Guided Tissue Regeneration Associated With Orthodontic Therapy

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Guided tissue regeneration (GTR) to enhance genuine new periodontal attachment may improve preorthodontic conditions for moving teeth into infrabony defects or for vertical movements of teeth with reduced bone support. The possible benefits of GTR for combined periodontal/orthodontic therapy are discussed and substantiated with preliminary experimental findings. (Semin Orthod 1996;2:39-45.) Copyright © 1996 by W.B. Saunders Company

In the orthodontic treatment of patients with advanced periodontitis, the crucial issue is often to what extent the osseous topography can be favorably influenced by the orthodontic tooth movement. The preorthodontic periodontal conditions can be characterized by infrabony defects, furcation involvement, interproximal craters, inconsistent margins, and hard and soft tissue dehiscences. Questions may be posed as to what effects on the epithelial and connective tissue attachment result from:

1. Bodily or tipping tooth movement into an intraosseous defect. Can the bony lesion be reduced or eliminated?
2. Moving teeth away from an intraosseous defect (extrusion or uprighting of inclined teeth with one- or two-wall bony pockets)?
3. Intruding migrated elongated teeth back into the reduced alveolar bone?

The answer to these questions is closely correlated with the type of attachment created by the preorthodontic periodontal therapy. In the past, efforts were made to induce periodontal regeneration with traditional methods (open or closed curettage, mechanical or chemical root preparation, filling of intraosseous defects with grafts).

This periodontal therapeutic objective has remained elusive. No matter which technique was used, the healing of a periodontal lesion resulted not in regeneration but in various repair mechanisms such as the formation of a long epithelial attachment, ankylosis or root resorption.1-5 This data confirms the results of previously published experimental and clinical studies dealing with the orthodontic movement of periodontally affected teeth.

Polson et al6 studied periodontal response after bodily tooth movement into infrabony defects. Radiological examination of the alveolar bone adjacent to the moved teeth no longer showed angular defect morphology on the pressure side, but histological examination showed a thin epithelial layer interposed between the root surface and the bone, with epithelium terminating at the apical limit of root instrumentation. It was concluded that orthodontic tooth movement into infrabony periodontal defects had no favorable effects on the level of connective tissue attachment. However, it is possible to move teeth with reduced healthy periodontium without attachment loss. This finding was confirmed by the experimental data published by Ericsson et al.7 Wennström et al8 reported from an animal study that bodily orthodontic movement of plaque-infected teeth with infrabony pockets enhances the rate of destruction of connective tissue attachment. It was concluded that moving teeth into and through inflamed intraosseous lesions creates a high risk of additional attachment loss.

Orthodontic extrusion of teeth with in-
frabony pockets is unproblematic. Ingber recommends this technique with one-wall and two-wall bony pockets that are difficult to treat by means of conventional periodontal therapy alone. The extrusive tooth movement leads to a coronal positioning of intact connective tissue attachment and the bony defect is shallowed out. The orthodontically induced improvement of the crestal bone structure has been reported in clinical trials and animal experiments.

The extrusive component is also the key factor in uprighting tipped molars with a mesial angular bony lesion. In these situations, moving the tooth away from the osseous defect in a disto-occlusal direction shallows out the slanted contour of the alveolar crest. Because of the tension of collagen fibers in the periodontal ligament, the alveolar bone follows the moving tooth on the mesial side, with the level of connective tissue attachment remaining unchanged. If the tipped molar has furcation involvement before orthodontic uprighting, simultaneous extrusion may increase the severity of the furcation defects, especially in the presence of periodontal inflammation.

