MetLife
Quality Resource Guide

MetLife designates this activity for 1.0 continuing education credit
for the review of this Quality Resource Guide and successful completion of the post test.

Periodontal Regeneration

Educational Objectives

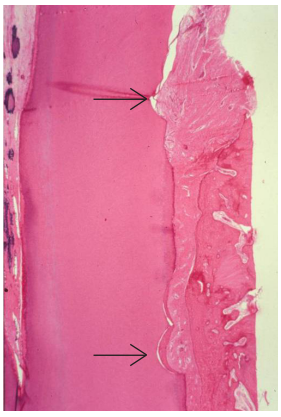
Following this unit of instruction, the practitioner should be able to:

1. Describe the clinical and biological goals of periodontal regeneration.
2. Recognize the clinical and radiographic features of periodontal defects that are favorable for successful periodontal regeneration.
3. Gain a familiarity with current treatment approaches for achieving periodontal regeneration.
4. Understand treatment outcomes based on recent evidence-based systematic reviews.
5. Identify conditions and factors that may adversely impact treatment outcome.

Introduction

Inflammatory periodontal disease can lead to destruction of the supporting structures of the teeth, including bone and connective tissue attachment, culminating in disfigurement, dysfunction, and tooth loss. Conventional surgical approaches, such as open flap debridement, provide critical access to evaluate and detoxify root surfaces as well as establish improved periodontal form and architecture. These surgical techniques, however, offer only limited potential in restoring or reconstituting the destroyed tissues.[1]

Figure 1



Histological evidence of periodontal regeneration (new bone, cementum, and periodontal ligament) following bone grafting with demineralized bone matrix. Note the reference notches placed in the root to mark the pre-treatment apical extent of calculus and height of the alveolar crest.

Courtesy of Dr. Gerald Bowers, Pasadena MD

This guide contains information that allows the dentist to describe the clinical and biological goals of periodontal regeneration. Clinical considerations are reviewed that help the practitioner identify the types of periodontal defects amenable to successful regeneration. An overview of current regenerative therapies is provided as well as a discussion of treatment expectations based on recent systemic reviews. Finally, consideration is given to the conditions and patient-related factors that that may negatively impact treatment outcome. Recognition of these latter factors is important for patient education and treatment planning.

Periodontal Regeneration: Clinical and Biological Goals

Conventional surgical approaches, such as open flap debridement, heal primarily through repair, characterized principally by the formation of a long junctional epithelial attachment to the previously diseased root surface. Long junctional epithelium can be produced rapidly during wound healing due to high proliferative activity of epithelial cells.[2] Limited evidence of formation of other component tissues, such as bone, is found following surgery.

Regenerative therapies are designed to support regeneration of the attachment apparatus; namely, the formation of new bone, cementum, and periodontal ligament. The biological goal of periodontal regeneration, therefore, is restoration of the lost periodontium. Repair is healing of the periodontal attachment apparatus by tissue, such as junctional epithelium, that does not fully restore

THIRD EDITION

Author Acknowledgements

Mark A. Reynolds, DDS PhD
Mary Elizabeth Aichelmann-Reidy DDS
Division of Periodontics
University of Maryland School of Dentistry
Baltimore, Maryland

Drs. Reynolds and Aichelmann-Reidy have no relevant relationships to disclose.

Originally published March 2009. Updated and revised March 2013 and July 2017. Expiration date: July 2020. The content of this Guide is subject to change as new scientific information becomes available.

ADA C·E·R·P® Continuing Education Recognition Program

MetLife is an ADA CERP Recognized Provider.

ADA CERP is a service of the American Dental Association to assist dental professionals in identifying quality providers of continuing dental education. ADA CERP does not approve or endorse individual courses or instructors, nor does it imply acceptance of credit hours by boards of dentistry.

Concerns or complaints about a CE provider may be directed to the provider or to ADA CERP at www.ada.org/goto/cerp.

Accepted Program Provider FAGD/MAGD Credit 11/01/16 - 12/31/20.

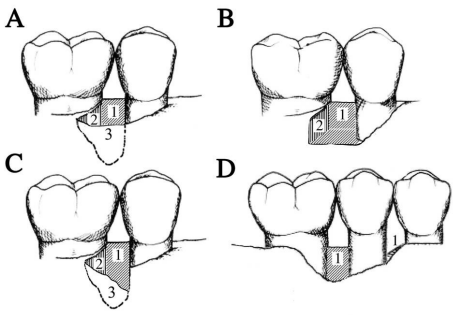
Address comments to:
dentalquality@MetLife.com
MetLife Dental
Quality Initiatives Program
501 US Highway 22
Bridgewater, NJ 08807

architecture and function. Currently, conclusive evidence of periodontal regeneration can only be provided through histological evaluation of treated intra-osseous defects using unambiguous reference points **(Figure 1)**. Emerging advances in imaging technology, however, may offer the potential for non-invasive three-dimensional evaluation of regenerative outcomes. Clinical outcome parameters consistent with successful regenerative therapy include reduced probing depth, increased clinical attachment level, and radiographic evidence of bone fill.

Periodontal Defects and Regenerative Success

Chronic inflammation can result in destructive changes in the component hard and soft tissues of the periodontium, culminating in loss of supporting alveolar bone and periodontal attachment. Resulting gingival pocket formation can be characterized as suprabony (supracrestal), where the base of the pocket is coronal to crestal bone, or intrabony (subcrestal), where the base of the pocket is apical to crestal bone. Suprabony pockets are typically associated with a horizontal pattern of alveolar bone loss that is not amenable to periodontal regeneration with available regenerative therapies. Intrabony pockets, in contrast, are associated with vertical or angular bony defects that are often amenable to periodontal regeneration.

Figure 2



Schematic illustration of intraosseous defects classified according to the number of bony walls present. **(A)** 3-wall defect; **(B)** 2-wall defect; **(C)** combination defect; **(D)** 1-wall defect. One-wall defects typically do not respond well to current regenerative therapies.

