# CHAPTER 13. INTERDISCIPLINARY CONSIDERATIONS

## Section 1. Periodontic-Endodontic Considerations

### DIAGNOSIS

One of the more perplexing problems confronting the patient and periodontist is the periodontic-endodontic lesion (PEL). Diagnosis of these lesions is based on an accurate, comprehensive history and a thorough examination (including vitality testing, radiographs, and root fracture assessment). It may be difficult, if not impossible, to determine the nature and chronology of a periodontic-endodontic lesion.

Hiatt (1977) has suggested that such lesions be considered endodontic in nature for treatment planning purposes, since endodontic therapy alone may resolve the lesion. However, resolution of the defect is highly dependent on the primary source and the chronicity of the lesion; treatment may eventually involve both endodontic and periodontal treatment (Benenati et al., 1981).

Pitts and Natkin (1983) reported on the diagnosis and treatment of vertical root fractures, acknowledging their diagnostic challenges. Many signs of a vertical root fracture are similar to those associated with pulpal necrosis. If possible, visual observation of the crack is preferred using such diagnostic aids as dye, fiberoptic lights, or fine explorers. Often a definitive diagnosis can only be derived following surgical exposure or extraction. Radiographic evidence of root fracture is usually absent, but may present as a "parapulpal" radiolucent line, separation of root fragments, extrusion of filling material, or radiolucency around the root apex in a halo-like configuration. While coronal fractures may manifest as a periodontal-like lesion, the presence of a narrow, step-like radiolucency is highly suggestive of a tooth fracture. Additional diagnostic signs of a vertical root fracture include external resorption along the fracture line and loosening of retrofill amalgams. Treatment is directed at eliminating the fracture while maintaining the maximum amount of tooth structure. Depending on the size and location of the fracture, treatment may range from root resection to extraction.

### CLASSIFICATION OF PERIODONTIC-ENDODONTIC LESIONS

Simon et al. (1972) provided a classification of periodontic-endodontic lesions based on possible etiology, diagnosis, and prognosis.

**Primary Endodontic Lesions.** These lesions may appear concurrently with drainage from the gingival sulcus area and/or swelling in the buccal attached gingiva. They are periodontal only in that they pass through the periodontal ligament area. In reality, they are sinus tracts resulting from pulpal disease. Radiographically, different levels of bone loss may be apparent depending on the avenue of sinus tract formation. Diagnosis may be facilitated by inserting a gutta percha point or silver cone into the tract and taking a radiograph to determine the origin of the lesion. When the pulp does not respond to an electric vitalometer or thermal tests, a necrotic pulp may be the offender. In addition, a minimal amount of calculus or plaque formation is usually encountered when probing. These lesions will usually heal with endodontic therapy alone.

**Primary Endodontic Lesions With Secondary Periodontic Involvement.** If the primary endodontic problem remains untreated, it may be affected secondarily with periodontal breakdown. The treatment and prognosis of the tooth are altered when plaque or calculus is detected on the affected root surface. Such teeth require endodontic and periodontal therapy. The prognosis depends primarily on the periodontal therapy, assuming that the endodontic needs have been met.

**Primary Periodontic Lesions.** These lesions generally manifest calculus at varying distances along the affected root surface. The pulp responds vitally to endodontic testing procedures and prognosis depends on the effectiveness of the periodontal therapy.

**Primary Periodontic Lesions With Secondary Endodontic Involvement.** As periodontal lesions progress apically, lateral or accessory canals may be exposed to the oral environment and contribute to pulpal necrosis. Resulting lesions may be radiographically indistinguishable from primary endodontic lesions with secondary periodontic involvement. Teeth undergoing periodontal therapy that do not respond as anticipated should be pulp tested. Prognosis depends on the periodontal care once endodontic therapy has been accomplished. These lesions will not respond to periodontal treatment alone.

**"True" Combined Lesions.** These lesions occur where an endodontically-induced periapical lesion exists on a periodontally-diseased tooth. The radiographic intrabony defect presents when the respective lesions merge along the root surface. These clinical and radiographic features are indistinguishable from the other lesions previously described which have secondary involvement. Periapical healing may be anticipated following successful endodontic therapy. Periodontic aspects may or may not respond to periodontal treatment, depending on the severity of involvement.

Hiatt (1977) provided a classification of periodontic-endodontic lesions, relating appropriate treatment and prognosis based on the primary etiology. Lesions of pulpal origin with associated periodontal involvement of short duration can be expected to resolve following endodontic therapy. Incomplete root fractures and periodontal lesions of short duration (i.e., periodontal abscess) with secondary pulpal disease primarily require treatment of the periodontium. Independent pulpal and periodontal lesions may merge into combined lesions and carry a poor prognosis similar to pulpal lesions which evolve into periodontal lesions following treatment. The major determinant of successful treatment of periodontic-endodontic lesions is the chronicity of the periodontal component.

## INTERRELATIONSHIPS OF THE PULP AND PERIODONTIUM

Sharp (1977) and Benenati et al. (1981) have discussed the relationship between periodontium and pulp. Embryologically, dental pulp originates from the dental papilla, while periodontal ligament and cementum originate from the dental follicle. These structures are mesodermal in origin and are initially separated by the epithelial root sheath (Hertwig's epithelial root sheath). Lateral root canals are formed when odontoblasts do not produce dentin and cementum in areas of blood vessels and nerves that have penetrated the epithelial root sheath, establishing a communication between the pulp and periodontal ligament (PDL). The authors suggest that accessory canals are primary channels through which microorganisms may move between pulp and periodontium. Although the percentage of lateral canals varies, the authors feel the frequency of this relationship warrants concern. Sharp (1977) suggests that periodontal disease does not affect the pulp until the lesion has extended to the root apex.

Several studies have attempted to examine the effect of the periodontium on the pulp. Mazur and Massler (1964) histologically examined the pulps of 106 caries-free teeth extracted for periodontal reasons. No relationship was observed between the amount of periodontally-exposed root and degenerative changes in the pulp. In a separate group of patients, the pulps of periodontally involved teeth were compared to homologous, non-periodontally involved teeth on the other side of the arch, or on the same side but in the opposite jaw. All teeth were caries-free and unfilled. No relationship could be established between morphologic changes in the pulp and sites with periodontal involvement. Langeland et al. (1974) provided support for the effect of periodontal disease on the pulp. The authors examined pulp tissue from 60 periodontally-involved teeth in an attempt to correlate the presence of bacterial plaque at the entrance of lateral or main canals in the presence of an inflammatory pulpal response. While the presence of inflammatory cells and pulpal calcification (true pathosis) occurred more frequently as the plaque front moved apically, as long as the principal (apical) canal was not seriously involved, the entire pulp did not necrose (despite involvement of one or more lateral canals and/or dentinal tubules).

