
Henry Salama, DMD*  
Maurice Salama, DMD†

Osseointegrated dental implants have enjoyed long-term success in the rehabilitation of totally edentulous patients.1-4 Every aspect of traditional treatment planning protocols continues to be reevaluated and updated to better incorporate the benefits of osseointegration into clinical practice. This is particularly evident as dentistry has endeavored to integrate this approach into the more varied environment of the partially edentulous patient.

Along with the many benefits of added predictability and enhanced options, the ever-evolving role of osseointegrated implants in the treatment of the partially edentulous jaw has also created new challenges. This becomes especially apparent when the periodontal and prosthetic demands of the periodontally compromised patient are incorporated in the treatment plan.

These challenges have created a clear need for new criteria to guide the planning of the periodontal, occlusal, and restorative aspects of the fixture-assisted dental restoration. One aim of these new criteria must be the preparation of a dimensionally adequate and potentially esthetic recipient site for the implant. Other important treatment planning considerations include (1) whether any teeth can be predictably maintained from a periodontal-prosthetic perspective; (2) whether any teeth should be extracted; (3) techniques to augment the subsequent potential receptor site when necessary; and (4) the optimal sequence of implant placement and mucogingival surgical modalities.

One of the more difficult problems arises when it is essential or preferable to place an implant at the site of an existing compromised tooth. Central to such cases is the question of how best to manage the residual defects often associated with the extraction of periodontally hopeless teeth and to place implants successfully at those sites. A complicating factor is the need to maintain functional and esthetic harmony with adjacent natural teeth. Simple extraction followed by a healing period of up to 12 months was recommended as part of the initial Brånemark protocol.5-7 Subsequent bone resorption of thin labial plates or at the crestal height of the extraction socket, however, may result in collapse of a significant part of the ridge. A severe defect may negate the implant option or prove too compromising in esthetically strategic areas. Because the ability to preserve or regenerate ridges postextraction has increased,9 the original approach seems inadequate or, at best, unnecessarily time consuming.

Abstract

A classification scheme that systematizes the wide range of regenerative potential of common extraction site topographies is presented. Within this system, the parameters for immediate implant placement and preliminary ridge augmentation are discussed. In addition, a new adjunctive role for orthodontic extrusion is introduced. This approach is intended to manipulate “hopeless” teeth to modify their local defect environments, thereby enhancing the predictability of subsequent implant placement at those sites. (Int J Periodont Rest Dent 1993;13:313–333.)
Extraction followed by immediate implant placement has been advocated as a more expedient approach to replacing hopeless teeth with implants.\(^{10-12}\) This approach incorporates the principles of guided tissue regeneration (GTR), a method that utilizes a barrier membrane to exclude epithelium and connective tissue from the wound site, thereby selectively promoting the ingrowth of bone around the exposed portion of the implant. This strategy also demands that there be a certain minimal amount of engageable bone at the apical end of the socket or beyond, to stabilize the implant.

While immediate implant placement can be used effectively in many situations with excellent results, it may be ineffective in areas where the periodontal breakdown around the hopeless teeth is particularly severe. Soft tissue defects, because of significant existing recession, can seriously compromise the final esthetic result. In addition, the potential for implant instability from a lack of engageable bone in the severely compromised ridge may preclude use of an implant. Where the potential implant receptor sites are thus compromised, alternative approaches must be employed.

Autogenous grafts have been used to augment severely atrophic arches in the vertical and horizontal dimensions prior to or at the time of implant placement.\(^{13,14}\) A review of the literature\(^{15-17}\) however, indicates that this technique is extremely resource demanding and may be more useful in the fully edentulous arch than in areas exhibiting small edentulous spans.