The intrusion of teeth with horizontal bone loss or infrabony pockets raises the question of whether attachment gain is possible. Although the positive periodontal effects of orthodontic extrusion can be predicted with certainty, the benefits of intrusive movement is controversial. The intrusion of plaque-contaminated teeth leads to the formation of angular bony defects and increased loss of attachment. Ericsson et al confirmed that tipping of a plaque-infected tooth may shift supragingivally located plaque into a subgingival position, resulting in periodontal tissue breakdown. Even in a healthy periodontal environment the question remains as to whether the orthodontic tooth movement intrudes a long epithelial attachment beneath the margin of the alveolar bone or whether the alveolar crest is continuously resorbed in front of the intruding tooth. Vanarsdall recommends extrusion as more predictable in solving periodontal problems. Clinical and histological studies by Melsen and a subsequent clinical investigation considered the preorthodontic and postorthodontic periodontal status following the intrusion of extruded and spaced incisors in patients who had severe periodontal disease. Judging by the clinical (probing depth) and radiological level there was a pronounced beneficial effect on the periodontal status. The clinical crown length was reduced and the marginal bone level approached the cemento-enamel junction. The total amount of alveolar bone support was unaltered or increased.

All reported clinical and histological findings relating to a combined orthodontic-periodontal approach must be assessed from the viewpoint that conventional periodontal treatment does not succeed in regeneration, but in the repair of lost periodontal tissue. The new techniques of guided tissue regeneration (GTR) have virtually revolutionized periodontal therapy. Melcher's vision of extensive restoration of lost attachment seems to be within grasp.

In light of these possibilities, orthodontic techniques in the periodontally diseased dentitions must also be reconsidered.

**Guided Tissue Regeneration: Altered Preorthodontic Conditions**

The fundamental change in the healing of periodontal lesions is the use of a barrier membrane to prevent cells of the gingival connective tissue and the epithelium from colonizing the decontaminated root surface. Cells of the residual periodontal ligament and from bone marrow spaces are allowed to initiate genuine periodontal regeneration and a new cementum layer with inserting collagen fibres and new alveolar bone. There is still controversy as to the role of additional bone grafting materials to support the formation of the new attachment.

Long-term studies by Schallhorn and McClain compared the treatment of severe periodontal defects (furcation defects degree II and
III, bone dehiscences, wide infrabony defects, horizontal bone loss) with membrane material alone and with composite osseus grafting and citric acid root conditioning. The combined membrane-grafting technique produced better clinical results with complete furcation fill found in 72% of the defects. Partial apposition of alveolar bone was noted in dehiscences and horizontal defects with combined therapy, but not at membrane-only sites.

The milipore filter of regenerative membrane material was e-PTFE (GoreTex, Gore Company), which had the drawback of having to be removed at a later time in a second intervention. More satisfactory results have recently been obtained with polymer-based biodegradable membranes (Vicryl, Guidor). It is conceivable that complete periodontal regeneration, even in cases of one-wall infrabony pockets or horizontal bone loss, may be achieved in the future with the additional use of bone morphogenetic proteins, cultured alveolar bone or periodontal ligament (PDL) cells.

The advancement of the techniques of GTR provides a distinct improvement in orthodontic therapy in the periodontally compromised patient. New supracrestal and PDL collagen fibers are gained on the tension side which can transfer the orthodontic force stimulus to the alveolar bone. This might be advantageous for extrusion or intrusion of teeth with intraosseous defects and for the uprighting of tipped molars with mesial angular lesions. It is also conceivable that an over erupted molar tooth with severe furcation involvement might be intruded, thus solving the furcation problem. The findings published by Polson should also be reconsidered in the light of the GTR technique. If preorthodontic measures can prevent the epithelium from proliferating apically, a bodily tooth movement into or through an intraosseous defect might be promising.

A variant of GTR is the restoration of lost bone around implants or in constricted bone areas in preparation for implantation. This guided bone regeneration (GBR) might also be useful for an orthodontic movement of teeth into a long-standing atrophied alveolar process. Experimental reports and clinical studies have shown that a reduction in vertical bone height is not a contraindication for orthodontic tooth movement and that bone height is re-created ahead of the moving tooth. Computer tomography analysis and human histological findings indicate that buccal or lingual bone dehiscences may be provoked by tooth movement into an area of reduced bone width. These defects are not revealed by conventional radiological diagnosis.

