de sobrevivência de 96% a 100%.

Conclusão: Apesar da variabilidade dos resultados obtidos, a extrusão ortodôntica lenta deve ser tomada em conta como uma estratégia válida para desenvolvimento de leito implantar, a par de outras opções, como enxertos ósseos ou de tecidos moles.

Palavras-chave: Extrusão ortodôntica, Desenvolvimento de leito implantar, Perda dentaria, Implante dentário, Osso alveolar

INTRODUCTION

On daily dental care, there are many reasons why a tooth is considered hopeless and indicated for extraction, such as extensive caries, dental trauma or periodontal disease, which is the main cause of tooth loss among adults (1,2).

Teeth are essencial to a proper mastication and to everyday social life, through speaking and smiling. Tooth loss impairs one's ability to eat properly, to speak and to laugh comfortably, which affect one's nutritional well-being and may lead to social isolation. Therefore, tooth loss has a severely negative impact on the quality of life, especially when appearance and ability to eat are compromised (2–4).

To rehabilitate these patients and restore oral function, many different treatment options are available, such as removable dentures, fixed partial prostheses or restoration supported by implants, which have been shown to have a 96% success rate in the long-term (5). The long term prognosis of implants heavily depends on the quality and quantity of alveolar bone and gingival tissues in the recipient sites (6).

Tooth extraction is unvariably followed by a continuous and progressive bone resorption around the extraction site, with around 40% to 60% happening in the first 6 months after tooth loss in both vertical and horizontal aspects of the alveolar bone (5,7–9). Bone resorption is especially pronounced on the buccal alveolar plate (6,8,10). Soft tissue topography is affected by the underlying hard tissue and, for that reason, any changes to the hard tissue will generate alterations in the soft tissue, which explains the gingival reduction also observed in post-extration sites (9). Aesthetics and long-term maintenance of the final implant restoration are greatly influenced by the soft tissue profiles (11).

The hard and soft tissue resorptions observed after tooth loss may affect implant placement and long-term prognosis, compromising prosthetic, functional and aesthetic outcomes (6,9) making it often necessary to perform tissue management and implant site development (ISD) in order to ensure good aesthetics, function and predictable results in the long-term (10,12).

A myriad of surgical procedures to improve hard and soft tissue profiles have been proposed and employed over the years. For hard tissue augmentation there are techniques such as onlay bone grafting, guided bone regeneration and distraction osteogenesis, whereas for soft tissue we have connective tissue or free gingival grafts and coronally positioned flaps, which are the most commonly performed treatments (6,13,14). In relation to non-surgical ISD

approaches, there is only one technique available, which is slow orthodontic extrusion (SOE) (12). SOE consists of the application of a light extrusive orthodontic force that imprints a coronal movement on the tooth (10). In SOE, the orthodontic force creates tension in the periodontal ligament and in the gingival fibers which, in turn, promotes the deposition of new bone along the alveolar bone crest, increasing bone height (BH) and tooth socket and promotes the vertical movement and augmentation of the gingiva (10,11,15–18). This technique preserves the relationship between the gingival margin and the extruded tooth, which also explain the increase in attached gingiva often observed (10,11). In 1993, Salama and Salama clinically implemented this technique, which they called “Orthodontic extrusive remodeling”. This approach made use of the hopeless teeth by subjecting them to extrusive forces, through orthodontic appliances, to incentivate hard and soft tissue growth in these sites, making implant placement more favourable (19).

Even though there is no concrete evidence suggesting that SOE is significantly better than surgical procedures when it comes to ISD, both techniques have showed clinical success, with SOE being much less invasive. (13).

According to what has been exposed above, the aim of this study is to evaluate the effectiveness of SOE in hopeless teeth for hard and soft tissue gain for implant placement.

MATERIALS AND METHODS

The present review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Mata-Analyses) statement in order to find na answer to the following question: “How efficient is orthodontic extrusion in hopeless teeth for hard and soft tissue gain?”