Techniques that preserve or augment the ridge at the time of extraction can eliminate future implant placement problems and should be considered when a treatment plan is developed for a compromised site. Once extraction defects become established over time, however, the principles of GTR, as they relate to the augmentation of the buccolingual osseous dimensions of localized ridge deformities, may be utilized.\(^{18-20}\) Nyman et al\(^{21}\) presented a case report wherein an implant site deficient in the buccolingual dimension was augmented, utilizing GTR, prior to implant placement. Buser et al\(^{22}\) also reported on the osseous augmentation of short edentulous spans with an emphasis on creating and maintaining a space for GTR during healing.

The augmentative techniques presently available treat the ridge defect and its ramifications either at the time of extraction or at a later date. Alternatively, it would be a great advantage to be able to positively modify the potential defect environment before extraction. Success in such an endeavor may reduce the need for further augmentative surgical intervention.

The efficacy of extrusive tooth movement to improve the soft and hard tissue architecture has been well documented.\(^{23-27}\) Brown\(^{28}\) and Ingber\(^{29-31}\) highlighted molar uprighting and forced eruption, respectively, as methods of modifying the osseous and gingival topography. Since the gingival fiber apparatus lacks elasticity, stretching it during tooth movement imparts tension to the alveolar bone. It is widely accepted that this tension stimulates bone deposition at the alveolar crest.\(^{32-34}\) Extrusive tooth movement also enhances the volume of the soft tissue by increasing the zone of attached gingiva.\(^{35}\) This increase occurs because during this type of movement the gingival margin migrates coronally while the mucogingival junction remains stable.\(^{36}\)

In view of these well-established processes, we have examined the role of controlled extrusive tooth movement as a means by which the position of the gingival margin and the bone crest may be shifted coronally prior to tooth extraction. By addressing isolated deformities in preparation for implant placement, this approach may effectively and uniquely create a greater volume of available bone and soft tissue in the vertical plane without surgical intervention.

The purpose of this paper is to introduce a new perspective, one that utilizes orthodontic extrusion of “hopeless” teeth to enhance the soft and hard tissue dimensions of potential implant recipient sites. To set clear parameters for its application, this technique will be presented within the framework of a systematic approach to managing the extraction defect environment. Several cases will be shown to illustrate rationale and technique.
Classification and treatment guidelines

Extraction sites involving compromised teeth exhibit a socket environment at the apical end and some form of extraction defect environment at the coronal aspect (Fig 1). Therefore, where treatment planning requirements make it necessary to place implants in the area of an existing compromised tooth, it can be anticipated that local deformities of varying complexity will be encountered. The criteria for treatment approaches to sites that are compromised will be discussed based on the severity of the residual defect environment (Fig 2).

The first step to successful treatment planning is the recognition and classification of the problem(s). We have formulated a classification system that focuses on the residual defect morphology and the regenerative potential at the extraction site. These guidelines are comparable to those used to classify periodontal infrabony defects. The regenerative potential of an extraction site can similarly be expected to be related to the number of osseous walls remaining. Accordingly, a socket environment is defined as being contained within four osseous walls and having the best regenerative potential. A defect environment, on the other hand, has three osseous walls or fewer and is associated with correspondingly less predictable osseous regeneration around exposed surfaces of an implant.
Potential extraction sites can be very different. Myriad proportions of the socket-to-defect environments may be exhibited. The degree to which one or the other environment is manifested and dominates the local topography serves as one of the determining factors for choosing the optimal treatment approach. An additional factor that influences treatment decisions is the quantity of the remaining labial plate of bone. This is especially important in the anterior segment because of the more demanding esthetic requirements. We suggest the following guidelines for classifying and treating extraction site deformities.

Type 1 extraction site

The Type 1 site is an incipient defect environment with a good regenerative potential and an acceptable esthetic prognosis:

1. The environment is dominated by the four-wall socket or the incipient three-wall dessorcence-type defect (5 mm or less in the apico-coronal direction). The osseous crests lie in the coronal third of the root to be extracted.
2. Adequate bone is available (ie, 4 to 6 mm) beyond the apex for initial stabilization of an implant.
3. Osseous crestal topography is harmonious, permitting an acceptable discrepancy between the head of the fixture, in the extraction socket, and the necks of the adjacent teeth. Usually a 3- to 5-mm offset is best, because it allows an optimal emergence profile of the restoration from the fixture.
4. The labial plate of bone is adequate, and recession on the tooth to be extracted is manageable, or where esthetics is not paramount (ie, in a patient with a low smile-line or in posterior quadrants).