Intrabony Defects

Intrabony defects are commonly described by the number of bony walls (1, 2, or 3 walls) and depth of the defect (measured from the crestal height of bone to the base of the defect) **(Figure 2)**. Periodontal probing and transgingival bone 'sounding' can provide important diagnostic information to aid the appropriate selection of regenerative therapy for intrabony defects.[3] Radiographs also provide a valuable tool for selecting defects suitable for regenerative therapy by aiding the estimation of interproximal bone loss; however, radiographic measures generally underestimate bone loss.[4]

Furcation Defects

Loss of periodontal ligament and bone exposing the furcation region of multi-rooted teeth can severely limit plaque control and compromise the tooth prognosis. Therefore, the goal of regenerative treatment is closure of the furcation entrance with hard and soft tissue to improve tooth prognosis and retention. Furcation invasion is most commonly classified according to the degree of horizontal extension within the furcation. For example, furcation invasion is often classified as Class I (incipient loss of bone limited to the furcation flute that does not extend horizontally within the furcation); Class II (variable bone loss that does not extend completely through the furcation; and Class III (bone loss extending completely through the furcation).[5]

Furcation defects are associated with an increased risk of progressive loss of connective tissue attachment, alveolar bone resorption, and tooth mortality. Although early or incipient Class I furcation defects are generally considered maintainable by nonsurgical therapy and effective plaque control, more advanced furcation defects (Class II and III) usually require surgical management for effective inflammatory disease control and retention.[5] Surgery permits access for root debridement, detoxification, and odontoplasty to promote periodontal regeneration. The primary clinical objective in the regenerative treatment of Class II furcation defects is closure of the furcation entrance to the oral environment. Class III furcation defects are generally not amenable to successful regenerative therapy and are usually treated with surgical debridement or resection.

Gingival Recession Defects

Gingival recession is most commonly a result of chronic inflammation secondary to injury - physical, bacterial, or both. Exposure of the root surface increases the risk of esthetic concerns, root sensitivity, and caries. The most widely used classification system of marginal gingival recession is based on defect characteristics which are correlated with treatment prognosis; namely, the potential to achieve complete root coverage with surgical therapy.[6] The Miller classification system, Class I – IV, is based on the level of the marginal tissue recession in relation to the mucogingival junction, relative tooth position in the arch, and the integrity of the interdental bone and soft tissue morphology. **(Table 1)**

Table 1

Miller's Classification of Marginal Tissue Recession[6]

Classification	Criteria
Class I	Marginal tissue recession that does not extend to the mucogingival junction
Class II	Marginal tissue recession that extends to or beyond the mucogingival junction, with no periodontal attachment loss
Class III	Marginal tissue recession that extends to or beyond the mucogingival junction, with periodontal attachment loss in the interdental area or malpositioning of teeth
Class IV	Marginal tissue recession that extends to or beyond the mucogingival junction, with severe bone or soft-tissue loss in the interdental area and/or severe malpositioning of teeth

Current Regenerative Therapies

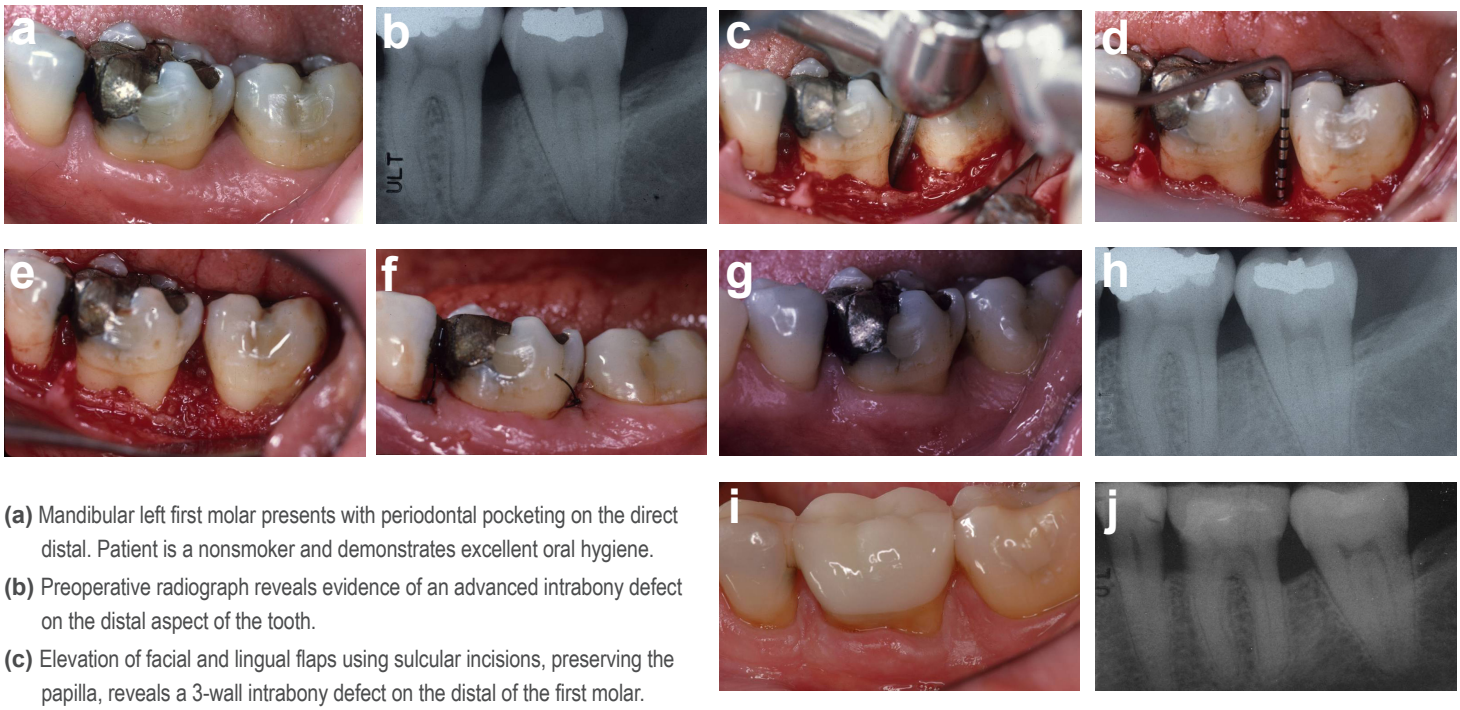
Contemporary therapeutic approaches to periodontal regeneration include bone replacement grafts, guided tissue regeneration (GTR) barriers, protein and peptide-based products (biological mediators), and gingival graft materials.[7-10] These regenerative therapies have been used in combination and in conjunction with agents to modify and promote wound healing.

