JO JOURNAL OF OSSEOINTEGRATION periodontics and prosthodontics

Inter-occlusal appliance for implant site augmentation and optimal implant positioning: a ten-year follow-up case report

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TO CITE THIS ARTICLE
Sant'Ana ACP, Stuani VT, Damante CA, Ragghianti-Zangrando MS, Greghi SLA, Rezende MLR, Passanezi E. Inter-occlusal appliance for implant site augmentation and optimal implant positioning: a ten-year follow-up case report. J Osseointegr 2018;10(2):37-43

DOI 10.23805 /JO.2018.10.02.02

ABSTRACT

Aim Orthodontic implant site augmentation was proposed for exodontia of a hopeless tooth to improve bone architecture before implant installation. However, the use of orthodontic appliances to perform slow vertical movements and tooth extraction demands an interdisciplinary approach, increasing time and costs. The aim of this study is to present a technique of orthodontic implant site augmentation by the use of an inter-occlusal appliance.

Case report A 48-year-old patient presented cervical external resorption and root fracture at the upper left central incisor. A slow orthodontic extraction of the tooth was performed by the use of an inter-occlusal appliance. After extrusion, the tooth was extracted and the implant was immediately placed. Tooth was extruded 6 mm in 8 months, at a slow rate of extrusion (0.75mm/month) along the tooth long axis, resulting in the formation of new bone at the apex and alveolar crest, leveling its height with neighboring teeth.

Results An increase in keratinized gingiva was observed. Final restoration was installed one year later, with adequate subgingival contour. No complications were observed after 10 years of follow-up.

Conclusions The use of an inter-occlusal appliance provided a simple method for orthodontic extraction and implant site development, allowing optimal implant positioning with no surgical augmentation procedures.

KEYWORDS Bone augmentation; Dental implant; Esthetics; Orthodontic extrusion.

INTRODUCTION

After exodontia, a vertical and horizontal progressive bone loss develops mainly from 6 months to 2 years following tooth extraction, altering osseous morphology and impairing optimal implant positioning (1-3). Substantial reduction in hard tissue volume is observed in the coronal portion of the socket, irrespective of the procedure (flapless or with flap elevation) used to extract the tooth (4).

Preservation or reconstruction of bone architecture, optimizing implant positioning, may be achieved by the installation of implants in fresh extraction sockets (5), socket preservation (6-9), or surgical augmentation of soft and hard tissues (10). However, these procedures present some limitations, such as: implant positioning into fresh alveolar sockets does not seem to interfere with the resorption process of alveolar socket walls (11,12); autogenous bone grafts show increased morbidity, do not seem to maintain alveolar socket dimensions and may be resorbed along with bone walls (13); inorganic bovine bone grafts are able to maintain alveolar socket dimensions after exodontia (4,7), but this delays wound healing and postpones implant installation (4); no biomaterial could guarantee complete preservation of alveolar socket after tooth extraction (3,14).

Optimal implant positioning is also compromised by severe destruction of periodontal tissues by periodontal disease (15). Considering that, orthodontic extrusion of hopeless teeth was proposed to provide vertical and horizontal hard and soft tissue gain (16). Slow orthodontic extrusion is able to promote vertical and horizontal bone augmentation (17) and increase the width of keratinized gingiva, proportional to the amount and following the direction of tooth movement (18). Since then, many case reports described the use of forced eruption for tooth extraction to correct bone architecture before implant placement (17,19-33). In all but one study (23), forced eruption was performed through the use of orthodontic appliances, which

requires an inter-disciplinary approach, demanding more time and higher costs to achieve good results.
The aim of this case report is to describe the principles of implant site augmentation by orthodontic extraction of a hopeless tooth by the use of an inter-occlusal splint and orthodontic elastics, as proposed before (34,35), as an alternative to the tridimensional reconstruction of the future implant site.