Czarnecki and Schilder (1979) also evaluated the degree of pulpal pathosis associated with periodontal disease. When pulps of periodontally involved teeth were examined, 6 of 34 exhibited pulpal pathology. All of these teeth had carious lesions or extensive restorations. Caries-free teeth had no histologic evidence of true pulpal pathology regardless of their periodontal condition. The authors concluded that pulpal health is unaffected by the presence or severity of periodontal disease. Teeth receiving previous periodontal therapy were excluded from this study since it was felt that periodontal treatment may induce pulpal changes. Torabinejad and Kiger (1985) histologically evaluated 25 teeth from the same patient which exhibited varying degrees of periodontal disease. The teeth were vital, had few restorations, and no histologic evidence of pulpal pathosis. Although calcifications were present, this was not considered pathologic.

The effects of periodontitis and periodontal therapy on the pulp were assessed by Bergenholtz and Lindhe (1978) using experimental ligature-induced periodontal disease in the monkey model. After induction of periodontal disease, no further treatment was performed in 1 group of teeth, while remaining teeth were subjected to gingivectomy followed by scaling and root planing (with an attempt at complete cementum removal). Following plaque accumulation for 2, 10, and 30 days, secondary dentin and inflammation were observed in the pulp tissue of all groups (including non-treated controls), tending to occur adjacent to exposed root surfaces. However, pulps in the majority of roots (health, periodontitis, and periodontitis with root planing) exhibited no pathology. Based on this relatively short-term study, the authors concluded that periodontitis and scaling/root planing do not predictably lead to pulpal changes.

Effects of extensive periodontal and prosthetic treatment on dental pulps were examined by Bergenholtz and Nyman (1984) who retrospectively examined 672 teeth 4 to 13 years after treatment for severe periodontal disease. The authors reported that abutment and non-abutment teeth displayed similar periodontal breakdown; however, endodontic complications resulting from pulpal necrosis occurred more frequently in abutment teeth (15% versus 3%), suggesting that prosthetic treatment may be a causative factor in pulpal disorders. The assumption that the periodontal status could have played a role as a causative factor for pulpal involvements was countered by the observation that pulpal necrosis of unidentified etiology occurred almost exclusively in teeth serving as bridge abutment.

## EFFECTS OF ENDODONTIC THERAPY ON PERIODONTAL THERAPY

Another area of controversy in the periodontic-endodontic literature relates to connective tissue attachment potential in endodontically treated teeth. Diem et al. (1974) addressed this question using endodontically treated teeth denuded of cementum in 6 Rhesus monkeys. Four teeth were used per animal: 1) an untreated control; 2) pulp extirpated and unfilled; 3) pulp extirpated and a camphorated parachlorophenol (CMCP) paper point placed in the canal; and 4) pulp extirpated and canal filled with gutta percha. Attachment loss was surgically created by removing 3 to 5 mm of bone from facial surfaces of the teeth. No relationship was found between the amount of connective tissue/alveolar bone regeneration and canal status, indicating cementum would form on roots of endodontically-treated teeth denuded of cementum. Interestingly, mean cementum regeneration was highest in teeth with CMCP medicated canals. Unfortunately, this experiment did not duplicate in vivo conditions, since the lesions were surgically created immediately after endodontic therapy. More recently, Dunlap et al. (1981) examined the ability of human gingival fibroblasts to attach to root-planed dentin of endodontically and non-endodontically treated, periodontally-involved teeth. Teeth were extracted and longitudinally sectioned following cementum removal on one side of the root. Root fragments were then incubated with fibroblasts in a tissue culture system for 72 hours prior to staining and evaluation. Fibroblasts grew on all root planed segments and none of the unplaned segments. No difference was detected between vital and endodontically treated teeth. The authors concluded that teeth treated endodontically and those with vital pulps should respond to new attachment procedures equally well and that delaying endodontic therapy until periodontal surgery is completed is not warranted. These findings differ from those of Sanders et al. (1983) who evaluated the use of freeze-dried bone allografts in human osseous defects. Results suggested that a significantly lower percentage of allografts placed in defects adjacent to endodontically obturated teeth resulted in complete or greater than 50% osseous regeneration as compared to those placed adjacent to non-obturated teeth of unknown pulpal status (33% versus 65%). While the authors concluded there is need for greater attention to osseous defects associated with endodontically obturated teeth, they felt differences were at least in part due to continuing endodontic pathology associated with inadequate obturations.

## ANATOMIC CONSIDERATIONS—ACCESSORY CANALS

It is felt that in order for the periodontium to affect the pulp there must be a means of interaction. Accessory canals may provide one such avenue. Gutmann (1978) evaluated the prevalence, location, and patency of accessory canals in the furcation regions of first and second molars. Under external vacuum, safranin dye was placed in the pulp chamber and forced through the tooth. Upon evaluating the external furcation for dye penetration, 28.4% (29.4% mandibular/27.4% maxillary) of the teeth exhibited patent accessory canals in the "furcation region" (defined as the actual furcation plus an area 4 mm extending apically along the internal aspect of the root surfaces). In addition, 10.2% of the teeth had lateral accessory canals, with little difference noted between mandibular and maxillary molars. Ability of the pulp and periodontium to communicate via dentinal tubules was also evident, especially where cementum was denuded. Although this study demonstrated the prevalence of accessory canals, it is quite different from the in vivo scenario where living cells (odontoblasts) can exclude material from dentinal tubules. The author emphasized that the mere presence of accessory canals does not imply that pathosis will spread from one entity to another. While necrotic tissue and bacterial plaque present in accessory canals may not severely affect the pulp, they may tend to perpetuate periodontal furcation lesions making therapeutic success impossible.

Since periodontally affected teeth have more exposed root surface area due to attachment loss than other teeth, Kirkham (1975) investigated the incidence of accessory canals adjacent to periodontal pockets by injecting a radiopaque solution into the pulp chambers of 100 extracted periodontally-involved teeth. Upon radiographic examination, 23% of the teeth exhibited one or more lateral canals. Most of the canals were located in the apical third of the root. No accessory canals were observed in the furca (although the furcation was not specifically examined). The frequency of lateral canals in mandibular premolars (53.5%) and mandibular molars (44.5%) was considerably higher than that of any other tooth group. Maxillary molars and mandibular incisors had the lowest percentage of teeth with accessory canals. Only 2 of 100 teeth demonstrated an accessory canal within a periodontal defect. Although 1 of these teeth showed histologic signs of pulpal necrosis, it was impossible to determine the exact origin of the periodontic-endodontic lesion.