Bone Grafting Materials

Bone replacement grafts are widely used in the correction of periodontal osseous defects. Bone replacement grafts serve as osteoconductive scaffolds that promote space maintenance, clot stabilization, and cell migration **(Figure 3)**. A wide range of graft materials, including autografts (self-derived), allografts (human-derived), xenografts (animal-derived), and alloplasts (synthetic), have been used in periodontal regeneration.[7] Commercially marketed bone grafting materials are regulated by the Food and Drug Administration (FDA) under statutes published in Code of Federal Regulations (Federal Register, Title 21). Human tissue intended for transplantation also comes under the regulatory control of this agency. The FDA requires that facilities engaged in procuring and processing human tissues for transplantation ensure that specified minimum medical screening and infectious disease testing has been performed and that records document screening and testing for each human tissue. The American Association of Tissue Banks (AATB) also sets standards, inspects facilities, and accredits tissue banks in North America. Tissue banks accredited by the AATB undergo examination for compliance with all aspects of the Association's standards and policies, including record-keeping, quality control, quality assurance, donor screening, testing and suitability determinations. There are no reports of disease transmission during the more than 30-year history of use of freeze-dried bone allografts in periodontal therapy, as posted by the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.[11]

Historically, the 'gold standard' for bone grafting in orthopedics and periodontics has been autogenous bone/bone marrow harvested from the iliac crest. Bone marrow is rich in stem cells and progenitor cells that have the potential to form bone (osteogenic) when transplanted into an osseous defect. A 1 cc graft of iliac crest marrow from an adult yields approximately 1,000 to 1,500 mesenchymal stem cells, which are

Figure 3



(a) Mandibular left first molar presents with periodontal pocketing on the direct distal. Patient is a nonsmoker and demonstrates excellent oral hygiene.

(b) Preoperative radiograph reveals evidence of an advanced intrabony defect on the distal aspect of the tooth.

(c) Elevation of facial and lingual flaps using sulcular incisions, preserving the papilla, reveals a 3-wall intrabony defect on the distal of the first molar. Rotary instrumentation using a multifluted surgical length bur was used to plane the root surface to the depth of the defect.

(d) Following debridement and root planing, the defect measures 5 mm from base to the alveolar crest. Small perforations are made to decorticate the bony walls of the defect, which increase bleeding, and citric acid (pH 1.0) is applied topically to decontaminate and condition the root surface.

(e) Demineralized freeze-dried bone allograft is placed with light incremental pressure until the bone graft slightly overfills the defect.

(f) Primary closure of the flaps is achieved using monofilament sutures.

(g) Clinical presentation of the surgical site 3 years following bone grafting surgery.

(h) Postoperative radiograph suggests nearly complete resolution of the intrabony defect, consistent with successful periodontal regeneration.

(i) Clinical presentation of the surgical site approximately 13 years following bone grafting surgery. Probing depths remain 3 mm or less.

(j) Postoperative radiograph demonstrates the stability of the site 13 years following bone grafting.

Courtesy of Dr Paul S. Rosen, Yardley PA

capable of differentiating into osteoblasts and other cell types required for periodontal regeneration.[12] Nevertheless, multiple clinical considerations, such as donor site morbidity, have limited the use of autogenous grafts. Numerous particulate bone grafting materials are commercially available, such as allogeneic bone, xenogeneic bone, calcium phosphate ceramics, bioactive glass, coralline calcium carbonate, among others. Currently, bone allografts are the most widely used grafting materials in periodontal regeneration in the United States. Demineralized freeze-dried bone allograft (DFDBA), or demineralized bone matrix, is allogeneic bone that has undergone extensive decalcification and mineral removal. DFDBA exhibits the capacity to induce bone formation (osteoinductive) in nonorthotopic sites, such as muscle, presumably due to the exposure of bone morphogenetic proteins.[13] DFDBA has been shown on a histologic level to support periodontal regeneration in humans.[14,15]

Bone grafts function as structural scaffolds and matrices for attachment and proliferation of anchorage-dependent osteogenic cells at the recipient site. A primary determinant of regenerative capacity is the mobilization of pluripotent mesenchymal stem cells, which have the capacity to differentiate into a variety of cell types, including osteoblasts and periodontal ligament fibroblasts, depending on the recipient site and the type of signals available.[16] Recent advances in tissue banking make it possible to preserve mesenchymal stem cells and osteoporogenitor cells as part of an allogenic cellular bone matrix. Allogeneic bone grafts that have undergone selective depletion of immunogenic cells while preserving mesenchymal stem and osteoprogenitor cells may offer the potential to achieve more predictable and robust regenerative outcomes, while minimizing risk of allogeneic rejection.[17] Current technologies allow for the selective retention of high numbers of mesenchymal stem and osteoprogenitor cells. Osteocel® (Ace Surgical Supply, Inc., Brockton, MA), for example, is a cryopreserved cellular bone matrix allograft that is processed to contain a minimum of 50,000 cells/cc with a cell viability of 70% or greater of the enzymatically released cells.[18] The bone matrix is stored on dry ice or at -80°C and must be thawed prior to clinical application **(Figure 4)**.

The success of regenerative therapy is influenced by multiple factors related to the patient, periodontal defect, and surgical management.[7,19] With the exception of autogenous bone/bone marrow grafts, allogeneic cellular bone matrix, and allogeneic demineralized bone matrix, most bone replacement grafts are considered passive scaffolds providing space maintenance and a framework for cellular migration and tissue formation. Recent attention has focused on the potential for protein and peptide-based products (biological mediators) to improve wound healing and enhance the clinical benefits of bone replacement grafts. There are two commercially available dental bone grafts with biologic components - PepGen P-15™ (Dentsply Friadent, Mannheim, Germany) and GEM 21S™ (Osteohealth/Luitpold Pharmaceuticals, Inc., Shirley, NY). PepGen P-15™ is bovine-derived hydroxylapatite (anorganic bone) that contains a short polypeptide chain of 15 amino acids, which is a biomimetic cell binding region of type I collagen. GEM 21S® is a completely synthetic grafting system composed of a purified recombinant human platelet-derived growth factor-BB (rhPDGF-BB) and ß-tricalcium phosphate (ß-TCP) scaffold. GEM 21S® is the first dental bone grafting material approved by the FDA with a recombinant growth factor. GEM 21S® contains over 1000 times the concentration of platelet-derived growth factor obtainable in current platelet rich plasma preparations.