Type 1 extraction sites, such as the ones exhibited about fractured roots, are best suited for immediate implant placement utilizing the principles of GTR. The critical requirement of initial stabilization is most readily achievable at these sites. In addition, although the volume of the socket can be large, the potential for regeneration in that environment is also great (Figs 3a to 3d).
The obvious advantages of immediate implant placement are its expediency and relative predictability. Compared to the duration of traditional periodontal-prosthetic procedures, the length of treatment with implant restorations is significantly increased because of the additional time involved in performing advanced regenerative techniques and in the healing phase of osseointegration. It is, therefore, fortunate that many cases are amenable to treatment with immediate implant placement. In more severely compromised sites, however, alternative adjunctive techniques become necessary, especially where esthetic detailing or an increased length of the fixture is required.

Type 2 extraction site

A Type 2 site is a moderately compromised regenerative and esthetic environment:

1. A moderate defect environment is predominant, and it extends through the middle third of the root; this includes dehiscences of greater than 5 mm.
2. The discrepancy between the osseous crests of the remaining socket and the necks of adjacent teeth is substantial.
3. Recession is significant and loss of the labial plate of bone is moderate. This is especially critical in the anterior region of the mouth in a patient with a high smileline.

While examples of successful osseous regeneration of three-wall dehiscences measuring 5 mm or less have been reported in the implant literature, no guidance is given for treating more extensive defects, such as the ones characteristic of the Type 2 site. In these cases, successful bone regeneration is limited by the reduced regenerative potential of the site and the increase in exposed implant surface.

Therefore, to achieve greater success in the Type 2 environment, therapy that increases the regenerative potential becomes vital. Preliminary ridge augmentation would serve this purpose. However, it requires an additional surgical procedure and is time consuming. A relatively more expeditious approach is orthodontic modification of the defect; hopeless teeth can be used to modify the Type 2 site.

For teeth designated as hopeless, the usual treatment planning perspective for the fixture-assisted restoration currently suggests only two possibilities. The first is to extract hopeless teeth strategically as part of inflammatory control and, when feasible, to place implants immediately. The second possibility is to retain the hopeless teeth temporarily to help stabilize a provisional restoration while implant fixtures are osseointegrated.

These hopeless teeth, however, afford other unique advantages prior to extraction that can enhance the results of cosmetic and regenerative procedures. Because hopeless teeth are not necessarily useless teeth, the most alluring advantage that these teeth offer resides in their remaining attachment apparatus, ie, periodontal ligament, bone, and cementum. It is ironic that so much effort is put into regenerating these valuable tissues, considering how quickly they are discarded as part of “strategic extraction.” By contrast, our approach to treatment planning capitalizes on these valuable resources. Specifically, manipulation of these tissues through tooth movement, in the more compromised environment, offers the potential for positively altering the potential implant recipient site and, therefore, for optimizing the treatment and final result.

The Type 2 extraction environment poses several functional and esthetic limitations. The reduced regenerative potential of the significant defect environment may force a more apical and possibly less than ideal placement of the implant (Fig 4). Anatomic restrictions may require the use of shorter fixtures. In addition, compromises in the form of longer restorations or uneven gingival margins may prove esthetically unacceptable. In view of these challenges, controlled extrusive tooth movement is presented as an adjunctive treatment approach for the Type 2 environment.

