PERIODONTAL REGENERATION: MANAGEMENT OF PERIODONTAL OSSEOUS DEFECTS BY THE PERIODONTIST-DENTAL HYGIENIST TEAM

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ABSTRACT
Periodontal health can be restored through assessment, diagnosis, treatment and management of periodontal osseous defects by the periodontist-dental hygienist team.

Background and Purpose
Treatment of periodontitis has evolved over time, with regenerative periodontal therapy at the forefront in cutting-edge periodontal care. While the techniques and materials available today are allowing therapists to push the limits of periodontal regeneration and achieve success in increasingly more difficult cases, the principles of successful regeneration remain the same. Case selection, identification and resolution of etiologic and contributing factors, proper surgical technique, follow-up and patient education are keys to obtaining a successful outcome. The impact of the dental hygienist in assessment and maintenance is highlighted.

Methods
Literature review of the key research studies evaluating the etiology and contributing factors in the development osseous defects, osseous defect and tooth-related characteristics, and principles of successful regenerative therapy. The authors draw upon their experience with patient care and clinical research to synthesize the evidence relevant to today’s dental hygienist.

Conclusions
Periodontal regeneration is a well-supported and predictable therapy that can be utilized to restore periodontal support and health. The dental hygienist is key in assessing and caring for the periodontal health of patients over time. Identifying who may benefit from regenerative periodontal therapy is an essential skill for today’s practicing dental hygienist.

Key words: Periodontal regeneration, osseous defect, intrabony defect, periodontal regenerative therapy

INTRODUCTION
Dental hygienists are vital to periodontal health management. In addition to providing non-surgical periodontal therapy, periodontal maintenance and prophylaxis, dental hygienists have the opportunity to assess a patient’s periodontal health and monitor for changes over time. An essential component of both prophylaxis and periodontal maintenance includes assessment of the patient’s periodontal health utilizing both clinical and radiographic parameters. Consequently, in many settings periodontal data collection is the responsibility of the dental hygienist,
which, when combined with the general dental examination provides a comprehensive picture of the patient's overall dental health. The comprehensive periodontal evaluation allows for establishment of a 'baseline' to compare current probing depths and attachment levels during a maintenance appointment for the purpose of assessing for adverse changes. As the primary providers of periodontal care and education in the clinical environment, dental hygienists are often the dental profession’s ‘front line’ in periodontal care. Identifying patients who may benefit from regenerative periodontal therapy and providing education is an essential skill for dental hygienists.

Regeneration of the periodontium is a primary therapeutic goal in the treatment of periodontitis. Periodontal disease associated with a bony defect formation provides the opportunity to regenerate lost periodontium, re-establish health and improve support for the dentition. Periodontal regeneration is defined as restoration of alveolar bone, cementum, and functionally-oriented periodontal ligament on a previously diseased root surface. While the definition of periodontal regeneration is based upon histology, clinicians rely on parameters including radiographic bone fill, probing depth reduction and gain in clinical attachment level to evaluate sites treated with regenerative therapy.

Periodontal regenerative procedures have evolved over time with current techniques utilizing various materials, including bone grafts, barrier membranes and biologic mediators. While the materials available allow therapists to push the limits of periodontal regeneration and achieve success in increasingly more difficult cases, the principles of successful regeneration remain constant. Such key principles include case selection, identification and resolution of etiologic and contributing factors, surgical management including defect debridement, root preparation and materials selection and post-operative care and maintenance. Dental hygienists often have the opportunity to assess, treat and educate patients about periodontal health on a long-term and consistent basis. As such, the dental hygienist has a pivotal role in identifying patients who would benefit from periodontal regenerative therapy.

**DIAGNOSIS**

Diagnosis of periodontitis and identification of periodontal defects amenable to regenerative therapy is the first step in treatment. The dental hygienist must be familiar with clinical characteristics associated with periodontitis and periodontal defects as well as etiologic and contributing factors. The pattern of bone loss caused by periodontitis varies among patients and among individual teeth. Horizontal bone loss provides minimal or no opportunity for restoration of the lost supporting structures (Figure 1). Conversely vertical or angular bone loss will often facilitate regenerative therapy, however, the characteristics of the defect and the tooth must be considered (Figure 2). Vertical bone defects are often termed intrabony or infrabony defects and are included in the larger category of periodontal bony defects. Periodontal bone

![](Figure 1. Radiograph demonstrating generalized, severe horizontal bone loss.)