CASE REPORT

A 48-year-old healthy non-smoking subject was referred to the Clinics of Periodontics of the School of Dentistry at Bauru Univerity of Sao Paulo (Brazil) complaining of pain during biting, mal odor and gingival bleeding in left upper central incisor (#21). Clinical examination revealed poor adaptation of the metal ceramic crown, bleeding on probing, swelling of gingival margin and moderate to severe probing depth (5-6 mm) at buccal and lingual sites. Radiographic examination showed apical and cervical root resorption, invading biologic width (Fig. 1). A longitudinal root fracture was noticed after the release of the fixed prosthesis. A "hopeless tooth" diagnosis was then made.
Treatment options were extraction of hopeless tooth followed by prosthetic rehabilitation with partial fixed prosthesis or implant installation. Patient agreed with the treatment by dental implants. However, considering the presence of bone loss, especially at the distal site, which could compromise optimal implant positioning and the esthetics of final restoration, orthodontic extraction of the tooth was proposed. Since the patient did not agree with orthodontic treatment, an inter-occlusal splint was fabricated for orthodontic extrusion after impressions and occlusal registration in wax in centric occlusion were taken (35).
Casts were mounted in a semi-adjustable articulator (BioArt, Gnatus, São Carlos, São Paulo, Brazil) for manufacturing the inter-occlusal splint in acrylic resin (ThermoCure Resin, Classico, São Paulo, São Paulo, Brazil). Intraoral adjustment of the splint was performed to allow function without occlusal interferences or discomfort. The inter-occlusal splint was adapted to allow tooth extrusion with Maxi-Cut burs (Fig. 2A). A hook was fabricated at buccal and lingual tooth cervical thirds with light-cured resin (Z100, Espe 3M, Campinas, São Paulo, Brazil). The incisal edges of the tooth were reduced by approximately 2 mm with a diamond bur in high speed, creating a 'space' between the tooth and the splint (Fig. 2B). After that, the inter-occlusal splint was positioned and elastic rubber bands (Medium Intraoral Elastic, Morelli, Sorocaba, São Paulo, Brazil) were connected to the hooks passing over the splint (Fig. 2C) to activate tooth extrusion. Patient was advised to change elastics every other day until the tooth reached the splint (Fig. 2D). After that, patient should keep using the appliance for another 12 days. Activation of

FIG. 1 Pre-operatory X-ray of the left upper central incisor evidencing external root resorption at cervical and apical regions.

