GUIDED TISSUE REPAIR OF COMPLETE BUCCAL DEHISCENCES ASSOCIATED WITH PERIAPICAL DEFECTS: A CLINICAL RETROSPECTIVE STUDY

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ABSTRACT

Apical surgery can enhance the success of restoring certain endodontically treated teeth. New regenerative surgical modalities, with emphasis on guided tissue regeneration, or GTR, have expanded clinicians' ability to retain teeth that previously were considered to be beyond restoration. The retrospective clinical study described in this article demonstrates that the use of GTR without the use of allograft demineralized bone achieves regeneration that is clinically and radiographically indistinguishable from the surrounding bone. The author presents the indications and contraindications for case selection, surgical management and postoperative findings for this treatment option.

An apicomarginal defect can be defined as a complete loss of buccal alveolus extending from what was once crestal bone to the apex of the tooth. The use of surgical techniques to successfully repair periapical bony defects has been well-documented.[1] Use of a technique to repair apicomarginal defects, however, has not been well-established.

Skoglund and Persson[2] suggested that such defects require combined endodontic-periodontic treatment; however, they reported a success rate of only 37 percent where this defect existed. They defined success as complete bone regeneration (seen radiographically) after an initial surgery where a complete loss of buccal plate had been noted. This definition of success has limitations, however, as it is not possible to determine from radiographic evidence alone whether a bony regeneration has occurred on the buccal surface. Hirsch and colleagues[3] reported a success rate of only 27 percent with complete loss of buccal plate. The overall success rate for periapical surgery, however, has been reported to range from 46 to 92 percent.[4-6] The presence of apicomarginal defects obviously decreases the chances of success; many practitioners, therefore, recommend extraction.

With the advent of guided tissue regeneration, or GTR,[7-10] and a technique using GTR to repair osseous defects,[11,12] there now is a predictable modality as well as specific surgical guidelines and techniques[13] to achieve osseous fill. Dahlin and colleagues[11] showed that GTR can be used when practitioners wish to intentionally create periapical defects so as to achieve osseous regeneration. These regenerative surgical modalities have increased clinicians' ability to retain teeth that previously were considered to be beyond restoration.

Anderegg and colleagues[14] showed clinical evidence of osteoid material under a Gore-Tex Augmentation Material membrane (W.L. Gore & Associates), or GTAM, with and without the use of grafting material. This study was based specifically on the periodontal treatment of osseous defects in molar furcations. The researchers found a statistically significant improvement in both horizontal and vertical bone repair when a demineralized bone graft was used with a GTR membrane vs. the use of a GTR membrane alone. This finding is consistent with the findings of Schallhorn and McClain.[15]

When dealing with periapical defects and, more specifically, apicomarginal defects, Kellert and colleagues[16] as well as Rankow and Krasner[17] used GTR with bone allograft. These authors described how they used decalcified freeze-dried bone allografts, or DFDBA, to provide space between the root and the membrane as well as for their osteogenic potential. There is, however, no long-term radiographic or clinical evidence that demonstrates bone fill or radiographic healing.

There is considerable controversy among researchers and clinicians as to the need to add allograft bone with a membrane exclusion technique in different clinical situations.

Freedman and colleagues[18] published a comparative study of expanded polytetrafluoroethylene, or ePTFE, periodontal membranes, with and without DFDBA. The authors, who were treating interproximal defects, determined that statistically significant clinical results with bone fill were found only when ePTFE barriers alone were used. The authors believed that "the addition of DFDBA to the defect may interfere with the space created by the barrier, thus preventing the repopulation of the site with periodontal ligament cells from the adjacent bone. DFDBA may inhibit the osteoblastic penetration of the site by creating a physical barrier."

Some histological evidence presented by Becker and colleagues[19] suggests that when human DFDBA is tested for its osteoinductive properties in athymic mice, the "predominant histologic feature was nonvital bone chips with minimal amounts of new bone." This study demonstrated that bone implanted after 21 days showed the average amount of nonvital bone chips to range between 78.4 and 92.5 percent. Becker and colleagues indicated that the use of human recombinant bone morphogenic protein, or rhBMP, when combined with DFDBA, produces significant amounts of new bone. The amount of new bone at 21 days with rhBMP was 96 percent. However, rhBMP is not available presently.