Preorthodontic GBR of markedly constricted alveolar ridges also has the advantage that tooth movement through cancellous bone is easier and less detrimental and the formation of interfering gingival invaginations is avoided. The GTR technique with its wide-ranging new perspectives provides a fruitful field for further orthodontic investigations.

Experimental Pilot Study

So far, relatively little has been known about the benefits of the GTR technique in orthodontic therapy. Diedrich et al published a preliminary pilot experiment on dogs in which the intrusive effects on periodontally affected teeth following conventional flap surgery and GTR were compared. A group of teeth with flap surgery served as a control. Poliglactin 910 (Vicryl) a bioreabsorbable polymer, was used as membrane material (Fig 1). During flap surgery the level of the initial osseous crest was marked by a reference notch in the root surface. In addition, non-stained undecalcified sections were examined by fluorescence microscopy to reveal the remodeling bone dynamics and formation of new cementum. Stains with calcium affinity had been administered intravitally at different time intervals using the polychromatic sequential marking technique.

Within the flap operation plus intrusion group, apical positioning of a long epithelial attachment was the rule. Only 6 of 24 evaluated root areas showed an attachment gain and bone support, ie, new cementum and functionally oriented PDL fibres extending beneath the alveolar crest. In areas with pronounced gingival inflammation the bone level was generally located apical of the marking notch, ie, continuous reduction of the alveolar bone margin occurred parallel to the intrusive tooth movement (Fig 2). This correlation between gingival inflammation and nonformation of new attachment was also evident in the GTR plus intrusion group.

However, in all root sections with minimal or
no signs of round cell infiltration the marking notch was located beneath the alveolar margin and new attachment was formed. The potential of the intrusive/regenerative mechanism was most impressive within the interradicular area. Fifty percent of the test teeth displayed complete reconstruction of bone septum and periodontal ligament. The polychromatic bone labeling tech-

Figure 1. (A) Open debridement after experimentally induced periodontitis, approximal and interradicular bone loss. (B) Before flap repositioning the curetted root surfaces are covered with a Vicryl membrane. After initial wound healing (6 weeks) intrusion was initiated.

Figure 2. (A) Intruded approximal root area with pronounced round cell infiltration in the gingival connective tissue. Despite intrusion, the marking notch is located above the bone level caused by progressive bone destruction (toluidin blue staining; original magnification ×250). (B) Higher magnification: proliferating junctional epithelium within the notch area.
Figure 3. (A) Interradicular finding after GTR and intrusion: completely reconstructed bone in the notch area up to the fornix of the furcation (toluidin blue staining; original magnification ×200). (B) The polychromatic calcium-labeling technique shows pronounced new formation of bone and cementum in the fornix of furcation (fluorescence microscopy; original magnification ×400). (C) Extensive bone remodeling processes in the septum, notch area (fluorescence microscopy; original magnification ×320). (D) Higher magnification of the periodontal ligament and interradicular bone in the notch area: new cementum layer and appositional bone formation (fluorescence microscopy; original magnification ×400).
Figure 4. (A) Pathological tooth migration as a result of an advanced periodontal lesion (female patient aged 56 years). (B) Severe intraosseous defect between the right central and lateral incisors (left radiograph). Three months after GTR-treatment (GoreTex membrane) partial reossification is evident, possibly new attachment (right radiograph). (C) A calculated force system from a TMA sectional wire controls space closure and intrusion of the lateral incisor. (D) Retention period after 6 months of orthodontic tooth movement indicating no root resorption and a consolidated alveolar crest. For permanent stabilization a titanium pin was inserted from canine to incisor.

nique proved that the functionally oriented PDL collagen fibers inserted into the newly formed cementum (Fig 3). These positive findings should be substantiated by further studies dealing with other three-dimensional tooth movement. Initial clinical observations (Fig 4) already indicate that GTR enriches the therapeutic spectrum not only in periodontics but also in a combined periodontal/orthodontic approach.

References