1) FOCUSED QUESTION

Population: Patients with hopeless teeth indicated for extraction

Interventions: Slow orthodontic extrusion

Comparison: Compare different protocols and appliances used for SOE

Outcomes: Clinical and radiographic bone gain and improvement of soft tissue quantity and quality

2) INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria for the present systematic review are:

- Records in portuguese or english
- Teeth indicated for extraction
- Orthodontic extrusion for implant site development
- Adult teeth
- Human application
- Clinical studies (randomized controlled trials, controlled clinical trials, case series)

The exclusion criteria considered are the following:

- Impacted teeth
- Crown lengthening
- Editorial letters, *in vitro* and animal studies, research based on secondary data, abstracts of conferences

3) SEARCH STRATEGY

For the identification of potentially relevant studies to be included in this review, an electronic search was performed for PubMed, Dentistry and Oral Sources Database via EBSCOhost, Web of science (All databases) and the Cochrane Library up to the 10th of May 2022.

PubMed: 163 records

(“Forced Eruption*”[All Fields] OR “Eruption, Forced”[All Fields] OR “Tooth Extrusion*”[All Fields] OR “Extrusion, Tooth”[All Fields] OR “Orthodontic Extrusion*”[All Fields] OR “Extrusion, Orthodontic”[All Fields] OR "Orthodontic Extrusion"[Mesh]) AND (“Dental Implant*”[All Fields] OR (“Dental”[All Fields] AND “Implant*”[All Fields]) OR "Dental Implants"[Mesh] OR “Gingiva* Recession*”[All Fields] OR (“Gingiva*”[All Fields] AND “Recession*”[All Fields]) OR "Gingival Recession"[Mesh] OR “Bone Remodeling”[All Fields] OR (“Bone”[All Fields] AND “Remodeling”[All Fields]) OR "Bone remodeling"[Mesh])

Web of Science: 189 records

TOPIC - (“Forced Eruption*” OR “Tooth Extrusion*” OR “Orthodontic Extrusion*”) AND (“Dental Implant*” OR (“Dental” AND “Implant*”) OR “Gingiva* Recession*” OR (“Gingiva*” AND “Recession*”) OR “Bone Remodeling”)

EBSCOhost: 104 records

(“Forced Eruption*” OR “Tooth Extrusion*” OR “Orthodontic Extrusion*”) AND (“Dental Implant*” OR (“Dental” AND “Implant*”) OR “Gingiva* Recession*” OR “Bone Remodeling”)

Cochrane:

#1 – 5 records

Orthodontic extrusion AND alveolar bone

#2 – 1 record

Orthodontic extrusion AND bone augmentation

#3 – 8 records

Tooth extrusion AND orthodontics AND dental implant

#4 – 11 records

Tooth extrusion AND orthodontics AND periodontics

4) STUDY SELLECTION

After the initial search, all records identified were exported to a reference manager. Firstly, the duplicates were identified and removed. After duplicate removal, the title and abstracts of the remaining records were screened and, whenever a record apparently met the inclusion criteria, the full texts were retrieved if possible. Then, all full text articles retrieved were screened and any ambiguity to the inclusion of the studies were discussed and resolved by consensus between the authors. The studies that did not meet the inclusion criteria after full text reading were excluded.

5) DATA EXTRACTION

Once study selection was completed, the selected studies were carefully analyzed and the following parameters was extracted: Author(s) names and year of publication, study design, number of participants, number and type of orthodontically extruded teeth, orthodontic appliance used and direction of forces applied to the teeth, alterations observed on the bone and gingiva, number of implants placed and implant survival rate. The extracted data is summarized in **Table 1** and **Table 2**.

6) EVALUATION OF RISK OF BIAS

To assess the risk of bias of the selected studies, the Joanna Briggs Institute's (JBI) critical appraisal tools were employed. The tools used were those for risk of bias assessment for case series studies and in quasi-experimental studies. The tool is comprised of a series of parameters to which the answers are "Yes", "No", "Unclear" and "Not Applicable" (N.A.). If a study scored 80% or higher affirmative answers, the risk of bias was considered low. If it scored between 50% and 80% affirmative answers, the risk of bias was deemed moderate. Scores bellow 50%, were considered high risk. The risk of bias is shown in **Table 3** and **Table 4**.

