Preexisting hard and soft tissue defects around hopeless teeth can impede the ideal esthetic and functional outcomes of implant therapy. Orthodontic extrusion has been described as a predictable nonsurgical alternative for vertical hard and soft tissue augmentation, commonly through the use of orthodontic brackets on multiple adjacent teeth. This case report describes an alternative technique via orthodontic extrusion, utilizing a digitally designed and milled fixed provisional restoration. The provisional restoration served as an anchor in the forced eruption of a maxillary lateral incisor for the development of a future implant site. Following forced eruption and a subsequent stabilization period, immediate implant placement was successfully completed with a customized healing abutment to preserve the soft tissue architecture. The use of a fixed provisional restoration as an anchor for orthodontic extrusion allows for predictable implant site development while maintaining favorable esthetics throughout the treatment.


Forced Eruption for Implant Site Development Utilizing a CAD/CAM Provisional Fixed Dental Prosthesis: A Case Report

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Implant therapy is often the treatment of choice for teeth with a hopeless prognosis. Preexisting hard and soft tissue defects are often associated with compromised teeth due to caries and periodontal disease, which add complexity to the implant treatment.1 The proper management of hard and soft tissue defects is critical in achieving optimal esthetic outcomes and longevity for implants placed in these areas. Orthodontic extrusion, or forced eruption, has been proposed as a nonsurgical technique to achieve bone and soft tissue augmentation.2–4 The technique relies on the application of orthodontic forces to the periodontal ligament in order to extrude the target tooth, which induces the apposition of new bone and increases the volume of soft tissue.5 Because the bone is regenerated purely from the biologic response of the host attachment apparatus to the applied extrusive forces, it precludes the need for biomaterials or surgical intervention. Furthermore, the favorable quality of the regenerated bone was demonstrated in 1997 by Celenza, who showed histologic evidence of osteocytes in the vital bone regenerated through the forced eruption process.6 As early as 1973, Brown identified the use of orthodontic extrusive forces to eliminate infrabony defects and reduce periodontal

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pocket depths. Forced eruption, in combination with fiberotomy, can also help restore the ferrule effect and gain supracrestal tooth structure for restorative purposes. The current literature supports orthodontic extrusion as an effective and predictable alternative for implant site development in cases of moderate bony defects. A linear bone gain between 0.6 and 8 mm³ and an average bone gain of 4.63 mm³ have been reported in the literature. However, there are no definitive guidelines for implementing a forced eruption technique for the purposes of implant site development. Most publications consist of case reports utilizing traditional orthodontic armamentarium, such as metal wires and brackets, which are often undesirable in the anterior esthetic zone in adults.

This case report aims to describe a forced eruption technique utilizing a CAD/CAM multiunit provisional restoration as an alternative to orthodontic brackets. This technique simplifies implant therapy by restoring soft tissue and vertical bone height without additional surgical augmentation procedures. Forced eruption followed by immediate implant placement shortens the overall treatment time and provides optimal patient comfort and esthetics during the course of treatment.

Case Report

A 51-year-old Hispanic woman presented to the Advanced Graduate Prosthodontics Clinic at the Harvard School of Dental Medicine. The patient wanted to address the periodontal and restorative issues with her maxillary anterior teeth and to improve the esthetics of her smile. A review of the patient’s past medical history revealed no medical contraindications to prosthodontic and periodontal treatment. The preexisting restorations on the patient’s maxillary right lateral incisor and both central incisors were esthetically compromised due to soft tissue recession, graying of the gingiva from the underlying darkened root structure, and a shade mismatch of the crowns compared to the surrounding dentition. Clinical and radiographic examinations (Fig 1) revealed vertical bony defects with 4-mm probing depths on both the mesial and distal aspects of the right lateral incisor along with buccal gingival recession. The crowns on the right lateral and central incisors exhibited recurrent decay at the margins.

Following initial periodontal therapy and caries control, the maxillary right lateral incisor was deemed nonrestorable due to insufficient remaining tooth structure and a compromised periodontal status. The patient consented to orthodontic extrusion of the left lateral incisor for implant site development. A final restorative treatment plan consisting of a single implant-supported crown on the maxillary right lateral incisor and replacement of the existing crowns on the maxillary central incisors was presented and agreed to by the patient.

The maxillary right lateral incisor had an intact periodontal attachment surrounding the apical third of the tooth, and the existing endodontic treatment was adequate with no periapical pathology. Subsequent to initial periodontal therapy, all probing depths were < 4 mm...
circumferentially, with an absence of inflammation. Intraoral scans were obtained chairside (CEREC Omnicam, Dentsply Sirona), and a splinted fixed provisional prosthesis was designed for the forced eruption procedure (Fig 2). Splinted provisional crowns on the maxillary right lateral and right central incisors with a palatal wing on the adjacent right canine were designed and milled in a polymethyl methacrylate (PMMA) block (Telio CAD, Ivoclar Vivadent) using an in-house milling unit (CEREC MC X, Dentsply Sirona). A ball-clasp wire was bent on the ball-head end to form a hook and serve as an anchor post (Fig 3).