Reynolds and Bowers[20] took en bloc sections of human DFDBA placed in intrabony defects and found that even at 6 months, there were considerable residual DFDBA particles. That study's results indicated that nearly 75 percent of DFDBA-grafted intrabony defects exhibited histological evidence of residual graft material. These researchers also used another form of allograft, which included osteogenin; these results showed a significantly greater increase in bone formation.

GTR frequently is used in combination with allograft bone. Tseng and colleagues[21] used this approach to treat a periradicular defect with an associated mucosal defect; McGuire[22] described a similar method to treat osseous defects on the facial surfaces of teeth; Duggins and colleagues[23] used GTR and bone allograft to repair an endodontic furcation perforation; and Trope and Rosenberg[24] described this technique to repair a vertically fractured root.

Figure 1. Case 1, preoperative radiograph. Note the complete radiolucency of the interproximal area between teeth nos. 24 and 25.

It now appears[18,19] that the use of DFDBA without the addition of osteogenin or rhBMP may not be as osteoinductive as once was thought.

The following case reports describe an alternative technique that uses GTR without the addition of bone-grafting material. The technique incorporates the opening of marrow spaces during the surgical procedure to help create an initial blood clot with increased cellular infiltrate. Care is also taken to eliminate any traumatic occlusion during the healing phase. I believe that the actions of creating the initial blood clot and opening the marrow spaces are the only necessary source of osteoprogenitor cells (that is, endosteal osteoblasts and marrow stem cells). In this article, I present evidence—both clinical and radiographic (when available)—to show that this ap-

Figure 2. Case 1, clinical presentation. An extensive apicomarginal defect extended from tooth no. 24 to no. 25, where there was minimal presence of lingual alveolus.

Figure 3. Case 1, 6-month re-entry. Note that the re-entry flap does not include the papilla between teeth nos. 23 and 24, as the Gore-Tex Augmentation Material membrane (W.L. Gore & Associates) was minimally exposed at this level. A full clinical regeneration is seen. There is no line of demarcation between the initial defect and the newly formed tissue.

Figure 4. Case 1, 5-year follow-up radiograph. Re-formation of a lamina dura indicates complete apical healing. Radiographic evidence of osseous regeneration is seen interproximally.

proach may be the best treatment option available to clinicians who perform periapical surgery that is complicated by the presence of an apicomarginal defect.

CASE REPORTS

Case no. 1. A healthy 23-year-old woman was referred for the evaluation and treatment of a mandibular left central incisor. I noted a history of trauma to the area. Electric pulp testing of the adjacent teeth, nos. 23 and 25, indicated vital pulp tissue. A radiographic examination of the area showed a periapical radiolucency that appeared continuous with an interproximal defect between teeth nos. 24 and 25 (Figure 1).

The patient had had endodontic therapy and retreatment before I evaluated her. I observed a Class II mobility on tooth no. 24 and a Class I mobility on tooth no. 25. There was a 5-millimeter pocket on the mesiobuccal aspect of tooth no. 24; I found no other abnormal probing depths.

Upon reflection of a full-thickness flap, a completely dehisced root was evident at tooth no. 24 (Figure 2). In addition to the tooth in question, the adjacent tooth, no. 25, was involved; it had a partially denuded root surface that appeared to be secondary to the pathology from tooth no. 24. I observed no interproximal bone between teeth nos. 24 and 25.

The area healed uneventfully for 6 months, at which point a mild gingival breakdown around the coronal aspect of the GTAM membrane developed. The membrane became minimally exposed below the papillae between teeth nos. 23, 24 and 25, and slightly below no. 26. The re-entry flap was designed to maintain the integrity of the gingival attachment on teeth nos. 23 and 24. Owing to the exposure of the GTAM membrane, I developed a modified incision to maintain the papillae between teeth nos. 22, 23 and 24 and then an intrasulcular incision from tooth no. 25 to no. 26, with a wide vertical release at the mesial aspect of no. 27.