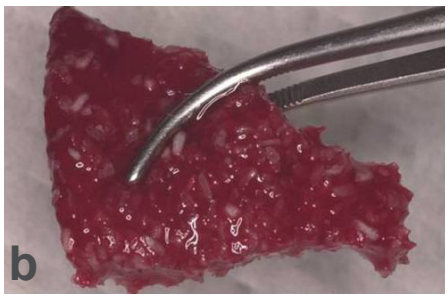
Unlike the particulate bone grafts, Emdogain® (Straumann USA LLC, Andover, MA) is an enamel-matrix derivative comprised of porcine proteins (amelogenins) delivered in a resorbable material (propylene glycol alginate). Emdogain® is classified by U.S. FDA as a device (biological material, dental) and regulated as a bone grafting material. It is approved for the topical application to root surfaces as an adjunct to surgery. The combination of enamel-matrix derivative and bone grafts may result in additional clinical improvements compared with those obtained with enamel-matrix derivative alone.[20]

Finally, bone grafts can be combined with growth factors obtained from the serum of a patient. Platelet-rich preparations (PRP), such as platelet-rich plasma and platelet-rich fibrin, collected from centrifugation of serum, provides a source of highly concentrated autogenous platelets containing growth factors, such as platelet-derived growth factor and transforming growth factor-ß, which are critical for normal healing.[21] When admixed with a bone graft, PRP facilitate graft placement and containment and may provide beneficial effects in the treatment of intra-bony defects.[22,23] **(Figure 5)**

Figure 4

Cellular bone matrix allograft contains mesenchymal stem cells capable of differentiating into cells, such as osteoblasts, necessary for periodontal regeneration. Blood from the surgical field is visible on the instrument (not the bone matrix).

Figure 5



(a) Platelet-rich plasma provides a source of autogenous growth factors, which can be admixed with the bone graft. **(b)** Adhesive properties of platelet-rich plasma can facilitate graft placement and containment.

Courtesy of Dr. James Kassolis, Baltimore MD

Guided Tissue Regeneration

Guided tissue regeneration (GTR) is a surgical procedure in which a barrier material in the form of semi-permeable membrane is interposed between the mucoperiosteal flap and the bone and tooth surfaces during surgery. Barrier membranes are designed to be biocompatible, cell occlusive, space making, and allow for tissue integration. By impeding epithelial and gingival cell migration onto the root surface and into the intra-osseous defect, barrier membranes promote the selective re-colonization of the periodontal defect with cells supporting the formation of new bone, cementum, and periodontal ligament. Historically, the synthetic membrane, expanded-polytetrafluoroethylene (ePTFE), served as the 'gold standard' in GTR therapy; however, ePTFE membranes require a second surgical procedure for removal. Currently, the most widely used barrier membranes are made from collagens or synthetic polymers, which undergo degradation and, therefore, do not require a second surgical procedure for removal.

Lasers

Clinical research continues to advance the incorporation of lasers into periodontal practice, including applications for regenerative therapy. As part of the minimally invasive laser-assisted new attachment procedure (LANAP®; Millennium Dental Technologies, Inc., Cerritos, CA) protocol, a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser is used to selectively remove pocket epithelium, reduce pathogenic bacteria, and stimulate hemostasis. Clinical studies document that the LANAP® protocol achieves favorable improvements in clinical parameters, including reductions in probing depth and gains in clinical attachment level.[24] Two case-series publications provide histologic evidence that the LANAP® protocol can induce periodontal regeneration, including new bone, cementum, and periodontal ligament.[25,26] Future controlled interventional trials will help provide important information on the comparative effectiveness and predictability of regenerative outcomes.

Gingival Grafting Materials

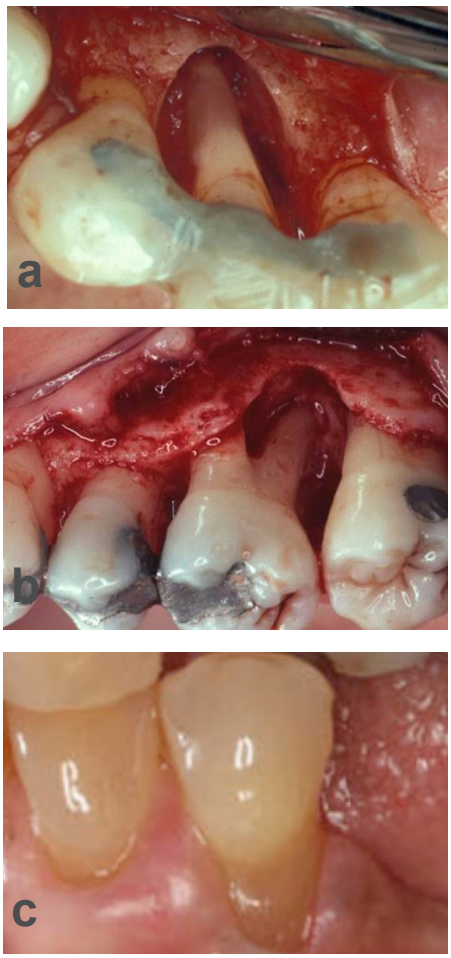
The surgical management of exposed roots always involves mobilization of a flap as part of the root coverage procedure. In most instances, the pedicle or coronally positioned flap is combined with an autogenous subepithelial connective tissue graft, allogeneic acellular dermal matrix, or GTR barrier membrane. A major advantage of the acellular dermal matrix is the ability to treat multiple recession defects in the same surgical procedure, which may not be practical or possible using autogenous grafts.[27]

Case Selection

In general, early or shallow intrabony lesions (defects of 3 mm or less) and class I (incipient) furcation defects can be effectively managed using nonsurgical or non-regenerative surgical therapies. Early intrabony defects are thought to have less potential for regeneration due, in part, to a limited potential for space maintenance and concomitant crestal bone resorption during healing.[28] Given adequate surgical access, the most predictable regenerative outcomes are typically achieved in 3-wall or combined 2- and 3-wall defects as well as class II furcation defects with proximal bone height at or above the level of the furcation entrance. With respect to predictable regenerative treatment of recession defects, root coverage is possible when there is no periodontal attachment loss (bone or soft tissue) in the interdental area, as in Class I or Class II recession defects. In contrast, advanced 1-wall intrabony defects, class III furcation defects ('through-and-through'), and recession defects with interproximal bone loss are currently poor candidates for periodontal regeneration **(Figure 6)**.