The lateral incisor was then decoronated and a post space was created, into which the anchor post was cemented (Fig 4a) utilizing a universal bonding agent (Scotchbond Universal, 3M ESPE) and a dual-cure resin cement (RelyX Ultimate, 3M ESPE). An inciso-palatal window was made on the provisional crown at the

Fig 2 Labial view of the digital design of the splinted provisional crowns, covering the maxillary right lateral and central incisor with a palatal wing on the adjacent right canine.

Fig 3 A modified ball-clasp wire served as an anchor post for forced eruption of the maxillary right lateral incisor. The surface of the post is sandblasted for maximal retention in the intracanal region.

Fig 4 (a) The anchor post was cemented in the canal space of the tooth to be orthodontically extruded. Note that the tooth was decoronated to the subgingival level to create room for forced eruption. (b) The splinted provisional restoration was placed. Note the prefabricated metal post embedded horizontally in the splinted provisional for the elastomeric chain to loop around. (c) Clinical view and (d) sagittal illustration of the forced eruption set-up for the maxillary right lateral incisor. The elastomeric chain engaged the root of the maxillary right lateral incisor to the provisional restoration.
maxillary lateral incisor site, and grooves were made to embed a pre-fabricated metal post horizontally through the splinted provisional (Fig 4b). The splinted fixed provisional was cemented with polycarboxylate luting cement (Durelon, 3M ESPE) at the maxillary right central incisor and with resin cement (RelyX Ultimate) at the palatal wing on the right canine. A short elastomeric chain (Energy Chain, Rocky Mountain Orthodontics) was engaged on the retentive hook attached to the root structure, wrapped around the horizontal metal post, and engaged back on to the hook to create an extrusive force vector along the long axis of the tooth (Figs 4c and 4d).

Forced eruption of the maxillary right lateral incisor was performed through the splinted fixed provisional for a total of 9 weeks. The patient was seen for a 1-week follow-up and then seen every 2 weeks until the stabilization phase. Regular replacement of the elastomeric chain was necessary to maintain adequate tension to promote tooth movement. At each follow-up, both the tooth root structure and the cervical portion of the provisional restoration at the target site were trimmed to create room for more coronal movement of soft tissue and for tooth eruption. By the end of week 7 of the forced eruption process, adequate coronal movement of the gingival margin 3 mm past that of the contralateral tooth was seen (Fig 5), as well as radiographic evidence of bone fill (Fig 6). At this time, a red patch of tissue was noted along the gingival margin. At week 9, a provisional composite core buildup was completed on the maxillary right lateral incisor, and a new splinted provisional spanning from the right lateral incisor to the left central incisor was made in PMMA (ALIKE, GC America) and cemented with Durelon for stabilization of the right lateral incisor.

After a stabilization phase of close to 4 months, a localized CBCT
scan was taken of the site, and an immediate implant placement procedure was planned. The remaining tooth structure was extracted using periotomes and delivered by forceps. A bone-level tapered implant (Roxolid with SLActive, Straumann; 3.3-mm diameter, 10-mm length) was placed in a flapless fashion with the implant head positioned 3 mm apical to the gingival zenith of the idealized prosthesis (Fig 7a). The gap between the buccal aspect of the implant and the buccal plate was packed with a xenograft (Bio-Oss, Geistlich), and a custom healing abutment was fabricated chairside and delivered. The splinted provisional was cemented with Duranon (Figs 7b and 7c). Patient healing was uneventful, with no reports of swelling or pain.

After 3 months of healing, the implant was provisionalized with a lab-fabricated PMMA crown (SR Ivocron, Ivoclar Vivadent). One month later, final impressions were taken of the implant in the maxillary right lateral incisor position as well as the tooth preparations on the central incisors to proceed with fabrication of the final crowns. Porcelain-fused-to-zirconia crowns were fabricated for the maxillary lateral incisor screw-retained implant crown and the natural tooth crowns (Fig 8). The implant crown was torqued to 35 Ncm, and the screw access hole was sealed with polytetrafluoroethylene tape, with the coronal 2 mm receiving packable composite (IPS Empress Direct, Ivoclar Vivadent) (Fig 9).

Discussion

Orthodontic extrusion has been shown to be effective in ridge augmentation. In a systematic review, Somar et al\textsuperscript{12} reported that orthodontic extrusion has an efficacy of 69% to 100% in vertical bone augmentation. Proper case selection

Fig 7 (a) An implant was placed at the maxillary right lateral incisor. A transfer piece was attached, showing implant angulation. (b) Clinical and (c) radiographic views after implant placement. Note the titanium coping and composite used for fabrication of the custom healing abutment.