![](Figure 2. Radiograph depicting a vertical bony defect at tooth #9 mesial, note that the bone levels at the distal aspect of tooth #9 and the mesial aspect of tooth #8 are at a normal level.)
Defects include the following defect types: circumferential, crater, funnel-shaped, hemiseptal and furcation-associated. Furcation-associated defects may be considered a separate category due to the unique anatomy and complexity of the furcation area of the tooth. In many cases, a defect is a combination of the different defect types as the number of walls can vary throughout the occluso-apical depth of the defect (Figure 3). Thorough periodontal examination, along with radiographic analysis, provide the basis for diagnosis.

**Diagnostic Tools**

Comprehensive periodontal evaluation (CPE) should be performed for all adult patients on an annual basis. Examination is one of the initial steps performed during a periodontal maintenance appointment or prophylaxis to compare current probing depths and attachment levels to the ‘baseline’ periodontal charting to assess for changes. Some of the components of the CPE include: clinical probing depth (PD), clinical attachment level (CAL), furcation involvement, tooth mobility, keratinized tissue and marginal soft tissue recession. Occlusal evaluation is also important, as occlusal trauma may play a role in disease progression. Clinically, an area of vertical bone loss often presents with deeper PDs localized to one, or more, surfaces of a tooth (Figures 4–6). Furcation involvement may present in variable patterns. The degree of furcation involvement is optimally assessed with a Nabors furcation probe or its equivalent (Figures 7 and 8).

Research suggests periodontal defects are more prevalent in posterior sites and sites with wider interdental spaces. Additionally, studies have found intrabony defect formation is more prevalent in the mandibular arch and at mesial, versus distal, sites. Despite the trends identified through research, vertical bone loss can also be associated with anterior teeth and these defects are often amenable to periodontal regeneration as well as sites in the posterior.

In combination with clinical examination, radiographic evaluation is essential for identification of periodontal defects. While the dentist is responsible for diagnosing periodontal disease, it is important for the dental hygienist to interpret radiographs and be familiar with the radiographic appearance of both vertical and furcation-associated bony defects. Radiographs provide valuable information regarding defect configuration and severity as well as the extent of involvement with the root (Figure 9). Conversely, it is important to recognize the limitations of radiographs and understand that periodontal defects can be both over- and under-estimated when utilizing radiographic criteria alone.

**OSSEOUS DEFECT ASSESSMENT**

Once an area of vertical or furcation-associated bone loss has been identified, the characteristics of the bone defect as well as the affected tooth are considered. The configuration of the defect helps to determine the predictability of regenerative therapy. Tooth-related characteristics such as root form and tooth mobility, extent of furcation involvement, and amount of remaining bone support are equally important in selecting sites that would benefit from regenerative therapy.
Defect Morphology
The morphology, or shape, of a periodontal defect directly impacts the prognosis for regenerative therapy. Periodontal osseous defects are characterized by the number of bony walls that surround the area of the root affected by the bone loss. For example, a three-wall intrabony defect on the distal aspect of a tooth would have a buccal, lingual and distal “wall” surrounding the area of severe bone loss. The bone ‘walls’ of a defect provide physical support and containment for the regenerative materials (Figures 10–12) and are a source of osteoprogenitor, or bone forming, cells in addition to cells derived from the PDL. Research has correlated an increased number of bony walls with greater bone fill within an osseous defect. For example, a study evaluating the results of regenerative therapy in different types of intrabony defects found 3-wall defects had 95% bone fill, 2-wall defects had 82% fill and 1-wall defects had 39% bone fill.8

In addition to the number of bony walls, the size or depth and width of the periodontal defect must be considered. Because the bone walls and PDL are the primary sources of bone-forming cells, a wide defect (Figure 13) presents a greater challenge to bone regeneration as the cells have further to migrate. Alternatively, a narrow defect (Figure 14) will provide more support and facilitate cellular migration and bone regeneration. Several studies have evaluated

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Figure 5. Clinical photograph depicting a localized 8 mm probing depth at #5 mesial which corresponds to the area of severe bone loss demonstrated radiographically in Figure 4.

Figure 6. Surgical photograph of tooth #5 (shown in Figure 5) demonstrating an intrabony defect associated with the mesial root surface; note the buccal “wall” of bone toward the top of the photograph and the bone at the distal surface of tooth #6 is intact.