The decision to extract teeth with a questionable prognosis (e.g., 50% or greater bone loss or class III furcation defects) must be based on factors, such as patient compliance, that impact the potential to achieve periodontal stability and contribute to the overall prosthetic rehabilitation. Similarly, the decision to retain teeth with progressive periodontal destruction must be carefully considered in relation to the potential impact of alveolar bone loss on future implant-supported prosthetic care **(Figure 7)**. Strategic extractions have been advocated for a variety of reasons - creating a more hygienic environment, improving the periodontal prognosis of adjacent teeth, and enhancing the overall prosthetic treatment plan.[29,30] Given the overall success rate of endosseous dental implants, the clinical parameters guiding the use of strategic extractions must now include consideration for preservation of alveolar bone for implant-supported prosthetic care.[31-34]

Figure 6



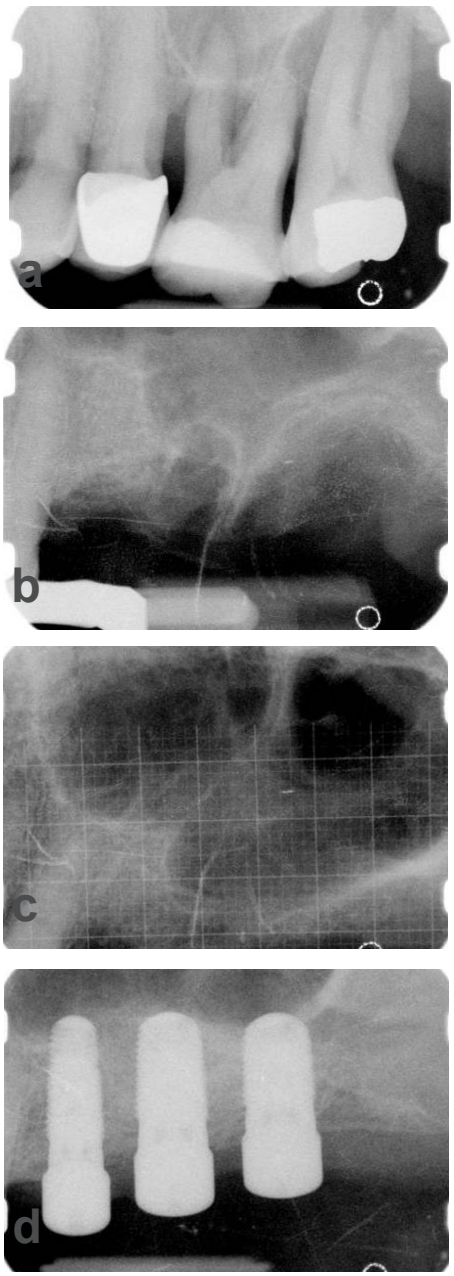
(a) Teeth with advanced intraosseous defects or **(b)** extensive furcation involvement respond poorly to regenerative therapy and can result in residual deformities in the alveolar ridge following extraction. **(c)** Teeth with marginal tissue recession and interproximal attachment loss are typically poor candidates for complete root coverage.

Treatment Outcomes: Expectations based on Evidence-based Reviews

Root Surface Biomodification

The topical application of chemical agents to modify the root surface is among one of the earliest reported clinical approaches to prepare root surfaces for optimal attachment of periodontal tissues and regeneration.[35] Clinical application of root surface

Figure 7



(a) Radiograph of maxillary left first and second molars with advanced periodontitis and hopeless prognosis. **(b)** Radiographs at time of extraction; and **(c)** 2-month post-healing illustrate the extensive alveolar bone destruction and remodeling that can result secondary to severe periodontal destruction. A ridge preservation procedure, such as a bone graft, can be used at the time of surgery to minimize the residual alveolar bone defect. In this case, **(d)** a sinus augmentation procedure was performed prior to dental implant placement and restoration.

Courtesy of Dr. Arnold Sindler, Baltimore MD

modification emerged in response to evidence of cementogenesis and new connective tissue attachment following citric acid demineralization.[36] A number of agents, such as citric acid, tetracycline, and ethylene diamine tetraacetic acid (EDTA), have been shown to result in surface alterations, including demineralization, detoxification, and exposure of collagen fibers (i.e., biomodification). A systematic review, however, concluded that the application of chemical root modifiers does not improve reductions in probing depth or gains in clinical attachment level following periodontal surgery.[37] Nevertheless, many clinicians routinely apply such agents in an attempt to promote true regeneration, because similar improvements in clinical attachment level can occur due to epithelial attachment, connective adhesion, or both.

Intrabony Defects

Systematic reviews of randomized controlled trials provide compelling evidence that bone grafting materials and GTR support demonstrable improvements in clinical parameters, including probing depth, clinical attachment level, and defect fill, when compared to open flap debridement alone in intrabony defects.[1,38-40] Literature-based estimates of bone fill range from 2.3 to 3.0 mm or 60% of the defect following grafting of intrabony defects.[41] Particulate bone grafting materials also appear to reduce crestal bone loss, whereas barrier materials may increase recession of the gingival margin.[1,38] The efficacy and safety of PepGen P-15®, Emdogain®, and GEM 21S® in the treatment of intrabony defects has been established in controlled clinical trials.[40,42-46] Histologic evidence of periodontal regeneration in intra-osseous defects has been reported most extensively for autogenous bone and DFDBA, although case reports provide 'proof-of-principle' of regeneration for other bone grafting materials, such as PepGen P-15® and Emdogain®. In contrast, despite gains in clinical attachment level, open flap debridement and alloplastic grafts support primarily periodontal repair, which is characterized by development of a long junctional epithelium.

Furcation Defects

Systematic reviews provide strong evidence that Class II furcations respond most favorably and predictably to a combinatorial approach using GTR and a bone grafting material.[38] Using this combination therapy, Bowers and coworkers achieved the highest rate of complete furcation closure in mandibular molar Class II facial defects with horizontal probing depths of 5 mm or less and interproximal bone at or above the level of the furcation entrance.[47] In general, the more advanced the furcation defect, the less favorable the prognosis for complete periodontal regeneration and furcation closure. Early treatment of furcation defects, therefore, is critical for improving the overall prognosis.