The ability of bacteria to traverse tooth structure was demonstrated by Adriaens et al. (1988) who histologically examined 21 extracted, caries-free human teeth and observed bacterial invasion of radicular cementum and dentin. Bacteria were found in the lumina of dentinal tubules, lacunar defects in cementum, and in spaces between remnants of Sharpey's fibers and the structures in cementum where these fibers inserted. Although bacterial invasion of the dentinal tubules was generally limited to the outer 300 μm, bacteria were detected on the pulpal wall in 2 teeth. Bacteria were never observed in intertubular dentin. The authors suggested that dentinal tubules and lacunae may serve as bacterial reservoirs from which pulpal pathosis or recolonization of treated root surfaces could occur. In general, these studies indicate that the periodontium does not predictably affect the dental pulp. When it does exert an effect, it most likely occurs via lateral canals (apical third and furcation) and in previously compromised pulps (through periodontal or restorative treatment).

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# Section 2. Periodontic-Orthodontic Relationships

## INTRODUCTION

Since orthodontic tooth movement may affect the surrounding periodontium, it is important to consider the interrelationships between orthodontic and periodontal therapy when such multidisciplinary treatment needs exist. Gryson (1965) presented a review of the orthodontic literature concerning the response of the periodontal ligament (PDL) to orthodontic forces of various magnitude. Strong forces literally crush the PDL on the pressure side as a result of direct contact between the root and bone. No movement occurs until adjacent bone is resorbed (undermining [rear] resorption) and the PDL regenerates. Moderate forces (in slight excess of capillary pressure) cause strangulation of the PDL and a delay in bone resorption. Light forces (less than capillary pressure [20 to 25 mm Hg]) merely cause ischemia in the PDL and tooth movement proceeds continuously with concomitant bone resorption and formation. The author concludes that although intermittent forces seem to offer the best chance of complete physiologic tooth movement, continuous light forces provide a compromise that is more time efficient and results in no permanent tissue damage. Retention of orthodontically repositioned teeth is necessary to allow tissues to reorient to their new position. Rotations are the most difficult movement to retain and are most effectively managed by early correction, over-rotation, and transeptal fiberotomy.

## ORTHODONTIC-PERIODONTIC RELATIONSHIPS

Keesler (1976) presented another review of the interrelationships between periodontics and orthodontics, noting that with the possible exception of hypofunction and severe overbite with impingement, there is no evidence that orthodontic correction of malocclusion will enhance or detract from periodontal health. Possible exceptions include severe overbite with impingement and hypofunction. Plaque retention and oral hygiene habits are the primary factors in periodontal disease with tooth position playing a minor role. Orthodontic treatment in adults should be approached with the understanding that compared to young individuals, adults lack skeletal growth potential, have decreased osteoblastic-osteoclastic activity, and have increased potential for tooth mobility with orthodontic movement. Initial periodontal therapy should be accomplished prior to orthodontic movement. The author suggests waiting 6 to 9 months after tooth movement before proceeding with periodontal surgical procedures. Improvement in periodontal health may be achieved by moving (e.g., tipping) affected teeth into a greater volume of bone or adjacent osseous defects. The author suggests that uprighting of molars should be approached cautiously due to the potential for furcation exposure and that movement into recent extraction sites should be avoided.

Orthodontic therapy may be directed toward correction of spacing and/or crowding of teeth. Silness and Roynstrand (1984) evaluated the relationship between spacing and dental health in 15-year-old children, reporting that children with more spacing had less plaque, gingivitis, probing depth, and interproximal restorations than those with minimal spacing. In a subsequent study, Silness and Roynstrand (1985) evaluated periodontal health adjacent to aligned and non-aligned interproximal surfaces in the same population. Patients with fewer non-aligned surfaces had a more favorable periodontal condition (less plaque, gingivitis, and probing depth) than patients with many non-aligned surfaces. Likewise, the greater the number of non-aligned surfaces present, the greater the number of interproximal restorations.

Orthodontic therapy has been utilized in attempts to improve the health of teeth with significant periodontal destruction. Brown (1973) examined the clinical and histological effects of molar uprighting on existing periodontal osseous defects in 5 patients. Molars with mesial osseous defects were uprighted for 90 to120 days, and stabilized for 3 months. A single molar which served as the control was not moved orthodontically but was scaled and root planed (S/RP) bi-weekly. All teeth were extracted via block section and examined histologically. Following uprighting, the gingival tissues exhibited decreased inflammation, a more apical location, and reduction in probing depth of 3.5 mm. The control tooth showed little improvement. Clinically and radiographically, there was a reduction in probing depth of 3.5 mm and a mean bone loss of 0.5 to1.0 mm for the uprighted molars.

The effect of tooth movement into adjacent osseous defects was studied in a monkey model by Polson et al. (1984). Intrabony defects were induced by placement of ligatures and elastics followed by restoration of health by S/RP and maintenance. The experimental teeth were moved up to 6 mm into the osseous defects over a 3-month period and were retained for 2 months prior to collection of block sections. Histologic evaluation of the pressure side showed narrowing of the angular defect while the tension side demonstrated conversion of the intrabony pocket to a suprabony pocket. On both the pressure and tension sides, epithelium extended to the level of root planing with no evidence of new connective tissue (CT) attachment. The authors concluded that teeth with a reduced but healthy periodontium may be moved orthodontically without detrimental effect on the attachment level.

Van Venrooy and Yukna (1985) evaluated the effects of orthodontic extrusion of single-rooted teeth with severe surgically-created defects in beagle dogs. Ligature-induced periodontitis resulting in loss of 1/3 to 1/2 of the periodontal support was followed by orthodontic extrusion using elastics with 20 to 25 grams of force over a 14 to 21 day period. Compared to non-extruded control teeth, extruded teeth exhibited shallower probing depths, less gingival inflammation, no bleeding on probing, a wider PDL, greater width of cementum, and increased crestal bone height. The authors suggested that the positive changes observed in extruded teeth may have resulted from conversion of the subgingival plaque to a supragingival plaque with decreased pathogenicity.

Conflicting findings have been published regarding the effect of labial movement of incisors on facial alveolar bone. Batenhorst and Bowers (1974) reported the clinical and histologic changes associated with facial tipping and spontaneous extrusion of mandibular incisors in monkeys. They noted an increase in width of the facial attached gingiva with no alteration in position of the mucogingival junction. The epithelial attachment maintained a close relationship to the CEJ on all surfaces except the facial where the epithelial attachment was longer and more apically located. As teeth moved facially, alveolar bone apposition occurred on the interproximal and lingual surfaces while dehiscences formed on the facial surfaces. Facial movement and extrusion also resulted in a parallel arrangement of connective tissue (CT) fibers along the facial root surfaces rather than a perpendicular arrangement as seen on the interproximal and lingual surfaces.

In a similar study, Wingard and Bowers (1974) used a different monkey model in an attempt to create dehiscences or fenestrations on the facial surfaces. Mandibular central incisors were tipped facially 2 to 5 mm while untipped lateral incisors served as controls. They reported no significant difference in mean alveolar bone level between experimental and control teeth; furthermore, no dehiscences or fenestrations were observed on tipped teeth. Histologically, there was thinning of the PDL and facial alveolar bone on the tipped teeth, with frontal resorption and enlarged narrow spaces consistent with undermining resorption. Results of this study agree with other authors who have concluded that compensatory bone formation occurs in order to maintain a tooth's normal supporting apparatus when the tooth is moved facially with proper forces.