The ability of a tooth to affect its environment orthodontically is contained across the entire length of its attachment. Therefore, it is recommended that, when feasible or necessary, the designated hopeless tooth be extruded almost to extraction to achieve maximal benefits. The authors suggest the term orthodontic extraction for this process, because its purpose is to extract the tooth with all the augmentative benefits inherent to the orthodontic extrusive process. This approach, used alone, works best for teeth with moderate soft and hard tissue defects, because these teeth usually still have a significant amount of attachment remaining. The aim of this technique is to manipulate this remaining attachment orthodontically to augment the gingival and osseous tissues in a vertical direction.
In essence, by relocating the more regenerative socket environment coronally we are eliminating the less regenerative defect environment and turning a Type 2 site into a Type 1 site (Fig 5). Also, where the compromised teeth have flared labially, retraction can be performed simultaneously during the extrusive process. This will favorably realign the socket environment palatally so that the implant can be placed at an angle that will not compromise the prosthetic restoration (Fig 6).

The osseous leveling effect of orthodontic extraction at the Type 2 site offers several benefits over the immediate implant placement procedure. The most important benefit is the creation of a greater volume of available bone to engage the implant at the time of placement. Recent studies of immediate implant placement into extraction sockets or areas that involve a dehiscence have revealed that some specimens exhibit an interposing fibrous seam between the initially exposed implant surface and the newly augmented bone.\textsuperscript{40,41} These results are preliminary and may eventually be attributable to the short observation period. However, we believe that acquisition of a natural and circumferentially more intimate contact between the implant and the adjacent bone at the leveled site may result in greater initial stabilization of the fixture and possibly earlier osseointegration over a larger surface area (Fig 7).
Fig 5  (A) A hopeless tooth with a Type 2 classification. (B) A pulpectomy is performed, periodontal inflammatory control is instituted, and extrusive mechanics is employed. (C) The result transforms a Type 2 site into a Type 1 site. (D) Greater predictable success with immediate implant placement may be achieved because more surface area of the fixture is in intimate contact with the surrounding bone than would have been the case in the original situation (A).

Further, the increase in the gingival dimension that is achieved embodies significant esthetic and technical benefits. Beside providing the considerable esthetic advantage of leveled gingival margins, this approach allows the regeneration of the gingival papilla (Fig 8). The lip of bone that follows the erupting tooth can create and maintain a papilla at the final restoration. The increased width of the attached gingiva, in addition, minimizes the need to lift the tissue to cover the extraction site, and thereby reduces the possibility that the vestibule will be shallow. In many instances, these soft tissue benefits will reduce or eliminate the need for mucogingival procedures later.
Fig 6a. A 58-year-old patient with hypermobile and flared anterior teeth presented for treatment.

Fig 6b. A panoramic radiograph reveals wide circumferential defects around the maxillary canines. The roots of the canines extend to the floor of the nasal cavity, and the amount of bone is not adequate to engage and stabilize an implant.

Fig 6c. A provisional restoration was placed from the right canine to the left first molar. The crowns of the canines were removed and pulpectomies were performed. The roots were debrided to the base of the pocket with a diamond used at high speed. Extrusive and retraction mechanics were employed within the provisional restoration.
Fig 6d  Tissue at completion of the orthodontic phase.

Figs 6e to 6h  Periapical radiographs of the right and left sides before and after extrusion.

Figure 6f

Figure 6g

Figure 6h
Figs 6i to 6n  Reformatted computerized tomographic scans taken before and after orthodontic extrusion. Note the vertical increase in engageable bone and the quality of the transformed recipient sites after extrusion. In Figs 6m and 6n, the effect on the ridge of simultaneous palatal extraction of the left canine is evident. (Courtesy of Biometrix Tech.)
Right Canine
Post

Vertical Extent of Available Bone: 10.2 mm
Slice Spacing: 1.5 mm

Left Canine
Pre

Vertical Extent of Available Bone: 4.3 mm

Left Canine
Post

Vertical Extent of Available Bone: 13.8 mm

Figure
Fig 6o. Stage 1 surgery. Note the complete elimination of the defect environment.

Fig 6p. The left lateral incisor and canine have been extracted and implants have been placed. A membrane will be placed for GTR on the two exposed threads on the labial aspect of the canine area and to augment the thin labial plate of bone.