A full osseous regeneration was achieved (Figure 3). The 5-year follow-up radiograph shows the re-formation of a lamina dura and complete healing (Figure 4). There were no probeable pocket depths greater than 3 mm.

Case no. 2. A 60-year-old man was referred for evaluation and treatment of tooth no. 10. The patient's medical history contributed no clues to his condition. Clinical evaluation revealed a small fistula at the midroot height. Endodontic

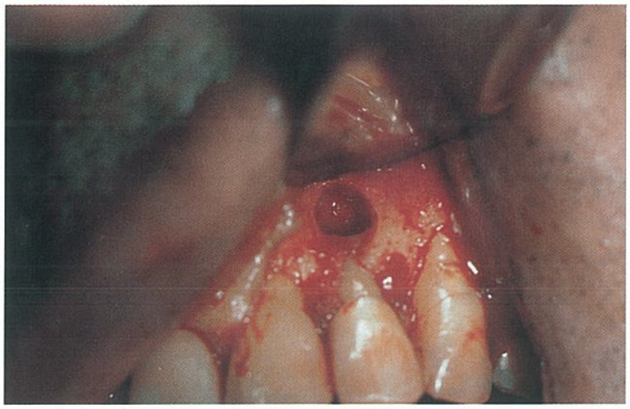

Figure 5. Case 2, clinical presentation. This is the classic apicomarginal defect without adjacent interproximal or interarticular involvement. At best, one could expect only a 27 to 37 percent possibility of osseous regeneration[2,3] when this defect is treated without a membrane.

Figure 6. Case 2, 6-month re-entry at the time of membrane removal. Note the complete clinical osseous regeneration.

treatment was completed although the fistula was not resolved. Probing depths were 3 mm or less. The periapical area was continuous with a complete loss of supporting buccal alveolus (Figure 5).

This case illustrates the classic apicomarginal defect as defined earlier. This particular defect, however, differs from those in the other cases in that the interseptal bone on the mesial and distal areas was intact.

A full regeneration of the alveolus was noted when I removed the membrane 6 months later (Figure 6).

Case no. 3. A healthy 35-year-old woman was referred for evaluation and treatment of tooth no. 20. On the radiograph, I noted a large periapical area at the apex and in close proximity to the mental foramen (Figure 7). Probing depths were 3 mm in all areas except the mesiobuccal aspect of tooth no. 20, which had a 4-mm probeable pocket. I observed a complete apicomarginal defect on tooth no. 20. This was continuous with and extended interproximally between teeth nos. 20 and 21. When I removed the GTAM, full regeneration had occurred. Figure 8 shows that the height of the crestal bone over the root surface is consistent with the adjacent height of crestal bone as seen in Figure 7. A radiograph taken immediately after the surgical procedure is shown in Figure 9. The 5-year follow-up demonstrates a complete radiographic regeneration (Figure 10).

Treatment commonalities among the cases. All three cases described above had the following elements in common.

- A full-thickness flap was reflected with a vertical release. (This enables the surgeon to adequately identify, diagnose and treat this type of defect.)
- Apicoectomies were performed on all teeth. All the roots were thoroughly débrided and root planed before membranes were placed.
- Access was created within the surgical defect to allow for decortication. This is accomplished by creating multiple perforations with the use of a 701L surgical bur, which penetrates the cortical wall or the inner wall of the surgical defect. These perforations allow a rich supply of osteoprogenitor cells to the area, thus ensuring an adequate blood supply for healing.
- A GTAM membrane—which has an inner nonporous and an outer porous component—was placed. The inner portion was positioned over the surgical defect and dehiscence root; the outer portion was positioned over intact bone. The final position of the membrane allowed for a distance of 2 to 3 mm from the gingival margin to the incisal border of the membrane.
- No bone-grafting material of any kind was used.
- Antibiotics as well as chlorhexidine gluconate rinses were prescribed for up to 1 week after surgery.
- A periodontal dressing was placed and maintained for 1 week.
- All GTAM membranes were maintained for 6 months.

DISCUSSION

A number of factors affect alveolar bone[25] and local healing after periapical surgery.[26] Practitioners' awareness of these factors allows them to more accurately diagnose and treat the underlying pathology.