Karring et al. (1982) studied the effect of facial movement of incisors on the supporting periodontal tissues in beagle dogs. In this study, meticulous oral hygiene was consistently performed and the tissues were maintained in a state of health. Maxillary incisors were initially moved in a facial direction over 5 months, resulting in formation of dehiscences extending halfway down the roots. The incisors on one side were moved back to their original position over 5 months and specimens were evaluated after a final 5-month retention period. Teeth that were moved facially and retained in that position failed to demonstrate repair of the dehiscences and exhibited CT fibers paralleling the root surface. Incisors that were moved back to their original position after facial displacement demonstrated complete regeneration of alveolar bone with CT fibers inserting perpendicularly into new bone and cementum. In the absence of clinical inflammation, the apical termination of the junctional epithelium (JE) in the orthodontically treated teeth was at the cementoenamel junction (CEJ), and no loss of CT attachment was observed.

## ORTHODONTIC MOVEMENT IN THE PRESENCE OF PLAQUE

Ericsson et al. (1977) compared the effects of orthodontic forces with tipping/intrusive components on healthy and plaque-infected periodontal tissues in dogs. Periodontal defects were created by placement of copper bands and were surgically corrected prior to tooth movement. This resulted in a reduction of healthy periodontium. Orthodontic forces were applied bilaterally over 6 months with plaque accumulation allowed on one side and oral hygiene procedures accomplished on the other. Clinically, there was a slight gain of attachment in plaque-free teeth and a slight loss in plaque-infected teeth. Histologically, while there was a trend for plaque-infected teeth to have a loss of attachment, there was no statistically significant difference in the level of attachment between the 2 groups of teeth. There was significantly more inflammation in the tissues adjacent to plaque-infected teeth and intrabony pocket formation was frequently associated with these teeth. The authors suggest that intrusive forces may have shifted the supragingival plaque to a subgingival location, resulting in intrabony pocket formation and loss of attachment. However, the data from this study indicate no difference in the CT attachment levels between plaque-free and plaque-infected teeth.

Since the majority of orthodontic patients are relatively young, the orthodontist may encounter patients with localized juvenile periodontitis (LJP). Folio et al. (1985) studied the clinical and microbiological effects of orthodontic therapy on 2 LJP and 2 post-LJP patients. The patients were placed on the "Keyes technique" oral hygiene regimen and were monitored clinically and by phase contrast microscopy. The authors observed increased levels of spirochetes, motile rods, and PMNs in all subjects within 1 to 6 months of appliance placement, prompting follow-up care including oral hygiene instruction, subgingival irrigation, S/RP, and/or systemic antibiotics. One episode of this treatment resulted in reduction or elimination of these organisms for the duration of the study (up to 78 weeks). Conclusions were that orthodontic therapy may aggravate plaque-induced diseases resulting in further breakdown and that periodontally compromised teeth may be successfully treated with orthodontics if excellent plaque control is maintained. It should be noted that phase contrast microscopy was used to monitor the patient's oral hygiene effectiveness, rather than the pathologic flora of LJP.

To evaluate the long-term impact upon the periodontium, Trossello and Gianelly (1979) performed a retrospective study comparing the status of 30 females who had received multibanded fixed orthodontic therapy at least 2 years previously with 30 age-matched controls. The only statistically significant differences between the 2 groups were related to root resorption and mucogingival defects. The orthodontically treated patients had a higher prevalence of root resorption (17% versus 2%) and a lower prevalence of mucogingival defects (5% versus 12%). Root resorption was most common in maxillary incisors followed by mandibular incisors. While not statistically significant, the orthodontically treated patients also had more crowding of tissue and loss of alveolar bone where extraction spaces were closed and slightly greater crestal bone loss overall. Because only minor differences were encountered, the authors concluded that effects of orthodontic treatment on the periodontium are minimal. Another study to evaluate the long-term effects of orthodontic therapy was performed by Polson and Reed (1984), in which cross-sectional assessment of radiographic alveolar bone levels in 104 patients who had completed orthodontic therapy at least 10 years previously were compared with 76 matched controls who had no orthodontic treatment. Overall, they found no significant difference in alveolar crest levels between the 2 groups, with one exception. In the orthodontically treated patients, the alveolar crest on the distal surfaces of the molar teeth was located at a more coronal level than in non-orthodontic controls. This may have resulted from intrusion of the molars secondary to orthodontic treatment.

## MUCOGINGIVAL CONSIDERATIONS

The treatment of mucogingival defects may involve orthodontic and periodontal therapy. Boyd (1978) reviewed the indications for and sequence of mucogingival therapy with respect to orthodontic intervention. He suggested that mucogingival defects in the absence of malocclusion-malalignment should be treated early to avoid further breakdown. However, he suggests that preoperative orthodontic intervention may improve or even eliminate gingival recession when malocclusion is a contributing factor. The author recommended that orthodontic consultation should be obtained when the: 1) involved area is related to a shearing effect of one tooth on another (e.g., deep overbite/crossbite with tripping of gingival tissue); 2) involved tooth may be elected for extraction due to tooth size discrepancy; and, 3) tooth with the mucogingival defect is in labioversion (lingual movement of the tooth may correct the mucogingival defect without surgery).

## ORTHODONTIC ROTATION

The periodontist is frequently called on to assist in the retention of orthodontically repositioned teeth. Tooth rotation is generally simple to achieve but difficult to retain. It is theorized that stretching of the gingival fiber apparatus during rotation is followed by recoil of the fibers during the retention phase, with resultant relapse of tooth malposition. Edwards (1970) tattooed the attached gingiva and alveolar mucosa around orthodontically rotated teeth in 12 patients. Following rotation and 8 weeks of mechanical retention, experimental teeth received a circumferential fiberotomy (number 11 blade placed into sulcus to and below the crest of bone). Control teeth received no surgical procedures. During tooth rotation, the tattooed fibers deviated in the direction of rotation. Upon release of mechanical retention, all control teeth demonstrated relapse with deviation of fibers in the direction of relapse. Conversely, teeth which received fiberotomies did not relapse. Within 20 to 40 hours post-fiberotomy, tattooed fibers had returned to the original pre-rotation position. Thus, Edwards demonstrated that fiberotomy relieves post-rotation tensional forces in the fiber apparatus, allowing recoil of the fibers without relapse of tooth malposition.