Figure 7. Clinical photograph demonstrating use of a Nabors probe to assess furcation involvement on the buccal surface of tooth #31; the probe is marked at 3 mm intervals, the furcation probing depth at this site is 6 mm.
periodontal defect width, defined quantitatively as the “angle” of the defect, and its influence on periodontal regeneration. These studies have demonstrated a correlation between a narrow defect, or more acute defect angle, and increased bone fill.9,10 Additionally, narrow and deep intrabony defects have been shown to respond more favorably to regenerative therapy than wide, shallow defects.11

Just as the presence and degree of furcation involvement can significantly impact the prognosis for a tooth, furcation involvement is an important consideration in determining the therapeutic approach and feasibility for periodontal regeneration. A common classification system for furcation involvement is the Glickman system which includes the following categories: class I = bone and attachment loss up to but not within the furcation, class II = bone and attachment loss within but not through the furcation region, class III = through-and-through bone loss involving the furcation area, class IV = similar to class III involvement but with the gingival margin apical to the furcation roof. The prognosis for regenerative therapy can be considered in relation to the degree of furcation involvement. For example, class II furcation involvement offers the greatest opportunity for successful regeneration, underlining the importance of early diagnosis and treatment of furcation involvement.

The anatomy of the furcation and the surrounding bone levels are important in case selection. First, the therapist must be
able to access the furcation for debridement, therefore the furcation entrance must be wide enough to allow instrumentation. Studies have shown a large percentage of furcation entrances are smaller than 0.75 mm. In select cases, the morphology of the furcation may be modified using rotary instrumentation in order to allow access to the furcation. Additionally, the degree and pattern of bone loss surrounding the furcation will also impact treatment. Successful periodontal regeneration has been demonstrated at sites with the following characteristics: interproximal bone height at a more coronal level than furcation entrance, root divergence of 3 mm or less but still accessible for debridement, shallower initial horizontal and vertical probing depths (Figure 15).

**Tooth-related Characteristics**

In combination with defect morphology, tooth-related characteristics significantly impact the success of regenerative therapy. The remaining bone support must be sufficient to provide stability of the tooth during healing (Figure 16). Tooth mobility and its effect on regenerative therapy is somewhat controversial, with some studies indicating no effect of mobility up to Miller class 2 (≤1 mm of horizontal tooth mobility in any direction) and others demonstrating tooth mobility has a negative effect on CAL gain following treatment. Two factors to consider in evaluating tooth mobility are the degree of remaining support and root form. A high degree of mobility may indicate that the remaining bone support for the tooth is poor or the root form is unfavorable; both factors can have a negative impact on the prognosis for regenerative therapy and ultimately the long-term prognosis for maintaining the tooth.

As dental hygienists know, thorough debridement of the diseased root surface is essential in treating a site affected by...
periodontitis; however, effective root debridement may be limited by root and furcation anatomy. Analysis of furcation areas reveals a high incidence of anatomic complications including bifurcation ridges and cervical enamel projections. In addition, root concavities and grooves are found on anterior as well as posterior teeth and can provide a pathway for apical progression of the plaque biofilm as well as an obstacle to effective debridement (Figures 17 and 18). Fortunately, the aforementioned factors can often be reduced or eliminated during surgical therapy, which may improve the treatment outcome and underlines the importance of surgical access in the treatment of periodontal disease.

When a vertical bony defect approaches the apex of the root, the endodontic status of the tooth must be evaluated. If a tooth has a combined endodontic–periodontic lesion, both conditions must be treated in order to successfully resolve the disease and achieve periodontal regeneration. Prior to periodontal surgery, endodontic therapy is necessary. It is important to understand that a primary endodontic lesion may present as localized periodontitis; in such cases, full healing can be obtained without the need for periodontal treatment. Following successful endodontic therapy, when indicated, on a tooth with a combined lesion, periodontal regeneration may also be performed with a similar level of predictability as that of regeneration on vital teeth.

**ETIOLOGY AND CONTRIBUTING FACTORS**

While bacterial plaque biofilm is the primary etiologic agent in periodontitis, individual patient and tooth-related factors are also involved in the development and progression of the
disease. Identifying and addressing etiologic and contributory factors is essential in both successful periodontal regeneration and prevention of disease recurrence and progression. Historically, vertical bony defects were thought to be primarily associated with occlusal trauma18,19; however several studies have demonstrated bacterial plaque is invariably associated with vertical bony defects.20,21 While calculus is not by itself causal, it can enhance disease progression by harboring pathogenic bacteria and extending the radius of biofilm-related destruction.

