Tridimensional Reconstruction of a Complex Iatrogenic Defect Using Orthodontic Forced Eruption and Minimally Invasive Bone Grafting

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Abstract: As the use of dental implants has become more common, so has the frequency of complications and unforeseen outcomes. This article describes the treatment of a complex iatrogenic defect secondary to a failed implant (No. 7) and multiple bone-grafting attempts in the maxillary anterior region. The patient's revealing smile line and high-risk circumstances demanded the use of an interdisciplinary treatment approach with high potential for predictable esthetic results. Forced eruption was performed to restore the alveolar height deficit and develop the compromised hard and soft tissues around teeth Nos. 6 and 8. The subperiosteal minimally invasive (a)esthetic ridge-augmentation technique (SMART) was subsequently used to provide horizontal bone augmentation while preserving the soft-tissue architecture. After bone-graft integration, immediate postextraction implants were placed at Nos. 6 and 8 using a flapless approach, and a screw-retained long-term polymethylmethacrylate provisional prosthesis was delivered during the same appointment. The synergy of these combined therapies resulted in a complete tridimensional reconstruction of the defect. Gingival and alveolar volumes and gingival margin levels were successfully restored.

The use of dental implants has become increasingly widespread and, along with it, the frequency of complications and unexpected outcomes has risen. In particular, iatrogenic sequelae from failed implant and bone-augmentation procedures in the esthetic zone pose a significant challenge because of the often catastrophic nature of the resulting gingival-alveolar defects. In the presence of a revealing smile, treatment of these complications represents a high-risk proposition for clinicians, which is compounded by potential medico-legal implications. The most difficult endeavor in these situations is the recreation of an ideal gingival architecture, particularly when dental implants are involved.

Alveolar ridge defects have traditionally been treated with surgical techniques that involve the reflection of a mucoperiosteal flap. Because these defects often require significant volume augmentation, a greater degree of flap reflection and advancement is needed to achieve adequate coaptation. The risk of complications is also increased, including incomplete wound closure and soft-tissue dehiscences, which could lead to exposure of the membrane or graft material, infections, and compromised hard- and soft-tissue outcomes.
An evaluation of the predictability of bone-augmentation procedures in the esthetic zone must take into account the resulting peri-implant soft-tissue architecture. This factor becomes a crucial concern in high-risk scenarios when improved esthetic outcomes are required and minimally invasive surgical techniques need to be considered. Additionally, the use of combined therapies, including orthodontic forced eruption and distraction osteogenesis, may provide more predictable alternatives to vertical bone augmentation while preserving the soft-tissue architecture.

The purpose of this article is to demonstrate, through the presentation of a case report, the use of an interdisciplinary approach that included forced eruption and a novel subperiosteal minimally invasive (a)esthetic ridge-augmentation technique (SMART) for the treatment of a complex iatrogenic gingival-alveolar defect.

Case Presentation
A healthy 20-year-old woman presented to the author's office requesting treatment for a large defect in the area of missing tooth No. 7. She exhibited a high smile line that revealed a clearly visible deformity, associated with pain and sensitivity on teeth Nos. 6 and 8 and in the area of tooth No. 7 (Figure 1). Although the patient wore a modified Essix retainer, the defect was still visible because of the magnitude of tissue loss and the revealing nature of her smile.

The patient reported previous comprehensive orthodontic therapy, part of which included the creation of adequate space for replacement of the congenitally missing maxillary right lateral incisor. After completion of orthodontic therapy, implant placement and bone grafting were performed in the area of No. 7. Unfortunately, both procedures failed, resulting in a large hard- and soft-tissue defect. A subsequent attempt to perform bone augmentation was also unsuccessful and, instead, resulted in a larger deficit and increased recession on teeth Nos. 6 and 8. After a recommendation to attempt a third bone graft, the patient decided to seek alternative options.

Clinical Examination
The intraoral examination revealed a substantial deficit of alveolar bone and gingival tissues in the maxillary right lateral incisor area. The ridge defect exhibited vertical and horizontal components, which were associated with a severe loss of clinical attachment on both the mesial aspect of tooth No. 6 and the distal aspect of tooth No. 8. Although probing depths were within normal limits, minimal keratinized gingiva was present and the soft tissues were acutely...
inflamed. Plaque removal was difficult because of the soft-tissue defect, gingival-margin location, and irregular soft-tissue architecture. Additionally, bone sequestration could be observed through the labial mucosa (Figure 2).

Tomographic images revealed a large tridimensional defect, with vertical and horizontal loss of bone extending to the apical third of teeth Nos. 6 and 8. Additionally, a buccal bone dehiscence was evident on tooth No. 5, and thin labial plates secondary to the orthodontic movement were present in several areas (Figure 3 and Figure 4).