Fig 6q. Two 13-mm fixtures and three 10-mm fixtures have been placed in the left and right sides, respectively. Periapical radiographs at 3 months.
Fig 7a  Maxillary right canine with 9-mm probing depth interproximally and 6-mm probing depths facially and palatally. Including the 5 mm of recession and the biologic width, the labial crest can be assumed to be approximately 13 mm apical to the cementoenamel junction; therefore, this is a Type 2 site.

Fig 7b  Use of an implant was planned to assist stabilization of a maxillary restoration. The canine was extruded and retracted to modify the recipient site.

Fig 7c  Postextrusion radiographs of the defect environment during stabilization, (left to right) at 0, 2, and 6 weeks.

Fig 7d  New coronal position of the (arrow) labial crest of bone.

Fig 7e  Implant placed completely in a socket environment.
Fig 7f  Tissue during osseointegration phase. Note harmony of mucogingival margin.

Fig 7g  Radiograph at 3 months.

Fig 8a  A 61-year-old patient presented for treatment with a failing maxillary restoration associated with recession. There is inadequate bone to place implants in the maxillary right quadrant.

Figs 8b to 8e  Maxillary right canine prior to extrusion.
Fig 8c  The vertical dimension of the bone at the recipient site is increased postextrusion.

Fig 8d  The postextrusion soft tissue changes are dramatic, as revealed by the formation of (arrow) new papilla.

Fig 8e  Compare soft tissue to that shown in Fig 8f.
mediate implants or sufficient remaining attachment for effective extrusion, the principles of GTR should be used to achieve preliminary ridge augmentation.

**Type 3 extraction site**

A Type 3 site is a severely compromised environment in which immediate implant placement is not an option:

1. Vertical and buccolingual dimensions of bone are inadequate for placement and stabilization of immediate implants.
2. Recession is present and loss of the labial plate of bone is severe.
3. Severe circumferential and angular defects are present.

In experiments with GTR, Gottlow and Nyman found that the volume and shape of the tissue generated under the membrane seemed to be determined by the configuration of the "artificial space." Seibert and Nyman recently presented a pilot study of localized ridge augmentation in dogs. Their findings suggested that some collapse occurred where the membrane was not supported. Additionally, in the areas in which the membrane did not retain its shape, less regeneration was observed. Therefore, space maintenance under the membrane is a critical component, especially when large defects are treated.

The eruptive phase in this technique usually requires 4 to 6 weeks. It is followed by 6 weeks of stabilization before the tooth is removed and the implant is placed. While this approach adds to the length of treatment, it is significantly more expedient than GTR ridge-augmenting techniques, which require 6 to 9 months before implant placement. Use of this technique to address the moderate defect environment allows more predictable placement of longer implants because the coronal relocation of the osseous crest. The technique also results in a more esthetic final restoration by creating a leveled implant receptor site in harmony with the adjacent natural teeth.

One contraindication for forcibly erupting teeth is the presence of chronic, uncontrollable inflammatory lesions, including combined endodontic-periodontic lesions and fractured roots. It is suspected that the fiber apparatus of such teeth is extremely compromised. Inability to control inflammation and acute infection may also adversely affect healing and overall response to treatment.

Even if the roots can be maintained, however, forced eruption only relocates existing attachment. It does not create new attachment. The ability of compromised teeth to influence their adjacent tissues is limited by the quantity of the remaining attachment and the integrity of the fiber apparatus. Polson et al. studied tooth movement into infrabony defects and found that only alveolar bone that was attached to the root via periodontal fibers accompanied the tooth in its movement. Hence, when hopeless teeth lack adequate surrounding bone for stabilization of immediate implants or sufficient remaining attachment for effective extrusion, the principles of GTR should be used to achieve preliminary ridge augmentation.