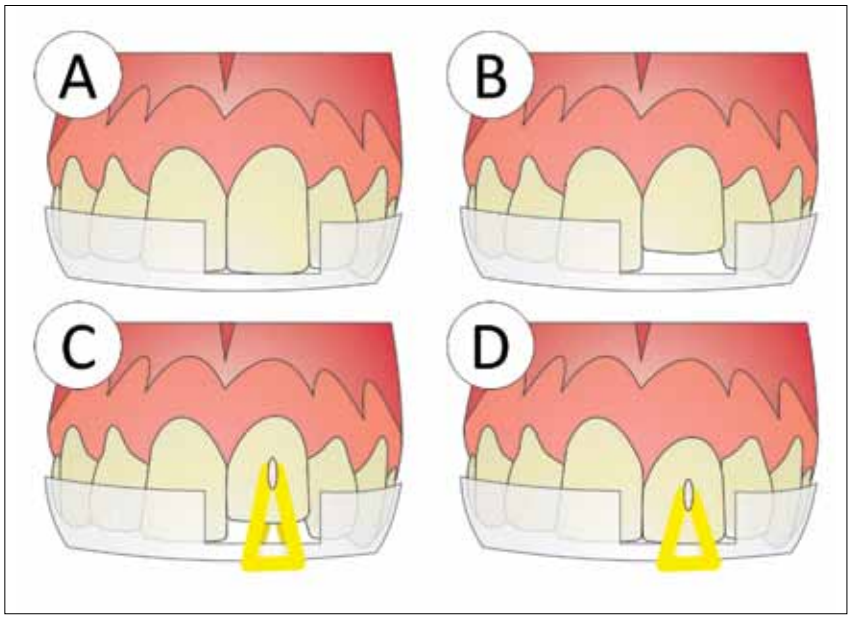

FIG. 2 (A) Adaptation of the inter-occlusal splint to allow tooth extrusion. (B) Reduction of incisal edges of the tooth by approximately 2 mm. (C) Light-cured resin hooks were fabricated at buccal and lingual cervical areas, followed by inter-occlusal positioning. Elastic bands were secured to the hooks, passing over the splint, to activate tooth extrusion. (D) When the incisal edge reached the splint, tooth was stabilized for 12-days, followed by additional activations until the desired amount of tooth extrusion was reached.

the tooth movement was performed again by reducing the incisal edges of the tooth of approximately 1 mm, followed by a stabilization period of at least 12 days, until the tooth extruded up to the desired position. Patient was instructed to use the inter-occlusal splint with the elastics all day long, except for eating and performing oral hygiene procedures.

X-ray images were obtained at follow-ups (Fig. 3A) to investigate bone formation apical to root apex. The total amount of extrusion needed was determined by the leveling of crestal bone of tooth #21 with adjacent teeth, achieving positive bone architecture after extrusion. Considering that some resorption of crestal bone may occur after tooth extraction, it is advisable to extrude the tooth 1-2 mm further than necessary. In the total, tooth was extruded 6 mm in 8 months, at a slow rate of extrusion (0.75mm/month), along the tooth long axis, resulting in bone apposition at the apex as well as at the alveolar crest of the tooth. The keratinized gingiva and the bone tissue followed the coronal movement of the tooth (Fig. 3B), maintaining a distance of 2-3 mm from CEJ to accommodate biologic width.

When a small portion of the root was surrounded by alveolar bone and bone formation was noticed apical to the root apex, flapless extraction of the tooth was performed (Fig. 3C), followed by immediate installation of the implant (15.0 x 3.75 mm; Master, Conexão Sistemas de Prótese, Guarulhos, São Paulo, Brazil). The implant was installed close to and parallel to lingual bone plate, to avoid resorption of buccal plate (Fig. 3D). A healing abutment was connected to the implant, which was kept non submerged during the osseointegration period (Fig. 3E). To protect the implant and to promote conditioning of gingival margin, a provisional restoration was attached to adjacent teeth with light-cured resin (Z100, 3M Espe, Campinas, São Paulo, Brazil).

Eight months later, an implant-supported provisional restoration was installed (Fig. 4A), allowing peri-implant gingival tissue recontouring (Fig. 4B-4C). Custom impression copings were used during impression to duplicate soft tissue contours and implant position in the cast, allowing the fabrication of a metal ceramic crown with adequate subgingival contour, which was connected to the implant 3 months later (Fig. 5A). Intra-oral X-ray image suggested a satisfactory implant positioning and adaptation of the definitive restoration (Fig. 5B). No complications were noticed after 10 years of follow-up (Fig 5C-5D).