**Rationale for Implant Therapy in the Esthetic Zone**

Establishing esthetic and restorative objectives is essential in treatment planning for complex defects in the maxillary anterior region. In the present case, teeth Nos. 6 and 8 required extraction and replacement with implants due to their poor prognosis. The patient's high smile line and esthetic demands precluded the use of any prosthesis incorporating pink restorative materials.

Esthetic outcomes in implant therapy are highly dependent on the architecture of the peri-implant soft tissues. Esthetic predictability of immediate postextraction implant placement has been well-documented. Lee and coworkers reported minimal changes in the thickness of the labial plate 6 months after treatment, and Chu et al similarly reported negligible remodeling of labial soft-tissue profiles.

Although different protocols have been advocated, recent publications show consensus on the importance of clinician experience and adequate site selection in achieving predictable esthetic outcomes with immediate postextraction flapless implant placement and provisionalization. Therefore, a rationale for the predictable treatment of severe gingival-alveolar defects in the esthetic zone may require development of compromised sites into ideal sites before implant placement.

In the present case, site development of Nos. 6 and 8 with predictable soft-tissue esthetics would be a complex endeavor requiring the use of interdisciplinary therapy. Whether subsequent immediate implant placement and provisionalization would result in absolute preservation of the hard and soft tissues is less relevant than a comparison between the esthetic outcomes of this approach versus those achieved with traditional flap-based surgical augmentations.

**Esthetic Predictability of Bone-Grafting Procedures**

Bone-grafting procedures have been shown to be efficacious in providing adequate bone volumes for dental implant placement. However, the effect of these procedures on the peri-implant soft-tissue profiles is an important consideration in the esthetic zone. Several authors have reported that bone augmentation, guided bone regeneration (GBR), and flap-based techniques exhibit an increased risk of complications and compromised peri-implant esthetics, frequently resulting in sequelae ranging from scar formation and gingival defects to recession and deficient papillae, particularly in thin-biotype scenarios.

In addition, the patient in this case report exhibited a large iatrogenic defect with a substantial vertical component, and, therefore, the predictability of vertical bone-augmentation procedures...
needed to be considered. In the results of an initial study, Merli and coworkers reported a 54% total complication rate in vertical augmentation procedures comparing the use of autogenous bone grafts with resorbable membranes and titanium plates versus titanium-reinforced barriers. In a subsequent study of vertical GBR outcomes using resorbable and nonresorbable membranes, Merli reported a total complication rate of 41%. The complications included membrane exposure, infections, and loss of the graft. Both studies were limited to posterior sites, and all surgical procedures were performed by a highly skilled clinician with more than 20 years of experience with dental implant surgery.

Because of the high-risk scenario in the present case, based on the iatrogenic nature and complexity of the defect, its location in the anterior maxilla, and the revealing smile line, traditional surgical bone-augmentation procedures (horizontal or vertical) were likely to present an unacceptable rate of complications and lack of esthetic predictability. Therefore, they were not considered as options for resolving the clinical challenges of this case.

Orthodontic Forced Eruption
Bone remodeling associated with orthodontic movement follows the basic principles described by Reitan. When a tooth is moved in a certain direction, bone resorption occurs on the side where pressure is applied to the periodontal ligament, while bone apposition is stimulated by the tension generated on the opposite side. In 1973, Brown reported the effect of orthodontic therapy on periodontal defects and the potential for changes in the hard- and soft-tissue architecture. In a classic report, Ingber described the use of orthodontic forced eruption and the resulting bone remodeling to treat periodontal infrabony defects. Pontoriero et al demonstrated how this technique could also be used to alter interproximal crest levels. Ingber subsequently reported on the benefits of soft-tissue remodeling associated with forced eruption in the treatment of cosmetic soft-tissue deformities. Salama and coworkers later described the use of forced eruption in hopeless teeth and how the resulting orthodontic extrusive remodeling of hard and soft tissues could be used to develop extraction-site defects before implant placement.

Due to its predictability in achieving bone remodeling and developing alveolar ridge height while preserving or improving soft-tissue architecture, forced eruption was included as part of the interdisciplinary approach to treat the patient in the present case (Figure 5). Only stretching forces are applied to the periodontal ligament during the forced-eruption movement. This provides the stimulus for bone apposition within the socket walls. Generally, the orthodontic movement should be controlled so the root is extruded without impinging on the socket walls. In the presence of periodontal health, bone apposition and gingival remodeling will result in coronal proliferation of the attachment apparatus.