RESULTS

1) STUDY SELLECTION

Electronic search resulted in 481 records, of which 211 were duplicated. After duplicate removal, the titles and abstracts of the remaining 270 records were screened, of which 10 apparently met the pre-established inclusion criteria. Out of the selected records, the full text of 2 were not retrieved despite the authors' best efforts and 3 were excluded after full text reading. At the end, 5 studies were considered for qualitative synthesis. The sellection process is depicted in **Figure 1**.

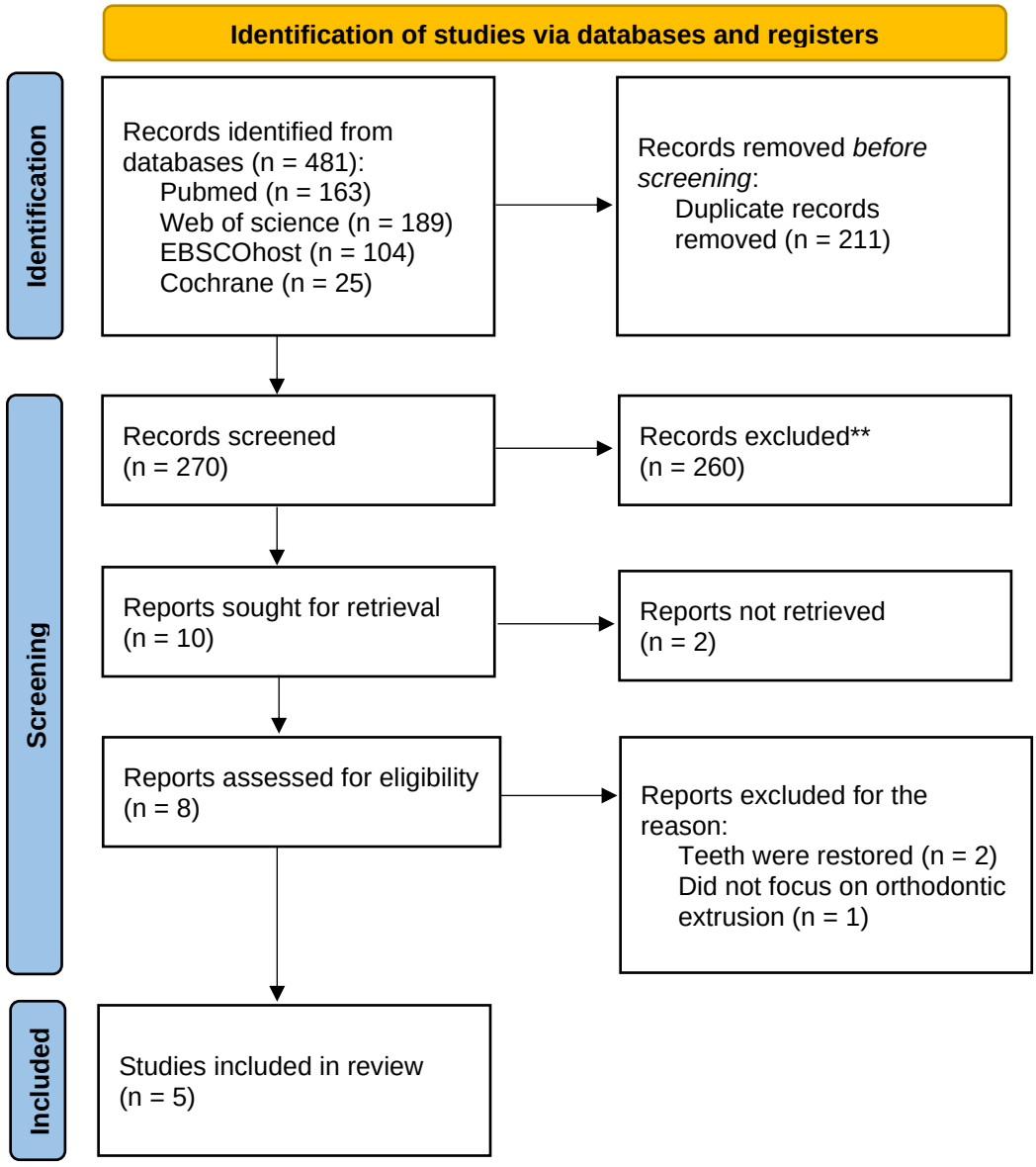

Figure 1 – PRISMA flow diagram for systematic search

2) STUDY CHARACTERISTICS

The characteristics of the sellected studies (5,7,8,17,18) are registered in **Table 1** and **Table 2**.