The clinician should watch for the presence of a partial or complete apicomarginal defect in the presence of the following

radiographic or clinical signs:
- a chronic fistula that is present at or near the mucogingival junction (the more coronally a fistula is located, the more likely it is that an apicomarginal defect exists);
- isolated inflammation around the area (the destruction of the periodontium usually has occurred secondary to the endodontic lesion and has developed over time);
- thinning of the mucosa over the buccal aspect of the root with or without palpable root structure evident (note, however, that this finding in the maxilla may be within normal anatomical variation);
- radiographic evidence of a periapical lesion that is continuous with the lateral aspect of the root and associated loss or widening of the lamina dura.

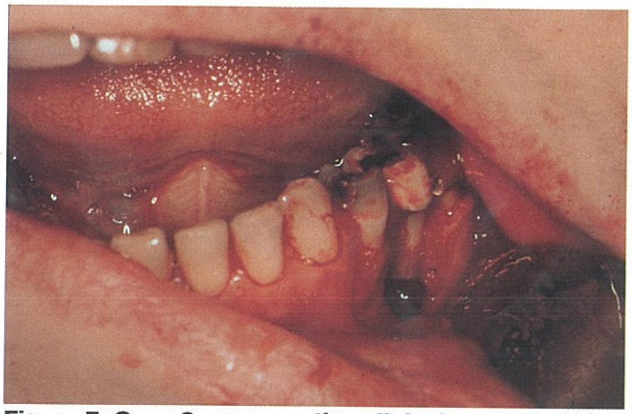
Figure 7. Case 3, preoperative clinical presentation. Note the complete apicomarginal defect on tooth no. 20 and the interproximal bone loss between teeth nos. 20 and 21.

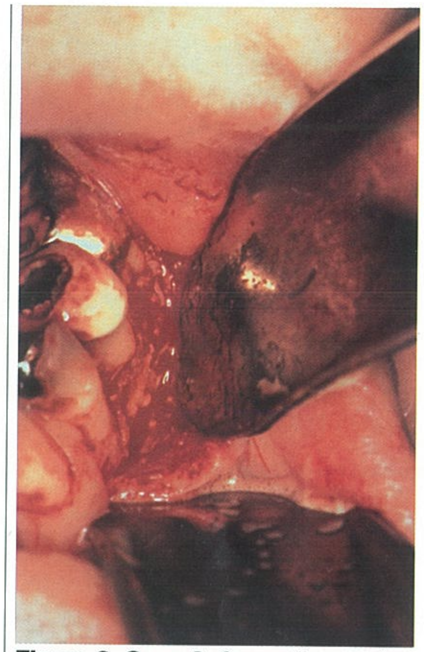
Figure 8. Case 3, 6-month re-entry at the time of membrane removal. Note the complete clinical osseous regeneration.

Although the above criteria suggest apicomarginal defects, they are neither pathognomonic nor all-inclusive. Any or all of the above radiographic or clinical signs can be, and are, seen in the presence of a vertical fracture of a root.

Exploratory surgery should be performed to rule out the presence of a fracture. However, even when a fracture is not evident visually, it may be present and may eventually necessitate the removal of the affected tooth.

Vitality testing should always be done as part of the dental workup. Although a vital pulp suggests nondental etiology, a nonvital pulp is not conclusive for a dental cause. The clinician should be aware of other possible underlying causes of the patient's pathology when he or she treats these people. When noting any isolated pathology without obvious dental etiology, the clinician should take a panoramic survey and a family history to identify any systemic diseases.

If apical lesions are complicated by apicomarginal defects, the success rate for the apicoectomy will be poor.[2,3]

This type of bone loss can suggest dual causes or secondary periodontal involvement. When a periodontal lesion also is present, healing most likely occurs by means of a more coronal connective-tissue attachment or the formation of a long, thin junctional epithelium.[27,28]

When lesions of endodontic origin are complicated by the loss of marginal attachment, the effectiveness of apical surgery may be diminished if epithelial cells are allowed to populate the denuded root surface.[16]

Proposed treatments. The treatments proposed for these types of defects vary considerably. In theory, bone regeneration in the presence of apicomarginal defects is unlikely (when the lesion is of pure endodontic origin) without the use of GTR.[2,3] With the proven effectiveness of barrier membranes, however, practitioners now have the option of a new approach.