Gingival Recession Defects

Complete root coverage can be anticipated in Miller Class I and II recession defects, where there is no periodontal loss in the interdental area and the tooth is well-aligned in the arch.[6] Although successful root coverage is possible using different treatment strategies, the autogenous subepithelial connective tissue graft, when combined with a coronally advanced flap, is generally considered the benchmark therapy for comparing the effectiveness of other root coverage procedures. The subepithelial connective tissue graft combined with a coronally positioned flap appears to provide superior and more predictable root coverage than GTR using a bioabsorbable barrier;[48,49] the connective tissue graft may also provide greater long-term stability.[50] Stable, clinically effective long-term (5 - 10 year) outcomes have been reported following treatment of Miller Class I and II recession defects with a modified coronally advance flap,[51] a subepithelial connective tissue graft combined with coronally advanced flap,[52] and enamel matrix derivative combined with a coronally advanced flap.[52] The comparative long-term effectiveness of acellular dermal matrix combined with coronally advanced flap procedures requires further clarification.[53,54] Root coverage procedures, in general, may not exhibit the same long-term stability when compared to the subepithelial connective tissue graft.[50] Certain habits, such as tooth brushing, appear to adversely affect the long-term stability of clinical root coverage.[55]

The potential for the regeneration of the periodontium in gingival recession defects has been shown with a protein-based therapy (rhPDGF-BB + ß-TCP + collagen wound-healing dressing in combination

with a coronally advanced flap).[56] However, human histological studies have shown that healing at the gingiva-root interface following pedicle flaps or free soft tissue grafts generally involves a long junctional epithelium with limited and variable amounts of new connective tissue attachment or bone regeneration.[57] Although clinically successful, current therapeutic approaches to the treatment of recession defects are achieved primarily by repair rather than regeneration.

Factors Impacting Treatment Outcome

The predictability of periodontal regeneration appears to be influenced by multiple factors related to the patient, defect morphology, and surgical management,[7,19] which contribute to variability in clinical outcomes following regenerative therapy.[58] Patient compliance with oral hygiene procedures and frequent periodontal maintenance are critical for optimal regenerative outcome and maintenance of long-term therapeutic success following regenerative therapy. Smoking adversely affects all regenerative outcome parameters and increases the risk for periodontal breakdown following treatment.[59] Surgical access is also a major determinant of whether intraosseous lesions, such as proximal furcation defects, can be successfully treated with regenerative therapy. Systemic antibiotics appear to provide a consistent but modest benefit in clinical attachment level gains following periodontal surgery;[60] therefore, the selective use of antibiotics should be guided primarily by a clinician's assessment of need based on a patient's dental and physical status.[61] Microbiologic identification and antibiotic sensitivity testing are generally limited to cases of aggressive or refractory periodontitis. Longitudinal studies document the stability of clinical outcomes achieved with regenerative therapy, although insufficient evidence is available to meaningfully compare the long-term stability of gains in periodontal support and tooth survival following various regenerative treatment approaches.[62]

References

1. Reynolds MA, Aichelmann-Reidy ME, Branch-Mays GL, Gunsolley JC. The efficacy of bone replacement grafts in the treatment of periodontal osseous defects. A systematic review. Ann Periodontol 2003;8:227-265.
2. Shimono M, Ishikawa T, Enokiya Y, et al. Biological characteristics of the junctional epithelium. J Electron Microsc(Tokyo) 2003;52:627-639.
3. Kim HY, Yi SW, Choi SH, Kim CK. Bone probing measurement as a reliable evaluation of the bone level in periodontal defects. J Periodontol 2000;71:729-735.
4. Eickholz P, Kim TS, Benn DK, Staehle HJ. Validity of radiographic measurement of interproximal bone loss. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:99-106.
5. Carranza FA, Jr., Jolkovsky DL. Current status of periodontal therapy for furcation involvements. Dent. Clin. North Am. 1991;35:555-570.
6. Miller PD, Jr. A classification of marginal tissue recession. Int J Periodontics Restorative Dent 1985;5:8-13.
7. Reynolds MA, Aichelmann-Reidy ME, Branch-Mays GL. Regeneration of periodontal tissue: bone replacement grafts. Dent Clin North Am 2010;54:55-71.
8. Reynolds MA, Aichelmann-Reidy ME. Protein and peptide-based therapeutics in periodontal regeneration. J. Evid. Based Dent. Pract. 2012;12:118-126.
9. Johnson SJ, Hunt CM, Woolnough HM, et al. Virtual reality, ultrasound-guided liver biopsy simulator: development and performance discrimination. The Br. J. Radiol. 2012;85:555-561.
10. Pini Prato G, Rotundo R, Franceschi D, Cairo F, Cortellini P, Nieri M. Fourteen-year outcomes of coronally advanced flap for root coverage: follow-up from a randomized trial. J. Clin. Periodontol. 2011;38:715-720.
11. Department of Health and Human Services. Frequently Asked Questions - Bone Allografts. What is the risk of disease transmission with bone allografts?. Available at: http://www.cdc.gov/OralHealth/Infectioncontrol/faq/allografts.htm. 2017.
12. Risbud MV, Shapiro IM, Guttapalli A, et al. Osteogenic potential of adult human stem cells of the lumbar vertebral body and the iliac crest. Spine 2006;31:83-89.
13. Urist MR. Bone: formation by autoinduction. Science 1965;150:893-899.
14. Bowers G, Felton F, Middleton C, et al. Histologic comparison of regeneration in human intrabony defects when osteogenin is combined with demineralized freeze-dried bone allograft and with purified bovine collagen. J. Periodontol. 1991;62:690-702.
15. Bowers GM, Chadroff B, Carnevale R, et al. Histologic evaluation of new attachment apparatus formation in humans. Part III. J. Periodontol. 1989;60:683- 693.
16. Slater BJ, Kwan MD, Gupta DM, Panetta NJ, Longaker MT. Mesenchymal cells for skeletal tissue engineering. Expert Opin. Biol. Ther. 2008;8:885-893.
17. Ryan JM, Barry FP, Murphy JM, Mahon BP. Mesenchymal stem cells avoid allogeneic rejection. J Inflamm (Lond) 2005;2:8.
18. McAllister BSH, K. Clinical Applications of a Stem Cell Based Therapy for Oral Bone Reconstruction. In: Li SLH, N.; Elisseeff, J. H., ed. Stem Cell and Tissue Engineering. Singapore: World Scientific, 2011:277-296.
19. Wang HL, Cooke J. Periodontal regeneration techniques for treatment of periodontal diseases. Dent. Clin. North Am. 2005;49:637-659, vii.
20. Matarasso M, Iorio-Siciliano V, Blasi A, Ramaglia L, Salvi GE, Sculean A. Enamel matrix derivative and bone grafts for periodontal regeneration of intrabony defects. A systematic review and meta-analysis. Clin Oral Investig 2015;19:1581-1593.
21. Bielecki T, Dohan Ehrenfest DM. Platelet-rich plasma (PRP) and Platelet-Rich Fibrin (PRF): surgical adjuvants, preparations for in situ regenerative medicine and tools for tissue engineering. Curr Pharm Biotechnol 2012;13:1121-1130.
22. Castro AB, Meschi N, Temmerman A, Pinto N, Lambrechts P, Teughels W, Quirynen M. Regenerative potential of leucocyte- and platelet-rich fibrin. Part A: intra-bony defects, furcation defects and periodontal plastic surgery. A systematic review and meta-analysis. J Clin Periodontol 2017;44:67-82.
23. Roselló-Camps À, Monje A, Lin GH, Khoshkam V, Chávez-Gatty M, Wang HL, Gargallo-Albiol J, Hernandez-Alfaro F. Platelet-rich plasma for periodontal regeneration in the treatment of intrabony defects: a meta-analysis on prospective clinical trials. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;120:562-574.
24. Nevins M, Kim SW, Camelo M, Martin IS, Kim D, Nevins M.A prospective 9-month human clinical evaluation of Laser-Assisted New Attachment Procedure (LANAP) therapy. Int J Periodontics Restorative Dent. 2014 Jan-Feb;34(1):21-27.