A total of 80 teeth in 38 patients were orthodontically extruded for ISD. Anterior maxillary teeth made up the majority of the extruded teeth and most teeth were extruded using orthodontic fixed appliances (OFA) which applied a strictly vertical movement to the teeth. Most studies reported positive changes in bone and gingiva height, only one did not (8).

Table 1 – Characteristics of the sellected case series

Authors	**Mantzikos and Shamus (1997)** (17)	**Mantzikos and Shamus (1999)** (18)
Study design	Case series	Case series
Number of participants	n=5	n=5
Number of orthodontically extruded teeth	n=10 Maxillary central incisors	n=10 Maxillary central incisors
Orthodontic appliance and direction of force	Vertical extrusion using OFA	OFA
Bone response to orthodontic extrusion	Mean bone defect reduction=5,32mm	• Mean bone defect reduction (right central incisor) =9,16mm • Mean bone defect reduction (left central incisor) =9,28mm
Gingiva response to orthodontic extrusion	Mean “red patch“height=4,5mm	• Mean “red patch” height (right central incisor) =4,5mm • Mean “red patch” height (left central incisor) =4,62mm
Implants placed	NA	n=10
Implant survival rate	NA	NA

Table 2 – Characteristics of the sellected prospective clinical studies

Authors	**Amato et al. (2012)** (5)	**Kwon et al. (2016)** (7)	**Papadopoulou et al. (2019)** (8)
Study design	Prospective controlled clinical study	Prospective controlled clinical study	Prospective observational clinical trial
Number of participants	n=13	n=8	n=7
Number of orthodontically extruded teeth	n=32	n=11 Anterior maxillary teeth with at least 1/3 to ¼ of intact periodontal attachment	n=17 Anterior maxillary teeth
Orthodontic appliance and direction of force	Vertical extrusion (with or without palatal root torque) with OFA	Vertical extrusion with a single bracket placed on the hopeless teeth	Vertical extrusion with OFA
Bone response to orthodontic extrusion	• New bone was formed in all treated sites • Average efficacy=70% (Orthodontic movement didn't convert totally into new bone, without significant differences between types of initial osseous defects)	• Significant increase (p<0,05) of 1,36±0,68mm in BH the interproximal BH • Significant decrease (p<0,05) of 0,67±0,25mm in alveolar ridge width	• Significant BH decrease (p<0,001) of 1,95±1,83mm in buccal central of areas • Significant BH increase (p<0,05) of 1,31±2,41mm in the palatal central areas • Nonsignificant BH increase in interproximal areas

Gingiva response to orthodontic extrusion	• Gingival margin moved coronally in all cases • Average efficacy=65% • Gingival growth on the adjacent teeth in all cases • Coronal migration of papillae in all cases (no exact measurements) • Keratinized gingiva width increase in most cases (1 case showed reduction and 2 showed no difference)	Significant increase (p<0,05) of 1,09±0,53mm in the interproximal papilla height	NA
Implants placed	n=27	NA	n=11 (6 sites were unable to host implants due to bone destruction caused by SOE)
Implant survival rate	96,3% (1 implant failed) Follow-ups varied from 18 to 61 months)	NA	100% (No implant failure reported at 6 months)

3) RISK OF BIAS

The risk of bias within the selected studies is shown in **Table 3** and **Table 4**. Both case series studies (17,18) scored a high risk of bias using the JBI tool for risk of bias assessment in case series. Amato et al. (2012) (5) scored a moderate risk of bias and Papadopoulou et al. (2019) (8) and Kwon et al. (2016) (7) scored a low risk of bias, all assessed with the tool for quasi experimental studies.