A proposed treatment for furcation defects in periodontal defects includes the use of GTR with DFDBA and the application of citric acid.[15] The literature is replete with examples of use of this method to treat osseous defects. The recommended length of time for which clinicians should submerge the GTR membrane usually is 6 weeks. It naturally follows that clinicians, when dealing with other osseous defects, may use a similar approach and time frame for membrane removal. Various articles describe a membrane exclusion technique that involves the addition of DFDBA to provide space below the membrane (and possibly for its osteoinductive potential) and to allow for its removal after 6 weeks.[16,17,22] Kellert

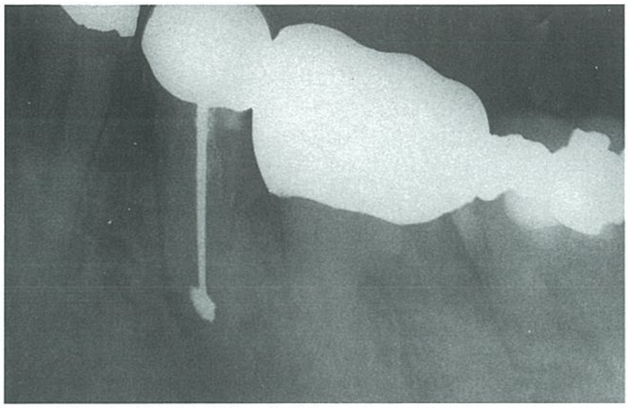

Figure 9. Case 3, immediate postoperative radiograph. Note that the periapical area is continuous with the interproximal defect between teeth nos. 20 and 21. Also note the lack of lamina dura at the apex of tooth no. 20 and at the interproximal marginal crest between teeth nos. 20 and 21.

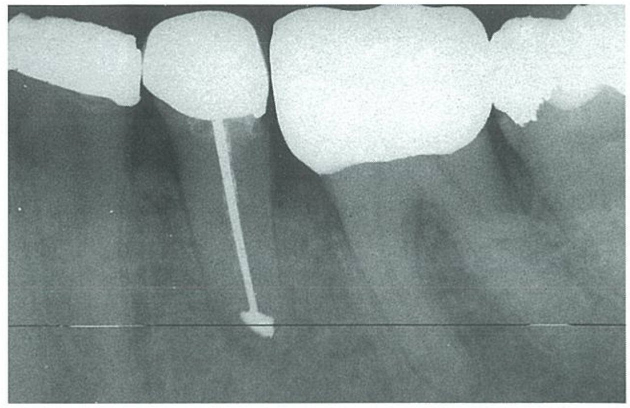

Figure 10. Case 3, 5-year follow-up radiograph. Reformed lamina dura is noted both at the interproximal marginal crest between teeth nos. 20 and 21 and at the apex of tooth no. 20.

and colleagues[16] stated that "healthy granulation tissue was evident in all marginal defects after removal of the Gore-Tex material, 6 weeks postoperatively." But there are no long-term postoperative radiographs or clinical photographs to validate the removal of a membrane at such an early period when treating this type of defect.

In the three cases described in this article, periapical pathology was treated with conventional endodontic therapy. All three patients had complete buccal dehiscences and denuded root surfaces; these would all be classified as complete apicomarginal defects. The first and third patients, in addition to their apicomarginal defects, also had osseous breakdown that involved loss of interproximal bone on the adjacent teeth (Figures 2 and 7).

Pros and cons of allograft bone material. My findings indicated that the use of allograft bone material is not necessary to repair such defects. Many authors believe that the bone graft material creates a space below the membrane that allows for the ingrowth of bone. It may be, however, that the opposite is true—that the DFDBA bone allograft, although functioning as a space filler, may also serve as a physical barrier that blocks osteoblastic activity within the defect below the membrane. I have found that if there is intact bone on either side of the osseous defect and the denuded root is housed within the envelope of the intact bone, a membrane that is placed over the initial blood clot will not collapse. Therefore, there is no need to tent the membrane with any material, such as miniature screws.