## ORTHODONTIC EXTRUSION AND FIBEROTOMY

During the forced-tooth eruption, the adjacent periodontium usually accompanies the root coronally. The coronally displaced tissues usually necessitate surgical crown lengthening to provide adequate clinical crown for the final restoration. Pontoriero et al. (1987) and Kozlovsky et al. (1988) have reported using a supracrestal fiberotomy procedure to sever the supracrestal gingival fibers during rapid extrusion of tooth. Pontoriero et al. recommend the procedure weekly, Kozlovsky et al. every 2 weeks. Both have reported case studies which have successfully avoided the need for crown lengthening surgery following extrusion. The supracrestal fiberotomy is believed to eliminate the tensile stress upon the alveolar crestal bone preventing crestal bone deposition. Following an intra-sulcular incision which parallels the cemental surface and engages bone-to-bone, the root is then thoroughly planed to the level of the alveolar crest. Berglundh et al. (1991) performed extrusions on 5 beagle dogs with and without a fiberotomy (at 2-week intervals) with histologic evaluation. The authors concluded that extrusion combined with a fiberotomy limits displacement of the gingival and supracrestal tissues coronally, and limits crestal bone apposition, but does not completely prevent the coronal migration of those tissues.

Advantages of the technique include: 1) ease and quickness of the procedure; 2) possibly a shorter retention period post-extrusion; 3) direct inspection of the extruding sound tooth structure preventing over- or under-treatment; and 4) possible elimination of the need for a crown lengthening procedure following extrusion.

## ORTHOGNATHIC SURGERY

As orthognathic surgical procedures have become more commonplace, interest has grown concerning the effect of such therapy on the periodontium. Foushee et al. (1985) evaluated 24 patients who had received advancement genioplasty with or without maxillary/mandibular osteotomy. Width of keratinized and attached gingiva was determined pre- and postoperatively. Following surgery, there was a significant decrease in the width of keratinized and attached gingiva in mandibular incisors and premolars. The initial width of keratinized and attached gingiva was unrelated to the susceptibility for recession after surgery. Of the 24 patients, 10 had post-treatment recession: 4 had slight localized recession (0.5 mm per site), and 6 had more severe and generalized recession (range of 0.5 to 3.0 mm). Since these patients received orthodontic treatment between the initial evaluation and surgery, it is difficult to determine if the recession resulted from the orthodontic or orthognathic treatment.



## IMPLANTS AND ORTHODONTICS

Higuchi and Slack (1991) reported the placement of 10-mm implant fixtures placed bilaterally in the third molar areas of 7 adult patients. The implants were allowed to integrate for 4 to 6 months, and were subsequently used as posterior anchorage (up to 400 g) for protraction and retraction. After completion of orthodontic treatment, the fixtures were placed in a non-functional state beneath the soft tissues. Measurements performed on the cephalometric radiographs revealed no movement of the implant fixtures. Fixture placement in the mandibular third molar area was described as difficult, and interference with the maxillary soft tissue and dentition was also reported.

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# Section 3. Periodontic-Prosthodontic-Restorative Interactions

## INTRODUCTION

The periodontium is the foundation which largely determines the function, esthetics, and longevity of the dentition. Factors impacting restorative/prosthodontic treatment include esthetics, function, and periodontal health. Periodontal health should be the foremost of these factors as the infringement of a restoration on the physiologic dimensions of the periodontium and/or the interference with plaque removal will potentially affect esthetics and function.

## BASIC CONCEPTS

### Dimensions of the Periodontium in Health

Garguilo et al. (1961) described the dimensions of the dento-gingival junction using human cadaver specimens. A range of dimensions was noted with the connective tissue attachment being most consistent with a mean measure of 1.07 mm and the epithelial attachment most variable with an average of 0.97 mm. The sulcus depth averaged 0.69 mm. This dento-gingival dimension has been referred to as the biologic width.

### Biologic Width/Physiologic Dimension

Ingber et al. (1977) discussed the maintenance of the biologic width when restoring fractured or carious teeth where marginal infringement on the dento-gingival junction was imminent. The authors concluded that "a minimum dimension of 3 mm coronal to the alveolar crest is necessary to permit healing and proper restoration of the tooth." Violation of this width potentially leads to adverse periodontal reactions including inflammation and alveolar bone loss. Ramfjord (1988) questioned the surgical creation of a 2- to 3-mm biologic width apical to a proposed restoration margin via ostectomy. He felt that bone should be removed to the minimum extent needed to ensure access for margin placement, but it may be better to "... let nature determine the biologic width over the coming years, with the patient maintaining adequate oral hygiene."

Maynard and Wilson (1979) described the following 3 aspects of the physiologic dimension: intracrevicular, subcrevicular, and superficial. The authors discussed the implications of restorative encroachment on the subcrevicular physiologic dimension or biologic width. They also noted that when "intracrevicular restorative margins" are placed at sites of insufficient gingival (or marginal tissue) width and/or thickness, "marginal tissue recession," apical migration of the attachment apparatus or both may result. The authors recommended 5 mm of keratinized tissue (3 mm attached and 2 mm free) and a minimum crevicular physiologic dimension of 1.5 to 2.0 mm when marginal coverage by free gingiva is dictated by esthetics.

## TISSUE-RESTORATIVE INTERACTIONS

### Overhanging Dental Restorations

Overhanging dental restorations can provide a niche for plaque accumulation, hinder oral hygiene, cause mechanical irritation, impinge on the interproximal embrasure space, and encroach upon the biologic width, leading to inflammation and potential periodontal destruction. Waerhaug (1976) hypothesized that overhangs extend the sphere of microbial influence. The prevalence of overhanging dental restorations range from 25% to 76% for restored surfaces and 32% to 90% for patients (Brunsvold and Lane, 1990). Even when identified, overhangs are often difficult to remove or the replacement restoration has an overhang. Pack et al. (1990) reported that 61% of teeth with overhanging restorations on pre-treatment radiographs had residual overhangs post-treatment.

Gilmore and Sheiham (1971) radiographically (Schei ruler) identified 0.22 mm proximal alveolar bone loss associated with overhangs in posterior teeth compared to non-restored proximal surfaces. Clinically, higher periodontal disease index scores were associated with the presence of overhangs. Similarly, Jeffcoat and Howell (1980) reported that medium and large overhangs were associated with greater radiographic bone loss compared to contralateral teeth without overhangs in 100 patients.

Lang et al. (1983) reported the clinical and microbiological effects of subgingival restorations with or without overhangs. In a crossover design, gold onlays extending 1 mm subgingivally were placed in 10 patients (20 sites). Half of the onlays had clinically perfect margins, the other half had 0.5 to 1.0 mm overhangs. The onlays were placed for 8 to 24 weeks and were subsequently switched (i.e., crossed-over) for 12 to 27 weeks. No oral hygiene was performed on the proximal surfaces of the onlays. Overhang surfaces were associated with bleeding on probing and a 1 to 2 mm increase in probing depth (without any loss of attachment). The overhanging restorations were accompanied by a shift in the subgingival microflora similar to that found in chronic adult periodontitis. This included increased proportions of Gram-negative anaerobic bacteria, black-pigmented *Bacteroides*, and an increased anaerobe:facultative ratio.