Aside from plaque biofilm, a number of factors can exacerbate ongoing periodontal disease. Contributing factors include the local, anatomic factors already discussed as well as occlusal and systemic issues. Rather than an etiologic agent, trauma from occlusion may be considered a contributing factor in the progression of periodontitis and thus development of vertical bony defects; however, the periodontal literature is divided surrounding role of occlusal trauma. Analysis of clinical studies suggests occlusal trauma, in the presence of periodontal inflammation, may promote bone and attachment loss.2,22 Furthermore, treatment of occlusal discrepancies when trauma from occlusion has been diagnosed, may improve outcomes of periodontal therapy and may enhance comfort and function for the patient.

Each time a patient is seen for therapy, a review of the medical history is important not only to ensure the patient is safe to treat, but to identify any underlying systemic factors that may be impacting the patient’s periodontal health. It is well-supported in the periodontal literature that the concurrent presence of a systemic disease, such as uncontrolled diabetes mellitus, may influence the course of periodontitis by affecting a patient’s immune response and limiting healing potential.23,24 In the same way, smoking is considered a primary, preventable risk factor for periodontitis. Analysis of the United States population reveals current smokers are four times more likely to have periodontitis than patients who have never smoked.25 Additionally smoking is known to have a dose–response effect, with increased cigarette consumption directly correlating with a higher incidence and greater severity of periodontitis.26–28

TREATMENT
Periodontal regenerative therapy, when properly applied, is a predictable procedure; however, the success of treatment depends heavily upon diagnosis, case-selection and analysis of etiologic and contributing factors. Additional therapeutic factors include excellent surgical technique, utilization of appropriate materials, and proper follow-up. Periodontal

Figure 17. Clinical photograph of a palatoradicular groove, and associated intrabony defect, on a lateral incisor; note the circumferential pattern of bone loss surrounding the portion of the root with the groove. The palatoradicular groove provides a “pathway” for apical migration of the plaque biofilm which can result in development of a bony defect.

Figure 18. Clinical photograph following reduction of the palatoradicular groove, shown in Figure 17, using rotary instrumentation in order to facilitate periodontal regenerative therapy within the intrabony defect.
regeneration is based upon the principle of “selective cell repopulation” of the root surface; defined as promoting of migration and proliferation of progenitor cells of the periodontium, which includes osteoblasts, cementoblasts and fibroblasts and excludes epithelial cells. The goal of periodontal regenerative surgery is to establish new cementum on a previously diseased root surface, new alveolar bone within the defect and a functional periodontal ligament attachment.

In order to facilitate population of the periodontal defect with cells derived from the periodontal attachment apparatus, and surrounding bony walls, and achieve successful regeneration, many therapeutic modalities exist. Defect morphology will influence both the surgical approach to regeneration as well as material-selection. For example, a barrier membrane may be indicated in a wide, non-supportive defect in order to help contain the bone graft and exclude epithelial cells during the healing process. Alternatively, a narrow, well-contained defect may be successfully treated utilizing a bone graft alone or in combination with a biologic agent, or possibly a biologic agent alone. A biologic agent is a biologically active material that can be applied to surgical sites in order to enhance the wound healing process; an example of a contemporary biologic agent is recombinant human platelet-derived growth factor. Currently, many FDA-approved materials are available for use in periodontal regenerative therapy. Categories of regenerative materials include bone graft or bone graft substitutes, barrier membranes, and bioactive agents such as growth factors.

**Surgical Technique**

Surgical technique in periodontal regeneration involves multiple facets including incision and flap design, surgical debridement and root preparation, placement and stabilization of the regenerative material(s), tissue positioning and suturing. Surgical flaps must be designed in order to provide access for debridement and evaluation of the root surface and defect. The initial incisions often dictate whether complete wound closure can be obtained, primary or complete wound closure can significantly increase the success of regenerative therapy. After gaining surgical access, thorough debridement of the defect with cleansing and preparation of the root surface is essential. After the defect and root debridement are complete, the surgeon will evaluate the defect configuration and select the appropriate regenerative materials.

**Follow-up, Assessment of Success, and Periodontal Maintenance**

Following regenerative surgery, special post-operative care is needed to ensure a successful outcome and an optimal long-term prognosis. Close follow-up and supervision are necessary in order to debride the surgical site and educate the patient on appropriate oral hygiene. In many cases, it is recommended that patients return on a weekly or bi-weekly basis until the tissues are sufficiently healed and the patient can perform full oral hygiene procedures without damaging the treated sites. Caution must be used when managing sites post-surgically as the new tissue can be easily traumatized by certain foods, instrumentation or probing forces.