When the root structure is completely outside the alveolus, I recommend tenting a membrane to create space, using screws to position the membrane. Titanium-reinforced GTAM membranes are available; these allow space below the membrane to be created more easily. My findings demonstrate that when the apex is outside the alveolar housing, an approach directed toward bringing the root apex within this osseous housing by performing an apicoectomy has very acceptable results and places the root and surrounding alveolus in an ideal periodontal position. The GTAM membrane that is now placed creates a contained defect to allow for repair. In effect, by performing an apicoectomy, the clinician creates a three-walled defect, and the placement of the GTAM membrane transforms the architecture into a contained, four-walled defect.

Hard-tissue regeneration. The re-formation of a lamina dura, as shown radiographically, may indicate the regeneration of overlying bone. If the overlying tissue is fibrous or cartilaginous connective tissue, the underlying tissue most likely is not able to re-form a lamina dura.

This does not, of course, give evidence of bony regeneration on the buccal aspect, as this cannot be seen on a two-dimensional representative radiograph. To demonstrate this, postoperative photographs of all the cases are shown in Figures 3, 6 and 8. In all three cases, the hard tissue was formed and there was no probing depth when a periodontal probe was placed on its surface. This impenetrability was exhibited by the adjacent hard tissue as well. This regenerated tissue appears continuous with the tissue adjacent to it, and no demarcation is evident as to the location of the initial margins of the periapical defect and the initially intact surrounding bone (Figures 3, 6 and 8). Both the tissue formed within the earlier defect and the immediately adjacent hard tissue that was found at the time of surgery and when the GTAM was removed were palpated and found to be solid, nonpenetrable and identical in appearance.

Unfortunately, in the cases discussed above, there is no way to determine with certainty which type of tissue has formed in the previous areas of pathology. If the surgical site has been healing uneventfully, both at the time of membrane removal and after surgery, the removal of tissue for biopsy may adversely affect the newly generated structures and possibly affect the prognosis.

Soft-tissue regeneration. Soft-tissue regeneration is more difficult to determine without the use of a histological specimen. If the re-formed physiologic space between the lamina dura and the root surface of the teeth in question is the same measured distance as the physiologic space between the lamina dura and healthy root structures adjacent to the area in question on the same radiograph, is it not more likely that we have periodontal ligament tissue and not a fibrous attachment or ankylotic state? In evaluating pre- and postoperative radiographs for the first and third cases (Figures 1, 4, 9 and 10), it should be noted, I found that the re-formed space between the newly formed lamina dura and the affected root was consistent with that between adjacent teeth on the same radiograph.

The repair process described in the three cases may involve one or more of a combination of several healing modalities[25]:

- the regeneration of a new periodontal attachment apparatus (alveolar bone, periodontal ligament and cementum);
- formation of new bone with a fibrous capsule around the affected root;
- ankylosis of the involved root;
- some other mechanism.

For a true regeneration, functionally oriented tissue must form.[29] To achieve functional reconstruction, bone must be properly immobilized or the resulting tissue will be more fibrous.

The second factor critical to regeneration is an adequate blood supply.[29] Both of these concerns are addressed and adhered to in the described technique. The teeth in question are kept slightly out of occlusion in centric and all lateral and protrusive excursions. The occlusion is equilibrated until fremitus to palpation on the buccal aspect of the tooth is eliminated in centric. This procedure should minimize any micromovement at the adjacent osseous margins. The vascular supply is enhanced by the opening of marrow spaces, and decortication allows a greater cellular infiltrate. I believe these two factors are basic to the eventual healing that is shown in these three cases and are consistent with traditional orthopedic guidelines for physiologic healing of osseous tissue throughout the body.

Paucity of literature. There are few contributors to the literature on the use of GTR and periapical surgery; all of these support use of allograft DFDBA.[16,17,21,22] Kellert and colleagues[16] advocated the removal of the GTAM membrane after 6 weeks.