Highfield and Powell (1978) examined the effect of posterior amalgam overhang removal on periodontal health. Eighty (80) overhangs received 1 of 4 treatments consisting of: 1) no treatment; 2) overhang removal; 3) professional plaque control every 2 weeks without overhang removal; or 4) overhang removal and professional plaque control every 2 weeks. Three-month results indicated that the group receiving overhang removal and professional plaque control had the greatest improvement in gingival index and bone score. Removal of plaque only or overhangs only failed to result in a dramatic improvement.

### Effects of Preparation

The effects of margin preparations which violate the biologic width were demonstrated in a report by Carnevale et al. (1983). Marginal and interproximal connective tissue was removed, exposing interproximal crestal bone in dogs. Teeth received one of the following margin preparations which extended to the alveolar crest: 1) chamfer; 2) feather edge; 3) shoulder; or 4) no preparation. Histological examination revealed complete healing by 90 days with the experimental sites demonstrating approximately 1 mm of crestal bone resorption while the control sites had no bone loss or attachment loss. Tooth preparation for crowns with crevicular margins can be accomplished relatively atraumatically with judicious treatment. Dragoo and Williams (1982A and 1982B) prepared human teeth scheduled for extraction. The teeth were subsequently removed in block section with the adjacent soft tissue. Histological examination indicated that tooth preparation preceded by retraction cord placement sustained minimal soft tissue trauma. Teeth prepared without retraction cord which subsequently received either retraction cord, electrosurgery, or rotary gingival curettage sustained various degrees of soft tissue damage.

### Margin Placement

When margins violate the biologic width, potential exists for attachment loss and apical migration of the junctional epithelium. Parma-Benfenati et al. (1986) placed amalgam restorations at or 4 mm coronal to the alveolar crest in dogs following partial thickness flap reflection. Flaps were subsequently apically positioned. Twelve-week histological results demonstrated approximately 5 mm of bone loss in thin osseous septa adjacent to the crestal restoration margins. In a similar study design, Tal et al. (1989) placed amalgam restorations with facial margins at the alveolar crest following mucoperiosteal flap access. Control sites received mucoperiosteal flap reflection but no restorations. At 57 weeks the experimental sites demonstrated a mean of 3.16 mm marginal recession, 1.17 mm bone loss, and 0.90 mm connective tissue attachment. Control sites presented 0.46 mm marginal recession, 0.15 mm bone loss, and 4.47 mm connective tissue attachment. Although the post-study "biologic width" apparently changed from the pre-study measurements, attachment loss was obviously related to the violation of the biologic width.

Dragoo and Sullivan (1982A and 1982B) examined the effects of subgingival margin placement using acrylic temporary crowns on human teeth scheduled for removal. Shoulder preparations with a gingival bevel were followed by placement of temporary crowns. Crown margins terminated at the length of the gingival bevel or shoulder. Clinically, crowns with short margins appeared to heal more favorably. Histologic examination of teeth and adjacent soft tissue removed at 4 weeks indicated that crowns with the long margins gave the most ideal healing response. This was attributed primarily to their ability to prevent soft tissue from collapsing onto the shoulder and compromising complete seating of the permanent restoration. Flores-de-Jacoby et al. (1989) studied the effect of crown margin location on periodontal health and bacterial plaque morphotypes (dark-field microscopy) at 6 to 8 weeks and 1 year after restoration placement. The plaque index, gingival index, probing depths, and sulcus fluid flow were significantly higher for subgingival-margin sites compared to gingival or supragingival margins. Plaque from the subgingival margin group also had significantly lower counts of cocci and higher counts of spirochetes, fusiforms, rods, and filaments as compared to gingival or supragingival margins. The authors concluded that subgingival margins are associated with higher bacterial accumulation and less favorable plaque composition. Supragingival margins were most favorable while there was no clear indication that gingival margins were harmful. Stetler and Bissada (1987) investigated the interaction of subgingival crown margins in areas of narrow ($< 2.0$ mm) and wide ($\geq 2.0$ mm) zones of keratinized tissue in 58 teeth. The authors assumed that areas showing recession in proximity to crown margins signified that the original crown margin was subgingival. Narrow zones of keratinized tissue had a significantly higher gingival index (GI) than subgingival margins with a wide zone of gingiva. The gingival index did not differ between narrow and wide zones of gingiva in areas without subgingival margins The authors recommended augmenting the zone of keratinized tissue if subgingival margin placement is planned in an area with $< 2$ mm of keratinized tissue and where optimal oral hygiene cannot be anticipated.

Reasons for intracrevicular placement of margins include removal of caries or faulty restorations, development of adequate retention, prevention of root sensitivity, and/or esthetics. When placement of intracrevicular margins is not indicated, every attempt should be made to keep margins supramarginal; there is no assurance that they will remain in the desired position. Valderhaug and Birkeland (1976) evaluated 98 patients with crowns and fixed partial dentures over the course of 5 years. Initially, 59% of crown margins were located intracrevicularly; after 5 years, only 35% remained in this location. Mean probing depth and GI increased and attachment loss was greater adjacent to teeth with intracrevicular margins, while teeth with supragingival margins had decreased probing depths, gingival indices, and less attachment loss.

Carnevale et al. (1990) retrospectively evaluated 510 single unit crowns (350 molars, 139 premolars, and 21 anterior teeth) that had been re-prepared during flap and osseous surgery at least 1 year previously. Non-restored teeth were used as controls. The crown margin locations were categorized as supragingival, subgingival, or at the gingival margin and were evaluated for clinically significant differences with respect to plaque, gingivitis, and probing depth. The 109 patients in the study had been treated for moderate to advanced periodontal disease and were seen on a 1 to 6 month recall interval. They found no statistically significant differences between the restored versus non-restored teeth relative to plaque and gingival inflammation. Crowns terminating at the gingival margin had the highest percentage of GI scores of 0, followed by subgingival and supragingival margins. At re-examination, 95.5% of the teeth had probing depths less than 3 mm; 4.1%, 4 to 5 mm; and 2 teeth ≥ 5 mm. Less than 1% bled upon probing.

### Crown Lengthening

Ross and Garguilo (1982) discussed the restorative alveolar interface (that area of the root surface located between the alveolar crest apically and the free gingival margin coronally) and felt that crown lengthening procedures should include modification of this area of root surface and provide adequate room for crown preparation and re-establishment of the biologic width. The authors suggested that these modifications would enhance the contours of the final restoration and facilitate hygiene and maintenance therapy.