Treatment of the Type 3 environment begins with a thorough debridement of the extraction site. In our protocol, this is followed by the placement of a mixture of decalcified freeze-dried bone allograft (DFDBA) and tetracycline, covered by GORE-TEX Augmentation Material barrier membrane (Gore). The main purpose of the DFDBA is to serve as scaffolding for space maintenance, especially where the natural anatomy of the defect environment is incapable of supporting the shape of the membrane. We have, on occasion, submerged roots of hopeless teeth as an alternative method of adding support to the tenting of the membrane (Fig 9). Buser et al. presented reports of cases in which minicortical screws were applied, in certain instances, for the same purpose.

Another advantage of utilizing DFDBA is for stimulating bone formation through the osteogenic properties of the bone-morphogenetic protein inherent in the graft medium. The tetracycline, on the other hand, is used to enhance the osteogenic potential of the allograft and to provide local antimicrobial coverage.

The above-described treatment option may be viewed as a two-step approach, similar to methods used to address long-standing ridge defects. The first step is the augmentation procedure, which usually requires 6 to 9 months for full mineralization to occur. The second step is the actual implant placement, which may itself require another augmentation procedure if the initial attempt is not sufficient.
Fig 9a  Radiographs reveal hopeless teeth with severe periodontal breakdown. It is likely that no bone is available for implant placement postextraction.

Fig 9b  At the time of extraction, a deep concavity is found in the right anterior region.

Fig 9c  The maxillary right first premolar has been extracted. The crown has been removed from the canine, but the root has been retained to tent the membrane. Interseal penetration has also been performed.

Fig 9d  The membrane became exposed at 3 months and was removed. Note the complete regeneration of the ridge. The tissue demonstrates a hard, cartilaginous consistency. Implants will be placed in the future.
The maxillary right first premolar and canine demonstrate probing depths of 6 to 9 mm. In addition, the premolar has a Class III furcation involvement. The original treatment plan included extraction of the teeth and replacement with implants.

Fig 10a

Initial extrusion. The palatal root of the first premolar was subsequently amputated and the buccal root was extruded.

Fig 10b

Postextrusion. The teeth were provisionally restored to stabilize the result.

Fig 10c

Two months postextrusion, the first premolar and canine exhibited minimal probing depths and were so stable that they were given permanent restorations. No surgery was ever performed.

(Courtesy of Bruce Goldman, DMD.)
Discussion

There can be several successful approaches to a problem. The development of a more rigid membrane, for example, may offer a better option than the use of screws, retained roots, or grafts for space maintenance. In addition, the development and availability of bone growth factors may enhance the regenerative potential around more compromised sites. The categories and treatments that have been outlined are intended as a general guide to viewing the potential extraction site. They highlight the complexities and choices that presently abound in treatment planning for fixture-assisted dental restorations, even for a specific application, such as the management of hopeless teeth and their compromised environment. At the same time, degrees of success vary with every modality of treatment. The techniques presented have offered the spectrum of successes. Probably the most satisfying experience is when the technique works so well that teeth initially designated as hopeless can be retained (Fig 10).

Summary

When compromised teeth are to be extracted, a well-organized and versatile treatment approach is necessary to maintain or achieve adequate dimensions at these sites for predictable implant placement. Hence, criteria and guidelines for the management of various extraction defect environments were outlined. Within that framework, a new perspective was presented that allows the optimal management and utilization of available assets, ie, hopeless teeth and their attachment apparatus, to augment both the soft and hard tissue profiles of potential implant sites.

Esthetic enhancement of the potential peri-implant gingival margin through orthodontic extrusion was demonstrated. In addition, the osseous profile in the vertical dimension was enhanced. Combined with GTR procedures, these techniques can result in more predictable placement of implants in sites that may initially have been inadequate.

Acknowledgments

We would like to thank Drs Masakazu Nishibori, Fernando Presser, and Jae Hwang, Graduate Students in Periodontal-Prosthesis at the University of Pennsylvania. Their clinical support and contributions helped to enrich this paper.

We are also very grateful to Daniel Freeman and Biometrix Technologies, Inc, for their technical help in reformatting and creating graphics for the CT-scans presented.

References

References