Table 3 – Risk of bias in case series studies

Study	**Mantzikos and Shamus (1997)** (17)	**Mantzikos and Shamus (1999)** (18)
Were there clear criteria for inclusion in the case series?	NO	NO
Was the condition measures in a standard, reliable way for all participants included in the case series?	YES	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES	YES
Did the case series have consecutive inclusion of the participants?	NO	NO
Did the case series have complete inclusion of participants?	NO	NO
Were there clear reporting of the demographics of the participants in the study?	NO	NO
Was there clear reporting of clinical information of the participants?	NO	NO
Were the outcomes or follow up results of cases clearly reported	YES	YES
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	NO	NO
Was the statistical analysis appropriate?	N.A.	N.A.
Overall risk of bias	**High**	**High**

Table 4 – Risk of bias in quasi-experimental studies

Study	**Amato et al. (2012)** (5)	**Kwon et al. (2016)** (7)	**Papadopoulou et al. (2019)** (8)
Is it clear in the study what is the "cause" and what is the "Effect"?	YES	YES	YES
Were the participants included in any comparisons similar?	YES	YES	YES
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	YES	YES	YES
Was there a control group?	NO	NO	NO
Were there multiple measurements of the outcome both pre and post the intervention/exposure?	YES	YES	YES
Was follow up complete and if not, were diferences between groups in terms of their follow up adequately described and analyzed?	YES	YES	YES
Were the outcomes of participants included in any comparison in the same way?	YES	YES	YES
Were outcomes measures in a reliable way?	YES	YES	YES
Was appropriate statistical analysis used?	N.A.	YES	YES
Overall risk of bias	**Moderate**	**Low**	**Low**

DISCUSSION

The present systematic review was conducted with the aim to synthesize the available, relevant literature that assesses ISD through the application of orthodontic forces in hopeless teeth.

Among all of the selected studies, a total of 38 patiens underwent orthodontic treatment for orthodontic extrusion of hopeless teeth and ISD. Most of the extracted teeth were anterior teeth on the maxillary arch. In accordance to what is observed in the general population (1,2), the most common reason for tooth extraction was periodontal disease. Papadopoulou et al. (2019) (8), Kwon et al. (2016) (7) and Amato et al. (2012) (5) specified the aethiology if tooth loss in every single extracted tooth, with 52 out of the 60 teeth being extracted due to periodontal disease. Even though Mantzikos and Shamus don't specify the reason for tooth extration in either of their studies, the initial bony defects observed were, on average, 8,76mm deep in 1997 (17) and 12,82mm deep in 1999 (18). The recruitment criteria applied varied greatly from study to study. Mantzikos and Shamus didn't specify any inclusion or exclusion criteria for the participants recruited for the study. The only common characteristic among all 38 patients was the application of orthodontic extrusion for ISD.

Since a healthy periodontal ligament is a prerequisite for hard and soft tissue remodeling during orthodontic treatment, it is mandatory that periodontal inflamation is brought under control prior the initiation of orthodontic extrusion, otherwise the surrounding tissues won't keep up with tooth movement, resulting in a clinical attachment loss (18,20). Only Amato et al. (2012) (5) and Kwon et al. (2016) (7) reported performing periodontal treatment on their participants prior to orthodontic treatment, and Papadopoulou et al. (2019) (8) excluded patients with active periodontal disease from the study.

Orthodontic multibracket systems with either nickel-titanium or stainless steel wires were the appliances used most often for orthodontic extrusion of the compromised teeth, agreeing with the general literature on the topic (12). Only Kwon et al. (2016) (7) didn't adopt this method, opting for the placement of a single bracket on the teeth to be extruded, making use of a nickel-titanium wire bonded to the adjacent teeth to create the extrusive force, and a stainless steel wire was also affixed on the adjacent teeth. This extra wire was put in place to provide additional anchorage to the adjacent teeth and prevent any tipping, which is a known and possible adverse effect (10,12).