Dahlin[30] found that there is a clinically significant increase in the amount of growth factors (insulin growth factor and platelet-derived growth factor) that occupy a surgical defect when a GTAM membrane is overlying the area. One could extrapolate from this that there also should be an increase in growth factors present during early mineralization. It seems logical that the early removal (or early resorption) of a membrane may be detrimental to the resulting quantity and quality of regenerated osseous material. It may in fact be beneficial, both quantitatively and qualitatively, to the resulting regenerated tissue if the membrane is left submerged and intact for an extended period (6 months or more). Dahlin and colleagues[31] and Buser and colleagues[32] did not advocate the use of DFDBA.

I have achieved positive results by leaving the membrane submerged for 6 months and not placing bone-grafting material.

I noted earlier that Freedman and colleagues[18] believed the presence of allograft bone may in itself be a barrier preventing the ingrowth and repopulation of the site with cells from the surrounding structures. This conclusion was based on the treatment of interproximal periodontal defects. This finding was supported by Stahl and Froum[33] in a human clinical study that used both barrier membranes and allografts in the treatment of human vertical defects. They proposed that the presence of the underlying allograft bone may expand the supracrestal space, thus causing initial shrinkage of the flap margin in the early healing stages. They also concluded that the graft's presence may serve as a physical obstruction to optimal coronal migration of progenitor cells.[33] I believe that if a space can be achieved with a membrane or screws, or by altering the anatomy of the site or the membrane structure (with titanium-reinforced GTAM), then ideal regeneration can occur without the addition of allograft bone material.

At what point during the long submergence of membranes may the membrane itself elicit a foreign-body response from the host? This event could cause the breakdown of any repair that may have occurred. Further research on this point is certainly indicated.

Ideally, these successfully treated teeth should be temporized with provisional restorations and should be observed for 6 months before a final restoration is fabricated. During this time, practitioners should assess and monitor the radiographic and periodontal health of the area.

There are no published studies providing long-term results of the use of resorbable membranes for regeneration of large periapical lesions or of the use of these membranes for apicomarginal defects. The question arises as to the longevity of the resorbable membrane vs. the rate of bone regeneration. If the membrane resorbs faster than the osseous regeneration, a complete regeneration may never occur. Uchin[34] demonstrated a relatively sparse regeneration with this approach. Certainly, there is a need for other clinicians and researchers to show clinical and radiographic osseous regeneration with resorbable membranes for apicomarginal defects.

Although use of the nonresorbable membrane requires a second surgery, that procedure offers confirmation of healing. Any minor periodontal defects, either in soft tissue or osseous architecture, can be treated at this time. This can only improve the prognosis. If there is no resolution of the osseous defect, then the tooth in question can be removed and alternative treatment plans previously discussed can be undertaken. This also may be an ideal time to graft or place an implant, if one is being considered. Therefore, the procedure to remove the membrane serves a diagnostic and corrective role. This approach can ensure a more lasting and ideal prognosis for the final restoration.

Although use of the nonresorbable membrane requires a second surgery, that procedure offers confirmation of healing.

INDICATIONS AND CONTRAINDICATIONS

Indications. The described surgical procedure is indicated when there is an absence of supporting buccal alveolus (this is the classic apicomarginal defect as described). Alternative restorative and surgical options also should be considered.

Contraindications. Absolute contraindications for using GTAM to repair an apicomarginal defect include

- the presence of a vertical fracture noted before or during the surgical procedure;
- a medical condition that would negate surgery.

Relative contraindications include the following factors:

- the presence of long-standing periodontal disease with associated alveolar bone loss preceding a periapical defect, which appears to be a poor prognostic indicator for successful regeneration. If the area adjacent to the tooth with the periapical defect has horizontal bone loss approaching the incisal level of the periapical area, repair is not recommended.
- a poor crown-to-root ratio. Ideally, there should be at least a 1:2 crown-to-root ratio. When the root measures less than the height of the crown, alternative restorative and surgical options (such as replacement with a fixed prosthesis, possible grafting with immediate or delayed placement of an implant or removable prosthesis) should be considered.[35]

CONCLUSION

The use of GTR without the addition of allograft bone provides an effective treatment for apicomarginal defects that result from long-standing periapical pathology. This technique for treating teeth that previously were considered to be beyond restoration offers another option to clinicians and patients alike. ■

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