25. Yukna RA, Carr RL, Evans GH. Histologic evaluation of an Nd:YAG laser-assisted new attachment procedure in humans. Int J Periodontics Restorative Dent. 2007;27:577-587.
26. Nevins ML, Camelo M, Schupbach P, Kim SW, Kim DM, Nevins M. Human clinical and histologic evaluation of laser-assisted new attachment procedure. Int J Periodontics Restorative Dent. 2012;32:497-507.
27. Aichelmann-Reidy ME, Yukna RA, Evans GH, Nasr HF, Mayer ET. Clinical evaluation of acellular allograft dermis for the treatment of human gingival recession. J Periodontol 2001;72:998-1005.
28. Laurell L, Gottlow J, Zybutz M, Persson R. Treatment of intrabony defects by different surgical procedures. A literature review. J Periodontol 1998;69:303-313.
29. Kao RT. Strategic extraction: a paradigm shift that is changing our profession. J Periodontol 2008;79:971-977.
30. Corn H, Marks MH. Strategic extractions in periodontal therapy. Dent. Clin. North Am. 1969;13:817-843.
31. Richards DW, Kao RT. Strategic extraction: comparison of traditional and implant therapies. J Calif Dent Assoc 2008;36:181-186.
32. Lundgren D, Rylander H, Laurell L. To save or to extract, that is the question. Natural teeth or dental implants in periodontitis-susceptible patients: clinical decision-making and treatment strategies exemplified with patient case presentations. Periodontol 2000 2008;47:27-50.
33. Spangberg LS. To implant, or not to implant: that is the question. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:695-696.
34. Davliakos J. Preventive and interceptive prosthodontics: bridging the gap between restorative and implant dentistry. Interview. Dent Implantol Update 2003;14:81-87.
35. Lowenguth RA, Blieden TM. Periodontal regeneration: root surface demineralization. Periodontol 2000 1993;1:54-68.
36. Register AA, Burdick FA. Accelerated reattachment with cementogenesis to dentin, demineralized in situ. II. Defect repair. J Periodontol 1976;47:497-505.
37. Mariotti A. Efficacy of chemical root surface modifiers in the treatment of periodontal disease. A systematic review. Ann Periodontol 2003;8:205-226.
38. Murphy KG, Gunsolley JC. Guided tissue regeneration for the treatment of periodontal intrabony and furcation defects. A systematic review. Ann Periodontol 2003;8:266-302.
39. Needleman IG, Giedrys-Leeper E, Tucker RJ, Worthington HV. Guided tissue regeneration for periodontal infra-bony defects. Cochrane Database Syst Rev 2001:CD001724.
40. Trombelli L, Heitz-Mayfield LJ, Needleman I, Moles D, Scabbia A. A systematic review of graft materials and biological agents for periodontal intraosseous defects. J. Clin. Periodontol 2002;29 Suppl 3:117-135.
41. Brunsvold MA, Mellonig JT. Bone grafts and periodontal regeneration. Periodontol 2000 1993;1:80-91.
42. Esposito M, Coulthard P, Worthington HV. Enamel matrix derivative (Emdogain) for periodontal tissue regeneration in intrabony defects. Cochrane Database Syst Rev 2003:CD003875.
43. Giannobile WV, Somerman MJ. Growth and amelogenin-like factors in periodontal wound healing. A systematic review. Ann Periodontol 2003;8:193-204.
44. Nevins M, Camelo M, Nevins ML, Schenk RK, Lynch SE. Periodontal regeneration in humans using recombinant human platelet-derived growth factor-BB (rhPDGF-BB) and allogenic bone. J. Periodontol 2003;74:1282-1292.
45. Yukna RA, Callan DP, Krauser JT, et al. Multi-center clinical evaluation of combination anorganic bovine-derived hydroxyapatite matrix (ABM)/cell binding peptide (P-15) as a bone replacement graft material in human periodontal osseous defects. 6-month results. J. Periodontol 1998;69:655-663.
46. Yukna RA, Krauser JT, Callan DP, Evans GH, Cruz R, Martin M. Multi-center clinical comparison of combination anorganic bovine-derived hydroxyapatite matrix (ABM)/cell binding peptide (P-15) and ABM in human periodontal osseous defects. 6-month results. J. Periodontol 2000;71:1671-1679.
47. Bowers GM, Schallhorn RG, McClain PK, Morrison GM, Morgan R, Reynolds MA. Factors influencing the outcome of regenerative therapy in mandibular Class II furcations: Part I. J Periodontol 2003;74:1255-1268.
48. Al-Hamdan K, Eber R, Sarment D, Kowalski C, Wang HL. Guided tissue regeneration-based root coverage: meta-analysis. J. Periodontol 2003;74:1520-1533.
49. Oates TW, Robinson M, Gunsolley JC. Surgical therapies for the treatment of gingival recession. A systematic review. Ann Periodontol 2003;8:303-320.
50. Nickles K, Ratka-Kruger P, Neukranz E, Raetzke P, Eickholz P. Ten-year results after connective tissue grafts and guided tissue regeneration for root coverage. J Periodontol 2010;81:827-836.
51. Hofmanner P, Alessandri R, Laugisch O, et al. Predictability of surgical techniques used for coverage of multiple adjacent gingival recessions--A systematic review. Quintessence Int 2012;43:545-554.
52. McGuire MK, Scheyer ET, Nunn M. Evaluation of human recession defects treated with coronally advanced flaps and either enamel matrix derivative or connective tissue: comparison of clinical parameters at 10 years. J. Periodontol 2012;83:1353-1362.
53. Cairo F, Pagliaro U, Nieri M. Treatment of gingival recession with coronally advanced flap procedures: a systematic review. J. Clin. Periodontol. 2008;35:136-162.
54. Gapski R, Parks CA, Wang HL. Acellular dermal matrix for mucogingival surgery: a meta-analysis. J. Periodontol 2005;76:1814-1822.
55. Moslemi N, Mousavi Jazi M, Haghighati F, Morovati SP, Jamali R. Acellular dermal matrix allograft versus subepithelial connective tissue graft in treatment of gingival recessions: a 5-year randomized clinical study. J. Clin. Periodontol. 2011;38:1122-1129.
56. McGuire MK, Scheyer ET, Schupbach P. Growth factor-mediated treatment of recession defects: a randomized controlled trial and histologic and microcomputed tomography examination. J. Periodontol 2009;80:550-564.
57. Trombelli L. Periodontal regeneration in gingival recession defects. Periodontol 2000 1999;19:138-150.
58. Aichelmann-Reidy ME, Reynolds MA. Predictability of clinical outcomes following regenerative therapy in intrabony defects. J. Periodontol 2008;79:387-393.
59. Johnson GK, Hill M. Cigarette smoking and the periodontal patient. J. Periodontol 2004;75:196-209.
60. Haffajee AD, Socransky SS, Gunsolley JC. Systemic anti-infective periodontal therapy. A systematic review. Ann Periodontol 2003;8:115-181.
61. Newman MG. The role of infection and anti-infection treatment in regenerative therapy. J. Periodontol 1993;64:1166-1170.
62. Trombelli L. Which reconstructive procedures are effective for treating the periodontal intraosseous defect? Periodontol 2000 2005;37:88-105.