For ISD purposes, a slow extrusion rate with light and continuous forces is usually recommended (10,20). All selected studies besides Mantzikos and Shamus (1999) (18)

reported using this type of forces, who did not specify force intensity, extrusion rate or direction of the applied force. The direction of the applied forces, when stated, was vertical in all studies which translated into a purely coronal movement along the long axis of the tooth. However, in spite of what is observed on the selected articles, there is no general consensus among authors or clinicians in the matter of the direction of tooth traction, with some recommending tooth extrusion along the long axis to avoid compression and fenestration of the buccal plate, while others advocate for orthodontic extrusion with buccal root torque to augment buccolingual bulk of alveolar bone (6,10). Orthodontic stabilization periods ranged from 4 weeks (8) up to 12 weeks (18) before tooth extraction.

Hard and soft tissue measurement methods varied a great deal among the selected studies (5,7,8,17,18). Clinical assessment with a periodontal probe, two dimensional intraoral radiographs and three dimensional cone beam computarized tomography (CBCT) were the methos used among the different studies (5,7,8,17,18). The parameters assessed varied in type and in quantity. For these reasons, comparison between studies should be made with caution and prudence.

Bone response to orthodontic extrusion was mostly positive across studies, with Amato et al. (2012) (5) noting new bone formed in all treated sites. Kwon et al. (2016) (7) measured significant increases in interproximal BH, while Papadopoulou et al. (2019) (8) only noticed nonsignificant BH increases. This difference might be due to the way these parameters were evaluated, with one using measurements through intraoral radiographs (7) and the other one using CBCT measurements. (8). A significant palatal bone increase was also noted (8). Alveolar BH in the central buccal aspect varied wildly between studies. On one hand, Mantzikos and Shamus saw bone defect reduction averaging 5,32mm (17) and 9,22mm (18), measured from the center of clinical gengiva to the pocket depth using a periodontal probe. On the other hand, Papadopoulou et al. (2019) (8) registered a significant BH reduction, which they attributed to the, the nature of the applied forces, causing compression on the buccal bone plate, hindering implant placement in 6 out of the 11 sockets. Additional buccal root torque, as has been suggested by some authors (6,12) might be contraindicated because it would only destroy the buccal plate even further. This difference between, Papadopoulou et al. (2019) (8) and most of the remaining literature regarding orthodontic ISD (5,12) might be due to the methods of evaluation, since Papadopoulou et al. (2019) (8) is the only study that used CBCT scans. Amato et al. (2012) (5) calculated that, on average, 70% of orthodontic extrusion resulted in bone gain, i.e., 70% of orthodontic movement resulted in newly formed bone, whether the remaining periodontal attachment only covered a few mm aroud the apex or the entirety of the root. The conical shape of the roots, and therefore an ever smaller cross

section of the root during orthodontic extrusion, determined a significant decrease inalveolar ridge width according to Kwon et al. (7).

There were no reports of gengiva loss in the selected studies, but it's response to orthodontic extrusion was much more varied than that of the bone. During forced eruption, a red patch appears coronally to the original gingival margin of the extruded tooth. This patch is the result of the eversion of the epithelium of the gingival sulcus and it's red because it's very thin and nonkeratinized, remaining erythematous for 28 to 42 days, until it finally keratinizes and resembles regular gengiva, resulting in soft tissue gain (17). Mantzikos and Shamus (17,18) registered the height of the red patch at around 4,5mm across studies. Amato et al. (2012) (5) noted that, not only did gengiva move coronally in all cases in the extracted teeth, it also moved coronally in the adjacent teeth, though not as much, and calculated that around 65% of extrusion converted into new soft tissue. An interproximal papilla height increase was observed by Amato et al. (2012) (5), even though exact measurents were not made, and by Kwon et al. (2016) (7), who measured a significant increase of 1,09±0,53mm. Amato et al. (2012) (5) recorded keratinized gengiva growth in all but three cases, one of which showed reduction of 1,5mm. The variability shown in the behaviour of soft tissue in response to orthodontic extrusion can be explained because gingival growth is affected by pocket depth, i.e., the deeper the pocket the later the sulcus everts and less new gingiva is generated (17), by bacterial and mechanical stimuli and by the structures to which the keratinized gingiva and the mucogingival junction are attached (5).