Fig 8 Final prostheses for the maxillary central incisors and right lateral incisor. Note the porcelain layering on the facial surfaces. The lateral incisor prosthesis is screw-retained.
is critical to achieving successful implant site development utilizing a forced eruption protocol. Hopeless teeth that are deemed nonrestorable, refractory to endodontic treatment, and must be extracted due to bone loss are good candidates for orthodontic extrusion prior to extraction in preparation for future implant site development. Contraindications for forced eruption include chronic, uncontrollable inflammation; active infection and periapical pathology; root fracture; and ankylosis of the tooth.

Once a tooth is deemed a good candidate for forced eruption, prophylactic endodontic treatment is usually necessary due to the need for coronal reduction to allow for extrusion over time, as well as the need for intracanal anchorage in cases where posts are embedded into the root canal itself. In addition, patient compliance is critical for a successful outcome of forced eruption. Frequent follow-up visits are essential for monitoring the extrusion progress to prevent unusual rates of eruption and to adjust any premature contacts that may deflect applied force and compromise treatment outcomes.

Conserva et al reported that the recommended extrusion speed should not be more than 2 mm per month, with a recommended extrusion rate of within 1 mm per month to allow periodontal ligament movement for the desired height increase in hard and soft tissues. Furthermore, the direction of extrusive force should be applied through the long axis of the tooth and should be centered on the root to avoid buccal tipping of the root, which may lead to fenestration or dehiscence of the buccal plate. In the present case, forced eruption was performed over a 9-week period, during which time approximately 5 mm of vertical eruption was achieved.

Another major benefit of site development through forced eruption is the concurrent gain of soft tissue volume, particularly tissue height, as the tooth is extruded. Forced eruption creates a reversal of the osseous architecture around the tooth being erupted and changes the gingival topography. Provided that the supracrestal gingival fibers are present and attached to the root surface, the soft tissue will...
generally follow the extrusive process. Hochman et al\textsuperscript{13} described the presence or absence of a periodontal pocket and the location of the mucogingival junction in relation to the buccal bony crest as the determining factors for the resulting soft tissue architecture. In the presence of a periodontal pocket, the soft tissue generally will not move coronally until the periodontal pocket is everted through the extrusive process. This eversion of the periodontal pocket often results in a zone of immature reddish tissue along the gingival margin, also known as Atherton’s patch,\textsuperscript{20} which eventually keratinizes. Atherton’s patch can also materialize in the absence of pathology from the inversion of the gingival sulcular epithelium.\textsuperscript{21} When the zone of attached gingiva, and therefore the mucogingival junction, is located apical to the bony crest, tooth extrusion will generally result in an increased zone of keratinized tissue. Alternatively, if the zone of attached gingiva is only attached to the tooth, a coronal displacement of the mucogingival junction can be expected with forced eruption. In the present case, an Atherton’s patch was noted at week 7, with keratinization observed by week 9. Furthermore, an increased zone of attached gingiva was observed following forced eruption.

While the majority of case reports describing forced eruption techniques utilized conventional orthodontic wires and brackets, several authors have presented techniques utilizing fixed provisional restorations to serve as anchor units for forced eruption.\textsuperscript{13,22} In the present case, a milled PMMA provisional was used as an alternative to conventional orthodontic armamentarium during the course of treatment. Compared to conventional self-cured PMMA, milled PMMA restorations have better material homogeneity and increased durability, which makes them more suitable in cases where long-term interim restorations are required.\textsuperscript{23} Similar to the hook technique utilized in Nozawa et al’s case report,\textsuperscript{24} a metal post with a coronal hook was utilized to perform the tooth extrusion with an orthodontic elastomeric chain. The force was applied along the long axis of the tooth through the provisional restoration. This setup is more advantageous than utilizing conventional orthodontic brackets, through which it is difficult to transfer the force vectors along the tooth’s long axis and can result in unwanted consequences, such as buccal movement of the root.\textsuperscript{13}

After completing all planned treatment for the patient described herein, the esthetic results showed significant improvement. Orthodontic extrusion followed by immediate implant placement resulted in a predictable vertical gain of both hard and soft tissues and promoted a minimally invasive, yet efficient, treatment workflow. Furthermore, the use of a CAD/CAM fixed provisional restoration as an anchor for orthodontic extrusion allowed for ideal force vector application to the tooth root as well as minimal esthetic compromise for the patient during the course of treatment.

Conclusions

Orthodontic extrusion is a predictable and efficient nonsurgical alternative to vertical bone and soft tissue augmentation in the development of future implant sites in the esthetic zone. Compared with traditional brackets, the use of a CAD/CAM short-span fixed provisional appears to be an effective and esthetic technique for the forced eruption of a single anterior tooth. In the replacement of a nonrestorable tooth with significant preexisting hard and soft tissue defects, a multidisciplinary approach involving orthodontic extrusion and immediate implant placement can result in excellent esthetic outcomes while minimizing surgical interventions and shortening overall treatment time.

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