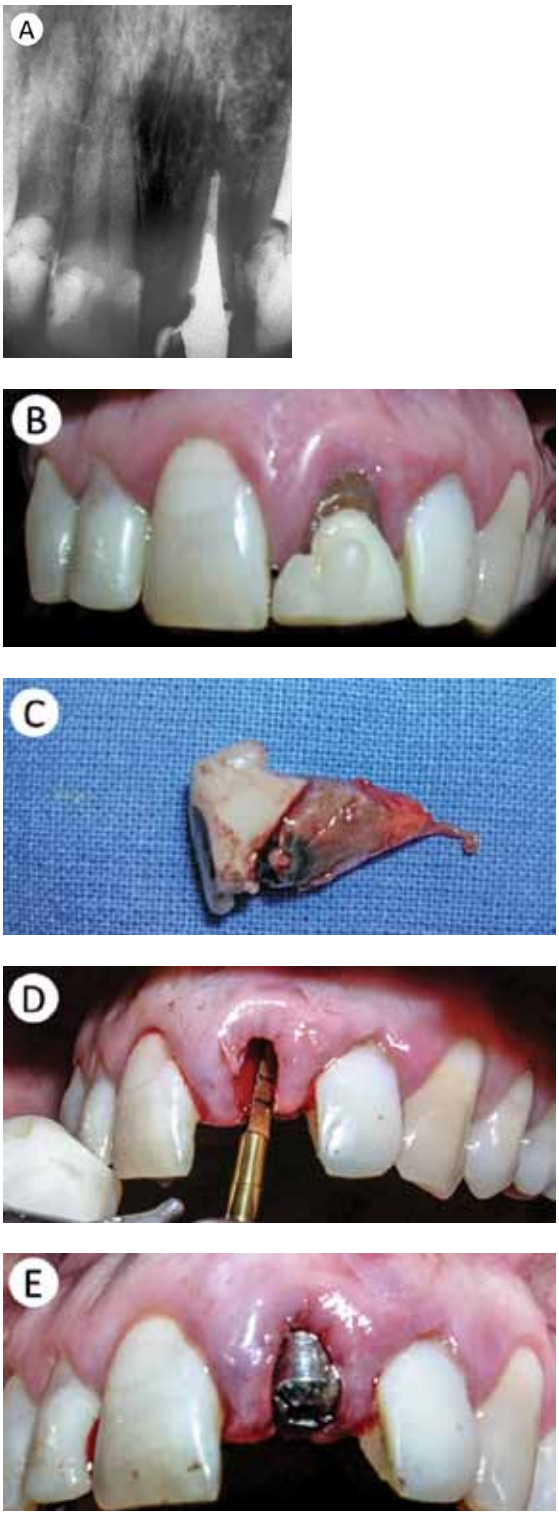

FIG. 3 (A) Intra-oral X-ray image suggesting bone formation apically to the root apex and leveled with adjacent teeth, determining the completion of tooth extrusion. (B) Clinical aspect of the tooth after the desired amount of extrusion was reached. Note a small red collar at the gingival margin, which partially followed tooth movement. The contour of gingival margin was in harmony with right upper central incisor. (C) Extracted tooth, evidencing apical root resorption and root fracture. (D) Subsequent flapless tooth extraction and immediate installation of the implant parallel to the lingual plate. (E) Healing abutment connected to the implant (non submerged).

DISCUSSION

This case report described a successful technique of orthodontic extrusion for extraction of a hopeless tooth and hard and soft tissue augmentation at the future site of implant installation by the use of an inter-occlusal

FIG. 4 (A) Provisional restoration fabricated in resin connected to the implant 8 months after implant installation. (B) Occlusal view of peri-implant sulcus and soft tissue volume. (C) Marginal soft tissue contour, evidencing the presence of an adequate gingival tissue around the future definitive restoration.

FIG. 5 (A) X-ray image obtained after final restoration was installed. (B) Final metal ceramic restoration installed showing good esthetics and function. (C) X-ray at ten-year follow-up. (D) Clinical aspect at the 10-year follow-up.

splint. This kind of treatment, that has been employed for many years in our clinical practice (35,36), can be applied for both cases of a compromised tooth (e.g.: subgingival caries, root perforations or root fractures violating biologic width) or to the periodontal tissues (e.g.: moderate to deep periodontal pockets, absence of an adequate width of keratinized gingiva). When the periodontal involvement is related to the tooth, a rapid extrusion is indicated, since the main goal of the treatment is to put the tooth out of the alveolar socket, allowing reconstitution of biologic width. When the periodontal involvement is related to the periodontal tissues, a slow extrusion is indicated, since it allows time for reconstitution of hard and soft periodontal tissues following coronal tooth movement.