Occlusal management during the forced-eruption process is essential to avoid premature contacts that may displace the teeth labially and cause resorption of the buccal plate. The author recommends providing 2.5 mm of occlusal clearance at the start of forced eruption and performing weekly occlusal adjustments to re-establish this distance through the duration of the forced eruption. The rate of extrusion may vary, so patients should be instructed to contact the office for ad hoc adjustments at any point where contact with the opposing dentition may be perceived. Additionally, supracrestal fibroscopy may be performed to sever the periodontal ligament fibers and control the coronal migration of the attachment apparatus. In the present case, supracrestal fibroscopy was performed biweekly on the mesial half of tooth No. 8 and the distal half of tooth No. 6.

Successful outcomes with forced eruption require the establishment of treatment endpoints, which may include overcompensation beyond the desired soft- and hard-tissue changes. For the present case, achieving ideal gingival–alveolar socket architecture required force-erupting tooth No. 6 to the level of the apical third and tooth No. 8 beyond the confines of its alveolus. As the gingival sulcus is everted through the eruption process, a gingival red patch corresponding to the nonkeratinized sulcular epithelium may appear, as shown around tooth No. 8 in Figure 8 and Figure 9. This tissue will develop into keratinized gingiva when exposed to the oral environment. Additionally, when forced eruption of this magnitude is performed, there may be a tendency for lingual displacement that needs to be addressed with root-torquing orthodontic auxiliaries (Figure 6 and Figure 7).
When forced eruption is completed, the teeth should be splinted for a 3-month stabilization period, which will allow mineralization of osteoid tissue and settling of the gingival remodeling process. The degree of forced eruption in the present case was such that extreme mobility precluded the use of a provisional restoration. Instead, a metal-reinforced direct composite splint extending from teeth Nos. 6 to 8 was fabricated in situ (Figure 8 and Figure 9). When compared with the preoperative condition (Figure 2), Figure 8 and Figure 9 depict the treatment progression with forced eruption. The restoration of adequate alveolar height was achieved while enhancing the soft-tissue architecture, and the everted sulcular epithelium on tooth No. 8 proceeded to develop keratinization. However, the pre-existing defect still manifested itself in the form of a residual cleft.

After 3 months of post-orthodontic stabilization, a cone-beam computed tomography scan was taken to re-evaluate the results and plan the future treatment sequence. Tomographic images clearly showed vertical gains in alveolar height, including in the edentulous area corresponding to tooth No. 7 (Figure 10 through Figure 12). The apex of tooth No. 8 was forced-erupted beyond its socket and could be visibly located within the soft tissue.

**Minimally Invasive Bone Grafting**

The effect of complications secondary to traditional bone-augmentation procedures on the peri-implant soft-tissue architecture is an important consideration. Evidence suggests that flap-based surgical techniques, such as bone augmentation and GBR, may have a deleterious effect on implant esthetics. Minimally invasive procedures offer the potential to decrease postoperative complications and morbidity. Although a variety of tunneling techniques with particulate bone grafting have been attempted, they have not been widely accepted in clinical practice. Recent interest has focused mainly on soft-tissue tunneling applications.

The author recently published a case series reporting the use of the SMART minimally invasive bone-grafting method. Bone augmentation was achieved in 60 sites within five treatment categories, with a maximum 30-month follow-up and human histology. The results demonstrated predictable and consistent bone augmentation, with a reduction in morbidity and complications. The mean horizontal augmentation in edentulous ridges was 6.47 mm with the SMART approach, while the average gain in ridge width for all treatment categories was 5.11 mm. These results compare favorably with previously reported horizontal augmentation outcomes using traditional GBR techniques.

For the present case, the SMART method was used to achieve horizontal bone augmentation while preserving the soft-tissue profiles developed using forced eruption. Flap elevation would have resulted in loss of gingival architecture and the residual root of tooth No. 8. A confined subperiosteal tunnel and pouch were developed using the SMART instrumentation and surgical technique to allow the delivery of an anorganic bovine-derived bone mineral and platelet-derived growth factor combination and horizontally augment the labial alveolar bone in area Nos. 6, 7, and 8. The rationale for selecting the biomaterial was based on its low substitution rate and ability to maintain the contours of the augmentation (Figure 13 through Figure 15).
After extraction of teeth Nos. 6 and 8, implants were placed and a screw-retained immediate three-unit provisional was delivered. Fig 22 and Fig 23. The implants selected for teeth Nos. 6 (Fig 22) and 8 (Fig 23) featured a tapered design. Fig 24. At 3 months post immediate implant placement and provisionalization, complete regeneration of the defect and adequate osseous crest levels and bone-to-implant contact were evident radiographically. Fig 25. Three months post-treatment, peri-implant soft tissues appeared healthy. Fig 26 and Fig 27. Three months post-treatment, favorable gingival architecture was preserved.
provisional restoration were modified to approximate the length of the contralateral teeth. The patient reported no complaints, discomfort, or symptomatology throughout the osseointegration period. The implants were stable, and all discernable clinical parameters were within normal limits. The radiographic assessment revealed adequate bone-to-implant contact and osseous crest levels. Similarly, the peri-implant soft tissues displayed a healthy appearance and satisfactory gingival margin architecture (Figure 24 through Figure 27).