After completion of active treatment, a re-evaluation is necessary to assess the results of therapy and establish a new periodontal ‘baseline’ charting for future comparison. While bone healing and maturation at a grafted site can span over 24 months post-surgery, collagen healing and maturation occurs more rapidly. It is recommended the re-evaluation be performed after a minimum of 6 months of healing post-surgery. If probing is necessary prior to the 6-month post-treatment time point, only light probing should be performed. During the re-evaluation, the therapist can determine if the goals of therapy have been achieved or if additional therapy is necessary to establish health. The appropriate periodontal maintenance recall interval will also be determined at the periodontal re-evaluation appointment.

Following surgical treatment, it is important to maintain a consistent 3-month periodontal maintenance interval. The dental hygienist and dentist must be aware of the patient’s risk status and understand that a history of periodontal disease can indicate increased susceptibility to future bone and attachment loss. Through treatment and maintenance, periodontal disease can successfully be controlled in the majority of cases, however periodontitis cannot be cured and the patient will be at risk for future disease progression. The periodontal literature supports a 3-month periodontal maintenance recall in maintaining patient stability and preventing tooth loss over time. While a 3-month periodontal maintenance interval is most common, it is important to consider the maintenance interval on an individual basis, dependent upon patient risk factors. Some patients may require a shorter interval due to factors such as advanced, progressive disease or poor plaque biofilm control. Conversely, a patient who has achieved stability and has excellent oral hygiene may be well-maintained on a 4-month interval. In addition to maintenance, plaque control is an important patient-based factor that significantly impacts surgical outcomes and long-term periodontal stability. Analysis of patients treated for periodontitis demonstrates a strong and direct correlation between poor plaque biofilm control and progressive disease, irrespective of the type of periodontal treatment performed. Often times the maintenance visits take place in the periodontal office during the critical healing period that may take up to 24 months.

Smoking is a risk factor that both predisposes patients to development of periodontitis and leads to progressive bone loss over time despite previous regenerative therapy. Analysis of patients who experienced progressive periodontitis and
those who lost teeth despite periodontal treatment, revealed smoking, particularly in combination with poor oral hygiene, as a significant risk factor. However, despite the fact that patients who smoke will likely experience increased disease progression over time, they should not be excluded from having regenerative therapy. Several studies demonstrate significant improvement can be achieved; it is important to note that treated sites in smokers are more likely to lose attachment over time.

In evaluating the success of a periodontal regenerative procedure, dental professionals must understand that 100% bone fill within a vertical defect is not a determinant of success and is not routinely anticipated following regenerative therapy. Multiple studies demonstrate residual, shallower defects following treatment while concurrently showing significant improvement in the periodontal support for the teeth. It has been proposed that defect fill of greater than 50% constitutes success. Additionally, conversion of a furcation lesion from a class II or III to a class I furcation is also considered a successful outcome as class I furcations can be successfully maintained on a maintenance program. Comprehensively, periodontal regeneration should be assessed based upon the resultant improvement of the long-term prognosis for the tooth and dentition as a whole. Evaluation of site-specific factors which can either predispose teeth to progressive attachment loss or facilitate stability, reveals that shallow probing depths are more successfully maintained than deeper probing depths. Many long-term studies have demonstrated that periodontal regenerative therapy is effective in improving long-term prognoses for teeth, both in intrabony and furcation defects.

CONCLUSION

The prevalence of destructive periodontitis is approximately 47.2% within the adult population of the United States (roughly 65 million Americans), with 70.1% of US adults 65 years and older affected. The demographics of periodontitis within the US adult population demonstrate a clear need for periodontal therapy as well as opportunity for dental professionals. The Comprehensive Periodontal Evaluation is essential in properly diagnosing patients affected with periodontitis. Once a diagnosis has been made, multifactorial analysis of etiologic and contributing factors is paramount to successful treatment and maintenance. Periodontal regeneration, when optimally performed, is a well-supported therapeutic modality to improve the support for affected teeth and long-term prognosis of the dentition.

Dental hygienists play an essential and unique role in caring for patients’ periodontal health over time. Informing patients about their periodontal health status and educating them about available treatment options is an important responsibility. Dental hygienists have the opportunity to provide care for their patients through in-office therapy; they can also facilitate necessary surgical periodontal therapy through patient assessment and education regarding treatment to preserve their dentition. Timely diagnosis and treatment can allow for restoration of periodontal health through periodontal regenerative therapy. In the broader view, establishment and maintenance of a healthy periodontium will aid in preserving and improving patients’ overall health, function and quality of life.

REFERENCES

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SUGGESTED READING