In agreement with these principles, Salama and Salama (16) proposed the use of "orthodontic extrusion" to the vertical movement of a hopeless tooth almost to extraction. The coronal movement of the tooth is accompanied by a coronal movement of crestal bone and keratinized gingiva attached to the root, providing a tridimensional reconstruction of hard and soft tissues at the site of future implant installation. More recently, many authors have described the use of "forced eruption", "forced eruption extraction", "orthodontic extraction" or "orthodontic implant site development"

to augment the site of implant installation before tooth extraction (15, 17, 19, 20, 22, 23, 25-27, 29-32, 36-39).
The use of orthodontic movements to extrude the tooth has some disadvantages, such as increased duration of the treatment, higher costs, and undesirable side effects that may occur even when using several teeth for anchorage (23, 32). Inter-occlusal splints are easy to manage and cheaper than the use of conventional fixed orthodontic appliances, making the treatment possible for a higher number of patients. Axial forces are applied, allowing the incidence of tension forces only at the tooth to be extruded. Besides, it is possible to precisely control the amount of extrusion obtained. The main disadvantage of the technique is the necessity of using the splint at all times, except during eating and oral hygiene, causing some discomfort for the patient (23, 35, 36).
Recently, a preliminary clinical study was performed to evaluate the soft and hard tissue response to orthodontic implant site management (18). A total of 32 hopeless teeth underwent orthodontic extrusion followed by extraction and implant placement (n=27) in 13 consecutive patients. Vertical-forward steps of 1 mm were designed to obtain 1 mm of extrusion along the tooth's long axis at monthly activations. The amount of tooth extrusion was determined by the total millimeters of activation. In the present study, the determination of the total amount of extrusion (6 mm) was possible by measuring the distance between the reduced incisal edge and the inter-occlusal splint at each activation appointment.
The level of alveolar crest of adjacent or contralateral teeth is used to define the amount of extrusion necessary (18). In this case report, the amount of extrusion necessary was planned according to the leveling of crestal bone at adjacent teeth, since bone loss following tooth extraction and as a result of biologic width violation would compromise esthetics. The moment of tooth extraction was determined by the formation of new bone both at the cervical area and apical to root apex, as observed in intra-oral X-ray images (32).
The orthodontic extrusion of hopeless teeth results in an increase in keratinized gingiva width, since gingival margin moves in a coronal direction, following tooth movement (15, 18, 23, 32). The increase in gingival dimension results in improved esthetics by the leveling of gingival margin of adjacent teeth, besides allowing interproximal gingival papilla formation (26,40) and minimizing the need to lift the tissue to cover the extraction site (16). Coronal growth of gingival margin was observed in all cases treated by Amato et al. (18), but only some showed a 1:1 gingival formation/vertical movement ratio (mean ratio of 65.2% ± 19.9%; 23%-100%). The amount of gingival growth was influenced by the depth of periodontal pockets and by previous periodontal treatment. In the presence of periodontal pockets, coronal movement of the tooth was followed by bone and gingival growth occurred only when the pocket was erupted out and healed, resulting in eversion of non keratinized epithelium of the gingival sulcus, which becomes keratinized after 28-42 days (29-31). That explains why in some cases a red collar in the gingival margin (red patch) is observed (29-31,36,39). It should also be considered that when the base of the pocket is located apical to the mucogingival junction, the tissue attached to the tooth which follows vertical movement is alveolar mucosa, resulting in little to none increase in keratinized gingiva (34). In this case, an adequate quantity and quality of keratinized gingiva was present before tooth eruption, which favored the migration of gingival margin following tooth eruption.
New bone formation is observed in all cases of orthodontic extrusion (18,28,29), but a 1:1 bone formation/vertical movement ratio is rarely, if ever, observed (18). A mean gain in bone level of 68.9% ± 17.3%, ranging from 10% to 97% was observed (18), suggesting that new bone was formed with different baseline attachment levels, indicating that is possible to regenerate osseous tissue even when attachment loss is extremely severe.
The vector of tooth extrusion is critical to bone formation at the facial aspect of the tooth (32). The physiologic response of bone tissue to compression forces is resorption, usually not counteracted by new bone formation. The use of vertical extrusion along tooth's long axis provided by the elastics around the inter-occlusal splint avoids compression at buccal and lingual osseous plates, and consequently, no pressure is exerted on socket walls, stimulating the formation of new bone at all sites, including interproximal regions (18,26,32,34,35,40).
As the tooth erupts, there is a decrease in the diameter and depth of the alveolar socket, creating a better environment for immediate implant placement by minimizing the gap between the implant and the surrounding tissue (15), with no need of bone grafts to fill the gap between the implant and socket walls or to increase horizontal and/or vertical dimensions of alveolar ridge before or during implant installation (20,23,24,33,39). Additionally, the extra time and cost required for orthodontic implant site management is justified only when the clinical situation allows for minimally invasive extraction and implant placement without the need for extensive bone regeneration (38), as it occurred in this case.
When the reconstruction of hard periodontal tissues is desired, a slow rate of movement should be applied, using light forces (15-80 g/mL) [15, 18]. In this case report, 6 mm of tooth extrusion was observed in 8 months of treatment (rate of 0.75 mm/month), the slow rate of tooth extrusio enabled the relocation of periodontal tissues in a more coronal position, thus restoring the biological dimension of the marginal periodontium (16,34). A slow movement was applied to extrude the