A total of 48 implants were placed across the studies that documented implant placement (5,8,18) and 13 teeth were replaced with pontics, either tooth or implant supported. Orthodontic induced destruction of the critical buccal alveolar plate made it impossible to place 6 out of 17 implants in their respective socket, which comprised 35% of sockets (8). Although implant survival rate is very good, with only 1 out of 48 implants reporting failure (5), the follow-up periods vary from 6 (8) to 61 months and Mantzikos and Shamus (18) don't report any follow-up at all, hence the need to interpret the data carefully.

CONCLUSION

SOE is a non-invasive way to build up hard and soft tissue for future implant placement.

SOE resulted in overwhelmingly positive alterations to soft tissue height and appearance, critical to the aesthetic outcome of the final restoration.

Although significant bone destruction of the buccal bone plate was observed, SOE resulted in BH augmentation in most cases, creating a favourable implant bed.

The variability of study methods and outcomes shown doesn't allow for clear answer to be drawn out. In spite of that, clinicians should keep orthodontic ISD in mind as a valid treatment option for their patiens, alongside other treatments such as surgical grafting.

ACKNOWLEDGEMENTS

Em primeiro, obrigado aos meus orientadores, pelo acompanhamento, disponibilidade e ajuda que me prestaram ao longo do ano.

Obrigado àqueles professores que me fizeram verdadeiramente gostar de ser estudante e que tornaram os dias de aulas mais fáceis apesar de todas as dificuldades pelas quais estivesse a passar.

Muito obrigado à minha família, por todo o apoio prestado, pelo incessante apoio e motivação e por estarem sempre lá para mim nos momentos mais difíceis e desafiantes.

Por último, mas não menos importante, um obrigado muito especial aos meus colegas e amigos, e em particular à minha binómia, que tornaram estes anos, e em particular este ano, os mais especiais dos meus 23 anos de vida.

REFERENCES

1. Periodontal (Gum) Disease | National Institute of Dental and Craniofacial Research [Internet]. [cited 2022 Jun 12]. Available from: https://www.nidcr.nih.gov/research/data-statistics/periodontal-disease

2. Aida J. Tooth Loss. 2021 [cited 2022 Jun 12];223–33. Available from: https://link.springer.com/chapter/10.1007/978-3-030-50123-5_13

3. Saintrain MVDL, De Souza EHA. Impact of tooth loss on the quality of life. Gerodontology [Internet]. 2012 Jun 1 [cited 2022 Jun 12];29(2):e632–6. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1741-2358.2011.00535.x

4. Gerritsen AE, Allen PF, Witter DJ, Bronkhorst EM, Creugers NHJ. Tooth loss and oral health-related quality of life: A systematic review and meta-analysis. Health Qual Life Outcomes [Internet]. 2010 Nov 5 [cited 2022 Jun 12];8(1):1–11. Available from: https://hqlo.biomedcentral.com/articles/10.1186/1477-7525-8-126

5. Amato F, Mirabella AD, Macca U, Tarnow DP. Implant Site Development by Orthodontic Forced Extraction: A Preliminar Study [Internet]. The International journal of oral & maxillofacial implants Int J Oral Maxillofac Implants; 2012 p. 411–20. Available from: https://web.p.ebscohost.com/ehost/detail/detail?vid=11&sid=df5f7996-c64f-437f-a35b-24ff6eabd43c%40redis&bdata=Jmxhbmc9cHQtcHQmc2l0ZT1laG9zdC1saXZlJnNjb3BlPXNpdGU%3D#AN=73759563&db=ddh

6. Korayem M, Flores-Mir C, Nassar U, Olfert K. Implant site development by orthodontic extrusion. A systematic review [Internet]. The Angle orthodontist Angle Orthod; Jul, 2008 p. 752–60. Available from: https://www.webofscience.com/wos/alldb/full-record/WOS:000257041700031

7. Kwon E-Y, Lee J-Y, Choi J. Effect of slow forced eruption on the vertical levels of the interproximal bone and papilla and the width of the alveolar ridge. Korean J Orthod [Internet]. 2016 Nov 1 [cited 2022 May 12];46(6):379. Available from: https://synapse.koreamed.org/DOIx.php?id=10.4041/kjod.2016.46.6.379