The patient subsequently enrolled in medical school, limiting her availability to continue treatment because of academic commitments and geographic location. As a result, she has been maintained with a long-term milled polymethylmethacrylate temporary restoration for an 18-month period and is currently scheduled to return for final impressions and completion of the definitive restoration.

**Discussion**

Predictability is essential when considering the treatment of high-risk scenarios in the esthetic zone. Therefore, the potential outcomes from bone-augmentation procedures must also be evaluated with regard to the achievement of adequate peri-implant soft-tissue architecture.

In this case report, the tridimensional reconstruction of a complex iatrogenic defect was accomplished using orthodontic forced eruption to restore the vertical height and minimally invasive bone grafting to achieve horizontal augmentation.\(^{27,28,48}\) This interdisciplinary approach allowed the predictable development and preservation of favorable peri-implant soft tissues. Gingival volume, margin level, and architecture were successfully restored while avoiding multiple hard- and soft-tissue grafting procedures. The only shortcoming was the length of the papillae adjacent to the area of the defect, which did not match the contralateral side.

The technique used provided adequate bone volume, while the soft-tissue disfigurements, complications, and morbidity associated with traditional GBR procedures were avoided.\(^{48}\) This procedure, however, may be technique sensitive, and predictable outcomes require the use of specially designed instruments, a specific surgical methodology, training, and experience.

**Conclusion**

Forced eruption in conjunction with minimally invasive bone grafting may provide synergistic advantages for the predictable and efficient reconstruction of gingival-alveolar defects in the esthetic zone. Further research and development are required to determine the full potential and limitations of this approach.

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Queries to the author regarding this course may be submitted to authorqueries@eegiscomm.com.
CONTINUING EDUCATION 2 | ESTHETIC RIDGE AUGMENTATION

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REFERENCES


1. Alveolar ridge defects have traditionally been treated with:
   A. orthodontic repositioning of adjacent teeth.
   B. surgical techniques that involve the reflection of a mucoperiosteal flap.
   C. orthotic appliances to remodel adjacent bone into a better architecture.
   D. electromagnetic stimulation of local osteoblasts.

2. Why is a greater degree of flap reflection and advancement needed to achieve adequate coaptation for failed implants?
   A. because alveolar ridge defects often require significant volume augmentation
   B. because these defects are infected
   C. because these defects have virtually no blood supply of their own after an implant has failed
   D. because these defects have approximately 25% shrinkage of the flap within 30 days

3. Establishing esthetic and restorative objectives is essential in treatment planning for complex defects in the:
   A. mandibular premolar region.
   B. mandibular molar region.
   C. maxillary molar region.
   D. maxillary anterior region.

4. The patient's high smile line and esthetic demands precluded the use of:
   A. a traditional metal framework removable partial denture.
   B. a provisional acrylic removable partial denture.
   C. any prosthesis incorporating pink restorative materials.
   D. metal copings.

5. Several authors have reported that which of the following exhibit an increased risk of complications and compromised peri-implant esthetics?
   A. bone augmentation
   B. guided bone regeneration (GBR)
   C. flap-based techniques
   D. All of the above

6. In a subsequent study of vertical GBR outcomes using resorbable and nonresorbable membranes, Merli reported a total complication rate of:
   A. 14%.
   B. 41%.
   C. 73%.
   D. 91%.

7. When a tooth is moved in a certain direction, bone resorption occurs on the side where:
   A. heat is applied to the periodontal ligament.
   B. cold is applied to the periodontal ligament.
   C. pressure is applied to the periodontal ligament.
   D. vibration is applied to the periodontal ligament.

8. For orthodontic forced eruption, bone apposition is stimulated by:
   A. the compression generated on the opposite side.
   B. the tension generated on the opposite side.
   C. the compression generated on the same side.
   D. the tension generated on the same side.

9. What type of forces are applied to the periodontal ligament during the forced eruption movement?
   A. vertical
   B. lateral
   C. stretching
   D. rotational

10. Forced eruption in conjunction with minimally invasive bone grafting may provide what type of advantages for the predictable and efficient reconstruction of gingival-alveolar defects in the esthetic zone?
    A. commensal
    B. synergistic
    C. parasitic
    D. esthetic