tooth with the inter-occlusal splint in this case because it seems to be the most appropriate method to preserve the integrity of the residual periodontal attachment and to promote bone apposition (18).

Stabilization periods varying from 1 month for each millimeter of extrusion to 6 weeks-6 months was proposed in literature to allow the formation and maturation of supporting periodontal tissues (15-22, 24, 25, 27-33, 36, 37, 39). In this case report, the stabilization of the tooth was provided by the continuous use of the inter-occlusal splint for 12 days after the tooth reached the splint edge, allowing the formation of new bone apical to the root apex. At the moment of tooth extraction, immediate implant installation was possible, avoiding loss of the bone and gingival tissues obtained during active movement (20, 23-25).

Orthodontic extrusion of fractured roots is contraindicated according to some authors (16, 32). However, the lack of an adequate recipient site secondary to alveolar bone resorption as a result of root fracture does not create a tridimensional hard and soft tissue architecture that optimizes implant positioning, limiting the predictability of a long term esthetic result of an implant-supported prosthesis, since gingival tissue tends to follow osseous crest reduction (20, 36). A case report (36) described the orthodontic extrusion of a horizontally fractured upper central incisor at the apical third in a young patient. Tooth extrusion was performed by the use of an orthodontic appliance after completion of endodontic treatment and cementation of a manual file to allow tooth extrusion. After a 4-month extrusion period and a 3-month retention phase, the orthodontic appliance was removed and the tooth was minimally invasive extracted. A 13 mm implant was inserted 3 months later and the final results show a discrepancy between gingival margin of the restored teeth and contralateral central incisor. This finding was probably due to the late implant positioning, as well as the installation of the implant buccally. The positioning of the implant in a more palatal position, as observed in the present clinical study, helped the preservation of the bone plate at buccal areas, enhanced esthetics. Also, it was possible to extrude the fractured tooth almost to extraction, without the need of performing further augmentation procedures, resulting in increased width of keratinized gingiva and bone tissue allowing the positioning of a 15 mm long implant at the upper anterior region with adequate esthetics and function.

CONCLUSION

The findings of this case report indicate that orthodontic extrusion of a hopeless tooth with elastics and an inter-occlusal splint is a predictable and accessible method to augment hard and soft tissues at the future implant site prior to its installation, favoring esthetic and functional rehabilitation without the need of performing surgical augmentation procedures.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images

Competing interests

The authors declare no financial and non financial competing interests.

Funding

The authors declare that they received no funding.

Acknowledgments

The authors want to thank Dr. José Henrique Rubo for the prosthetic rehabilitation of the patient. The authors declare that there is no conflict of interest regarding the publication of this paper.

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