POST-TEST

Internet Users: This page is intended to assist you in fast and accurate testing when completing the "Online Exam."
We suggest reviewing the questions and then circling your answers on this page prior to completing the online exam.

(1.0 CE Credit Contact Hour) Please circle the correct answer. 70% equals passing grade.

1. **Statement 1: Freeze-dried bone allografts are considered safe by the CDC.**
   Statement 2: They are the most commonly used bone graft material.
   a. The first statement is true; the second statement is false.
   b. The first statement is false; the second statement is true.
   c. Both statements are true.
   d. Both statements are false.

2. **GEM-21S® contains which of the following recombinant human growth factor?**
   a. fibroblast growth factor (FGF)
   b. platelet derived growth factor (PDGF-BB)
   c. epithelial growth factor (EGF)
   d. periodontal ligament activating factor (PL-AF)

3. **Histologic evidence of periodontal regeneration is strongest following the clinical application of the ____ laser.**
   a. CO_2
   b. Er:YAG
   c. Nd:YAG
   d. Diode

4. **In guided tissue regeneration (GTR), a barrier membrane is used to exclude which of the following cells from the root surface)**
   a. osteoblasts
   b. epithelial cells
   c. periodontal ligament fibroblasts
   d. endothelial cell

5. **Bone morphogenetic proteins are found in this osteoinductive graft material:**
   a. bioactive glass
   b. demineralized freeze dried bone allograft (DFDBA)
   c. Emdogain®
   d. GEM-21S®

6. **A graft material that is described as being of bovine origin can be classified as a(an)____.**
   a. alloplast
   b. autograft
   c. allograft
   d. xenograft

7. **The formation of long junctional epithelium following periodontal flap surgery represents ____.**
   a.. regeneration
   b. reattachment
   c. repair
   d. reconnection

8. **What is the main difference between a Class II and Class III recession defect?**
   a. Position of the apical base of the recession defect relative to the mucogingival junction.
   b. Probing depth is greater in a Class III.
   c. Recession width is greater in a Class III.
   d. Interproximal bone and soft tissue height is present in Class II defects.

9. **Which of the following is a major advantage of the acellular dermal matrix in treating gingival recession defects?**
   a. Reduces need for mobilization of a gingival flap
   b. Considered the gold standard for root coverage
   c. Permits treatment of multiple defects in one surgical procedure
   d. Predictably results in true periodontal regeneration

10. **Which of the following furcation defects is most likely to regenerate using a barrier membrane (GTR) combined with a bone graft material?**
    a. Class I
    b. Class II
    c. Class III
    d. Class IV

REGISTRATION/CERTIFICATION INFORMATION (Necessary for proper certification)

Name (Last, First, Middle Initial): _____

PLEASE PRINT CLEARLY

Street Address: _____ Suite/Apt. Number _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____

Date of Birth: _____ Email: _____

State(s) of Licensure: _____ License Number(s): _____

Preferred Dentist Program ID Number: _____ ☐ Check Box If Not A PDP Member

AGD Mastership: ☐ Yes ☐ No

AGD Fellowship: ☐ Yes ☐ No Date: _____

Please Check One: ☐ General Practitioner ☐ Specialist ☐ Dental Hygienist ☐ Other

FOR OFFICE USE ONLY

Quality Resource Guide - Periodontal Regeneration 3rd Edition

Providing dentists with the opportunity for continuing dental education is an essential part of MetLife's commitment to helping dentists improve the oral health of their patients through education. You can help in this effort by providing feedback regarding the continuing education offering you have just completed.

Please respond to the statements below by checking the appropriate box, using the scale on the right.	1 = POOR 1	2	3	4	5 = Excellent 5	
1. How well did this course meet its stated educational objectives?	☐	☐	☐	☐	☐	
2. How would you rate the quality of the content?	☐	☐	☐	☐	☐	
3. Please rate the effectiveness of the author.	☐	☐	☐	☐	☐	
4. Please rate the written materials and visual aids used.	☐	☐	☐	☐	☐	
5. The use of evidence-based dentistry on the topic when applicable.	☐	☐	☐	☐	☐	☐ N/A
6. How relevant was the course material to your practice?	☐	☐	☐	☐	☐	
7. The extent to which the course enhanced your current knowledge or skill?	☐	☐	☐	☐	☐	
8. The level to which your personal objectives were satisfied.	☐	☐	☐	☐	☐	
9. Please rate the administrative arrangements for this course.	☐	☐	☐	☐	☐	

10. How likely are you to recommend MetLife's CE program to a friend or colleague? *(please circle one number below:)*

10 9 8 7 6 5 4 3 2 1 0

extremely likely neutral not likely at all

What is the primary reason for your 0-10 recommendation rating above?

_____

11. Please identify future topics that you would like to see:

_____

Thank you for your time and feedback.

To Complete Program Traditionally, Please Mail Your Post Test and Evaluation Forms To:

MetLife Dental Quality Initiatives Program
501 US Highway 22
Bridgewater, NJ 08807