Bragger et al. (1992) evaluated the changes in periodontal tissue immediately and 6 months after crown lengthening surgery on 43 teeth in 25 patients. The surgeries created a 3-mm distance between the restoration margins and the osseous crest. Treatment proceeded after 3 weeks of healing, with clinical measurements recorded at baseline, 6 weeks, and 6 months. Osseous crest reductions of 1 mm, 2 mm, and 3 to 4 mm were observed 32%, 21%, and 4% of the time, respectively. Mean apical soft tissue recession was 1.32 mm immediately after suturing. No further significant change in mean soft tissue position accompanied healing. However, on a site basis, 33% of the sites had 1 to 3 mm of coronal soft tissue displacement and 29% of sites had 1 to 4 mm of recession between 6 weeks and 6 months. No further changes in attachment loss occurred after the initial 6 weeks of healing, nor did probing depths change. The study emphasized the need to delay margin placement in areas of esthetic concern up to 6 months following crown lengthening surgery.

### Temporary Restorations

Waerhaug (1980) created cavity preparations which extended subgingivally in monkeys and dogs. The preparations were subsequently filled with self-curing acrylic resin, zinc oxide and eugenol, or gutta percha. Histological observation 13 to 283 days after restoration placement indicated initial plaque formation at the tooth-restoration interface which spread over the restoration and eventually over the tooth surface apically. Even in the absence of plaque, submarginal gingivitis accompanied restorations. Attachment loss of more than 0.2 mm was invariably associated with apical migration of the subgingival plaque (1.0 mm at 18 days). Vigorous toothbrushing was effective up to 0.7 mm below the gingival margin, suggesting that submarginal extension of restorations should be limited to no more than this distance.

### Osseous Resective Surgery

Guilbert et al. (1988) reviewed restorative treatment for patients with severe periodontal disease who were treated with osseous resective surgery for pocket reduction. Prognostic considerations included patient age, systemic condition, patient behavior, clinical form of the disease, disease rate of progression, tooth anatomy, malocclusion, and habits. The strategic value of individual teeth was evaluated by comparing anterior and posterior and left and right segments. Molars and canines were assigned a value of 3; second molars, second premolars and centrals, 2; and first premolars and laterals, 1. These values were decreased by 1 if the tooth had 50 to 80% bone loss, Class I furcation invasions, or mobility. With > 50% bone loss and more involved furca, the strategic value was reduced by 2. Each segment had to score ≥ 3 for a fixed prosthesis to have a favorable prognosis. According to the authors, esthetic considerations for osseous resective surgery include increased crown length, with the lip frame, lip line, and anterior overbite requiring consideration. Treatment plans should include initial preparation; caries control and defective restoration repair; pathological tooth migration correction; provisional stabilization; endodontics; surgical periodontics, postsurgical endodontics; clinical and radiographic re-evaluation at 12 weeks; final restorative phase and final periodontic, endodontic, and prosthetic evaluations prior to final cementation. The authors felt that the final prosthesis should be divided into segments of ≤ 6 units, occlusal forces should be directed along the long axis of the teeth, and initial cementation should be temporary (3 months) followed by re-evaluation.

## OTHER PERIODONTAL-PROSTHODONTIC RELATIONSHIPS

### Soft Tissue

The environment associated with pontic placement is a prime determinant of long-term success of a fixed partial denture. If soft tissue form and surface characteristics are deemed unacceptable, corrections should precede fabrication of the restoration (Hunt, 1980). Circumstances permitting, pontics should be placed over keratinized tissue rather than alveolar mucosa. Ridge augmentation may be accomplished by internal connective tissue grafts, free soft tissue onlay-autografts, or ridge transposition. When the ridge is covered by excessive amounts of soft tissue, ridge reduction can be accomplished by gingivoplasty or internal soft tissue wedge reduction (e.g., tuberosity reductions). Osseous surgery may be indicated when a bony portion of ridge is covered by a thin layer of soft tissue. Ridge reduction surgery may be required to increase the vertical clearance between the residual ridge and opposing occlusion. Surgery (vestibuloplasty-free soft tissue autograft) may also be required in areas where shallow vestibules complicate oral hygiene or predispose to adverse interactions between the soft tissue and pontics associated with fixed or removable prostheses.

Allen (1988) described mucogingival treatment techniques to enhance anterior tooth esthetics. He recommended having the gingival margins on incisors peak slightly distal to the midline of the teeth. Central incisors, with an average length of 11 to 12 mm, should be 1.5 mm longer than laterals. These recommendations should take into account whether full coverage restorations are to be utilized with root exposure avoided if restorations are not planned.

## Crown Contour

Eissmann (1971) discussed physiologic design criteria for effective restorative function, comfort, and hygiene. The author advocated axial forms that provided protection and stimulation. Protective contours were described as convex (prominences) while stimulatory contours were concave (sluiceways, embrasures). Protective convexities relate to clinical crown length, decreasing in prominence as the distance from the occlusal table to the free gingival margin increases.

Physiologic tooth contouring is directed at minimizing plaque retention by exposing the largest possible area of the clinical crown to cleansing by food flow patterns, musculature, and mechanical oral hygiene devices. Overcontouring causes plaque accumulation and inflammation and is potentially more detrimental to the periodontium than undercontouring (Youdelis et al., 1973).

Supragingival and subgingival contours should have a flat emergence profile or angle (Kay, 1985). The subgingival contour is an extension of this relationship into the sulcus. The character and dimension of the gingival tissues are the primary variables affecting subgingival contours. Thin friable tissue is less tolerant of subgingival restorative invasion and is more susceptible to shrinkage and marginal recession.

Becker and Kaldahl (1981) emphasized access for oral hygiene and suggested guidelines for crown contours. The guidelines included: 1) "Flat," not "fat" buccal and lingual contours: the normal bucco-lingual contour of teeth without caries is flat with a bucco-lingual bulge, usually $<$ 0.5 mm wider than the cemento-enamel junction. 2) Open embrasures: embrasures should be wide enough to allow adequate room for the papilla and accessibility for cleaning. 3) Contact areas should be in the coronal third of the crown and buccal in relation to the central fossa. This creates a large lingual embrasure for optimum health of the lingual papilla. 4) Exposed furcations should be "fluted" or "barreled out."

## Pontics

Stein (1966) examined 500 pontics to determine associated soft tissue reactions of various pontic designs and materials. Ridges with visible inflammation were termed "involved," while those without visible signs of inflammation were considered "uninvolved." All ridges exhibited histologic signs of connective tissue infiltration with the involved areas demonstrating more superficial and severe infiltration. When tissue was excised from the residual ridge, a transient reduction of 1 mm in tissue height occurred; however, the original ridge height returned within 1 year regardless of whether a pontic was placed. When polished ridge-lap pontics were placed, 90% produced visible inflammation of mucosa regardless of the material (gold, porcelain, acrylic); furthermore, daily flossing under the pontic aggravated the problem. The author concluded that pontic design was more important than the material used in the pontic construction. The ideal design should have pinpoint, pressure-free contact on the facial slope of the ridge, and all surfaces should be convex, smooth, and highly polished or glazed. This configuration has been termed the "modified ridge-lap" pontic. This pontic design offers the most favorable balance between comfort, support, and hygiene, but may appear unesthetic anteriorly. Becker and Kaldahl (1981) recommend the modified ridge-lap design posteriorly and the ridge-lap facing design anteriorly.