8. Papadopoulou AK, Papageorgiou SN, Hatzopoulos SA, Tsirlis A, Athanasiou AE. Alveolar ridge alterations in the maxillary anterior region after tooth extraction through orthodontic forced eruption for implant site development: a clinical CBCT study. 2020

Jun 23 [cited 2022 May 11];42(3):295–304. Available from: https://pubmed.ncbi.nlm.nih.gov/31081905/

9. Yeo ABK, Cheok CBC. Management strategies of the unsalvageable tooth. Dent Update [Internet]. 2006 [cited 2022 May 11];33(1). Available from: https://pubmed.ncbi.nlm.nih.gov/16512093/

10. Alsahhaf A, Att W. Orthodontic extrusion for pre-implant site enhancement: Principles and clinical guidelines. J Prosthodont Res [Internet]. 2016 Jul 1 [cited 2022 Jun 22];60(3):145–55. Available from: https://pubmed.ncbi.nlm.nih.gov/26979626/

11. Seibert JS, Salama H. Alveolar ridge preservation and reconstruction. Periodontol 2000. 1996;11(1):69–84.

12. Bauer C, Boileau MJ, Bazert C. Implementation of orthodontic extraction for pre-implant soft tissue management: A systematic review. 2019 Mar 1 [cited 2022 May 11];17(1):20–37. Available from: https://pubmed.ncbi.nlm.nih.gov/30770331/

13. Magkavali-Trikka P, Kirmanidou Y, Michalakis K, Gracis S, Kalpidis C, Pissiotis A, et al. Efficacy of two site-development procedures for implants in the maxillary esthetic region: a systematic review. Int J Oral Maxillofac Implants [Internet]. 2015 Jan [cited 2022 Jun 22];30(1):73–94. Available from: https://pubmed.ncbi.nlm.nih.gov/25615917/

14. Borzabadi-Farahani A, Zadeh HH. Adjunctive Orthodontic Applications in Dental Implantology. J Oral Implantol [Internet]. 2015 Aug 1 [cited 2022 Jun 22];41(4):501–8. Available from: https://pubmed.ncbi.nlm.nih.gov/24175964/

15. Bach N, Baylard JF, Voyer R. Orthodontic extrusion: periodontal considerations and applications. J Can Dent Assoc [Internet]. 2004 Dec 1 [cited 2022 Jun 22];70(11):775–80. Available from: https://europepmc.org/article/med/15588553

16. Hochman MN, Chu SJ, Tarnow DP. Orthodontic extrusion for implant site development revisited: A new classification determined by anatomy and clinical outcomes. Semin Orthod. 2014 Sep 1;20(3):208–27.

17. Mantzikos T, Shamus I. Forced eruption and implant site development: Soft tissue response. Am J Orthod Dentofacial Orthop [Internet]. 1997 [cited 2022 May 11];112(6):596–600. Available from: https://pubmed.ncbi.nlm.nih.gov/9423691/

18. Mantzikos T, Shamus I. Forced eruption and implant site development: An osteophysiologic response. Am J Orthod Dentofacial Orthop [Internet]. 1999 [cited 2022 May 11];115(5):583–91. Available from: https://pubmed.ncbi.nlm.nih.gov/10229894/

19. H Salama MS. The role of orthodontic extrusive remodeling in the enhancement of soft and hard tissue profiles prior to implant placement: a systematic approach to the management of extraction site defects.

20. Huang G, Yang M, Qali M, Wang TJ, Li C, Chang YC. Clinical Considerations in Orthodontically Forced Eruption for Restorative Purposes. 2021 Dec 1 [cited 2022 May 11];10(24). Available from: https://pubmed.ncbi.nlm.nih.gov/34945246/

APPENDIX

BH – Bone height

CBCT – Cone beam computarized tomography

ISD – Implant site development

N.A. – Not applicable

OFA – Orthodontic fixed appliance

SOE – Slow orthodontic extrusion