## Overdentures

Johnson and Sivers (1987) discussed periodontal considerations for overdentures. Selection of abutment teeth is based on prosthodontic and periodontal considerations, including bone support and architecture, width of attached gingiva, tooth mobility, root anatomy, and tooth position. A minimum of 5 to 6 mm of bone support is suggested. A greater width of attached gingiva may be necessary when the tissue is subjected to mechanical stresses and plaque accumulation accompanying the prosthesis. Mobility patterns are often improved by reducing the crown to root ratio during abutment preparation. Molars and furcated maxillary premolars make poor abutment choices due to concavities, grooves, and possible furcation invasions. However, resected teeth may be suitable abutments. Periodontal surgery may be necessary to reduce pockets, augment attached gingiva (keratinized tissue), and increase vestibular depth where indicated.

Maintenance is essential to the long-term success of overdenture abutments. Hygiene adjuncts using end-tufted brushes and daily application of fluoride are beneficial. Overdenture abutments generally have an increase in gingivitis, and patients with poor oral hygiene and sporadic professional maintenance frequently experience increased caries and attachment loss at overdenture abutments.

## Longitudinal Evaluation of Periodontal-Prosthetic Treatment

Nyman and Lindhe (1979) longitudinally evaluated combined periodontal and prosthetic treatment of patients with advanced periodontal disease. Participants included 251 patients with dentitions devoid of 50% or more of the periodontal support who had received periodontal surgery and prosthetic rehabilitation. Initial clinical and radiographic evaluations were completed following treatment and annually for 5 to 8 years. Low plaque and gingival index scores were maintained over the 5 to 8 year period. No additional attachment loss occurred and bone levels were maintained for all types of fixed partial dentures, including cantilevers. This study suggests that periodontal tissues surrounding fixed partial denture abutments do not react differently from tissues around non-abutment teeth. It should be noted that supragingival margins and excellent oral hygiene were consistently observed in the study population.

Nyman and Ericsson (1982) randomly selected 60 fixed partial dentures (FPD) from the previous study at the 8 to 11 year point for further evaluation. Radiographic assessments of the root surface area, percentage of root in bone, normal PDL area for pontics, and percent of abutment to pontic PDL surface area were determined. Only 5 FPDs met Ante's law, with the PDL surface area of the abutments being equal to or greater than the calculated area of the pontic root surface. The bone heights for all the FPDs were unchanged over the observation period. None of the FPDs failed due to periodontal reasons over the 5 to 8 year period, while 26 of 332 failed as a result of loss of retention, fracture of the abutment teeth, or fracture of the bridgework.

Silness (1980) reviewed selected investigations of periodontal health adjacent to fixed prostheses, examining the concepts that had emerged, and relating these to actual clinical practices. The review included 342 individuals with 357 bridges that had been in place up to 6 years. The patients were divided into 2 groups. Group 1 consisted of 197 subjects who had received periodontal treatment and were given oral hygiene instructions prior to prosthodontic treatment. Group 2 was comprised of 145 subjects who had not received these instructions. Further subgroups and sub-studies were devised to evaluate the distributional pattern of plaque, gingivitis, pocket formation, periodontal effects of the crown margins, influence of full and partial crowns, the relationship between the pontic and the periodontal condition, and the effect of splinting adjacent teeth. Abutment teeth were compared to uncrowned contralateral control teeth. The PI, GI, and PD affected interproximal surfaces more than buccal surfaces, with no difference between abutments and controls. Group 1 values were lower than Group 2 values. Bridges did not change the distribution of plaque and periodontal disease. Subgingival margins showed higher PI, GI, and PD values than margins above the gingival margin, which, in turn were better than margins even with the gingiva. The authors suggest that the subgingival zone should be as smooth as possible in order to avoid harmful tissue reactions; splints should only be used when retainer margins are supragingival and embrasures facilitate cleaning; and pontics should be convex in all directions.

In 38 patients who had received removable partial dentures (RPDs) 8 to 9 years previously, Chandler and Brudvik (1984) evaluated clinical parameters and caries rates, comparing the results with those recorded at the 1 to 2 year periods. Teeth were categorized as abutments, indirect abutments (with rest seat), and non-abutments. Thirty-three (33) of 44 RPDs were still serviceable, with occlusal function rated fair to good. Of the 291 teeth included in the study, 8 were lost in 5 patients. All were mandibular teeth and 3 were lost as a result of periodontal disease. Approximately 50% of the caries occurred on surfaces covered by the RPDs, but no significant differences were observed between the 3 groups of teeth. Probing depths were significantly increased for all 3 groups when compared to the pre-insertion depths, but no significant differences were observed between the groups. The abutment teeth had significantly greater increases in mobility when compared with the 2 time periods. Although no significant differences in gingival inflammation were reported for the 2 time periods, by 8 to 9 years, more gingival inflammation was present in regions covered by the RPDs. Alveolar bone level changes were not significant between either the time periods or the groups. These results of this study indicate that long-term dental health may be maintained in patients wearing RPDs.

Bergman et al. (1985) also reported that RPDs did not compromise long-term dental health. They completed a 10-year longitudinal study of 30 patients who had been treated restoratively, periodontally (as required), and prosthetically with RPDs. An attempt was made to place crown margins supragingivally when possible. Conventional RPDs were designed and fabricated to keep denture bases, clasps, and bars as far from the gingiva as possible. Recalls for oral hygiene and necessary restorative treatment were maintained. Clinical parameters including oral hygiene, GI, PD, mobility, alveolar bone levels, decayed and filled surfaces, and prosthetic concerns, were recorded at day 0, and at 1, 2, 4, 6, and 10 years. During the 10-year follow-up period, no changes were observed relative to the plaque and gingival indices, probing depth, and mobility. Small, insignificant differences were found in proximal marginal alveolar bone levels for direct abutment teeth with distal-extension RPDs. The number of surfaces at risk for decay or restoration that were restored increased from 50.5% to 54.2% over the 10-year period, with an average of 1 new surface per patient with caries. Restoration service time averaged approximately 8 years before replacement. The authors concluded that with an effective preventive dentistry program, RPDs will not adversely impact the progression of periodontal disease or carious lesions.

## SUMMARY

One of the primary goals of restorative therapy is the reestablishment of function commensurate with contour and design that will facilitate the long-term maintenance of periodontal health. Careful attention to detail relative to the effects of crown contour, margin placement and pontic design on the surrounding soft tissue is essential if this goal is to be achieved.

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