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Periodontal considerations in restorative and implant therapy

PERRY V. GOLDBERG, FRANK L. HIGGINBOTTOM & THOMAS G. WILSON, JR.

Successful restorative dentistry can be best accomplished when healthy and stable tissues surround the teeth or their implant replacements. This chapter addresses the interactions between periodontal tissues and restorative procedures. Close attention to both soft and hard tissues around teeth and implants before, during, and after restorative procedures will greatly increase the probability of a successful outcome.

Fig. 1. A minimal band of keratinized gingiva was associated with recession following placement of restorations approaching the free gingival margin.

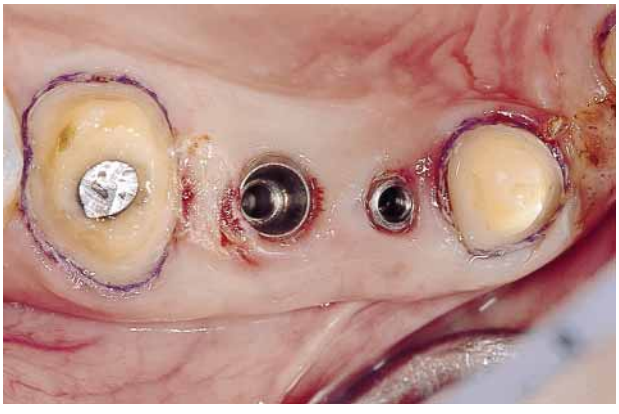

Fig. 2. Two retraction cords have been placed to ensure adequate coverage of the margins by the impression material.

Mucogingival considerations

While the need for attached and keratinized gingiva in maintaining health around the natural dentition and dental implants can be debated, the importance of these tissues adjacent to restorative margins is clear. Specifically, attached gingiva is needed to reduce the probability of gingival recession in areas of aesthetic margin placement, to facilitate impressions, and in some cases, to increase patient comfort.

The margins of some restorations must be extended slightly into the gingival sulcus. The extension of any restorative margin into the gingival sulcus should be considered a compromise (29–32), but aesthetic or retentive demands often make it necessary. Because margins in aesthetic areas must be camouflaged or concealed, any gingival recession that occurs following final placement of the restoration can compromise aesthetics (Fig. 1). To minimize the probability of recession, the gingival tissues should be clinically healthy before beginning restorative procedures. In addition, there should be an "adequate" band of keratinized and attached gingiva (34). The important question then becomes what is "adequate"? While there is no universal answer, thicker tissues with 2 mm of keratinized gingiva and 1 mm of attached gingiva have been found by the authors to provide adequate protection against recession. This assumes that: 1) the health of the tissues is maintained, 2) restorative margins do not extend into the sulcus more than 0.5 mm, 3) atraumatic retraction and impression procedures are used, and 4) the final restoration has optimal contours and marginal fit (Fig. 2, 3).

The accuracy of subgingival impressions depends on exposure of tooth preparation margins. This is

best achieved when the soft tissues can be gently and atraumatically retracted and allowed to rebound after these procedures. An adequate band of keratinized and attached gingiva will increase the probability of this tissue rebound.

Some patients with dental implants experience gingival tenderness and food impaction where there is inadequate attached gingiva. This problem can be eliminated by surgical gingival augmentation. Augmentation can take several forms and is beyond the scope of this chapter. The reader is referred to other sources for a discussion on this topic (35). The authors have found that subepithelial connective tissue grafts in aesthetic areas satisfy functional and aesthetic demands more predictably than other procedures.

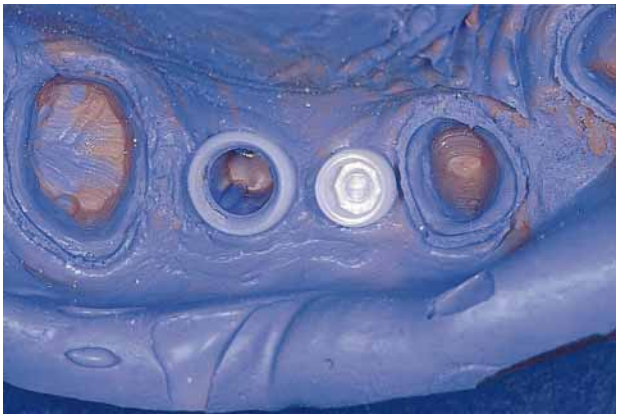

Fig. 3. The impression from the case seen in Fig. 2.

Fig. 4. The margin of this restoration is located just coronal to the free gingival margin. This allows the patient to clean the interface where there are no aesthetic concerns.

Tooth/implant preparation – margin placement

As previously stated, subgingival margins should be considered a compromise (1, 18, 28, 22–25), and supragingival margins are preferred (13, 19). Where aesthetics are not a concern and adequate tooth structure exists, supragingival margins (for both the natural dentition and dental implants) are recommended (Fig. 4). In areas where inadequate tooth structure is present coronal to the soft tissues, crown lengthening (see Wang & Greenwell in this volume) or orthodontic extrusion can be used to increase clinical crown length.

For both the natural teeth and dental implants, several principles should be taken into consideration when subgingival margin placement is necessary. First, the marginal fit should be optimal because rough restorations or open margins lead to an accumulation of bacterial pathogens that are associated with inflammatory periodontal diseases (10). Second, the margins of restorations around natural teeth should extend only slightly into the gingival sulcus. This is to facilitates oral hygiene and avoids encroachment on the "biological width" (see below). Third, materials used for the restoration should be compatible with the soft tissues and lend themselves to the precise interface needed to minimize marginal discrepancies that encourage retention of bacterial plaque.

In areas of aesthetic concern, the connection of the implant and the prosthetic element is located below the soft tissue margin. To minimize the effect of the bacterial trap at this implant/restorative junction, the clinician should consider selection of an implant system that: 1) has this interface coronal to the facial and lingual bone, 2) provides the closest possible implant/abutment interface, and 3) allows screw-retained restorations (as opposed to cemented) (9) (Fig. 5, 6). Although more technique sensitive in achieving passively fitting prostheses, screw-retained restorations that use machined components result in smaller implant/restorative discrepancies, and therefore, minimize accumulation of subgingival bacterial plaque.

Crown lengthening and biological width

Crown lengthening or the increasing exposure of coronal tooth structure is a valuable adjunctive procedure in restorative dentistry that may be indicated for a number of reasons. The first of these is where

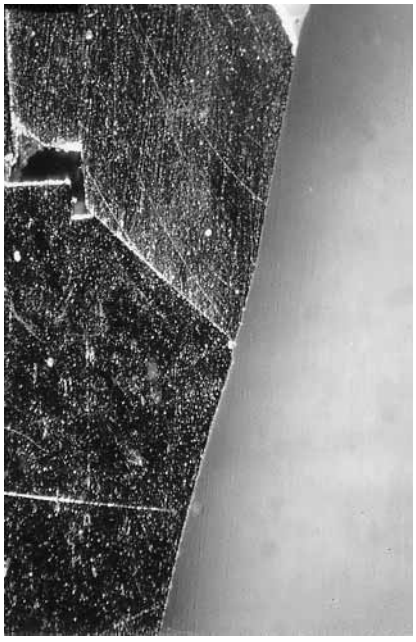

Fig. 5. Transverse section of a screw-retained specimen of an ITI implant. Compare the space between the implant and the crown with that seen in Fig. 4 in which the crown is cemented (*in vitro*) (original ×40). Courtesy of Scott E. Keith.

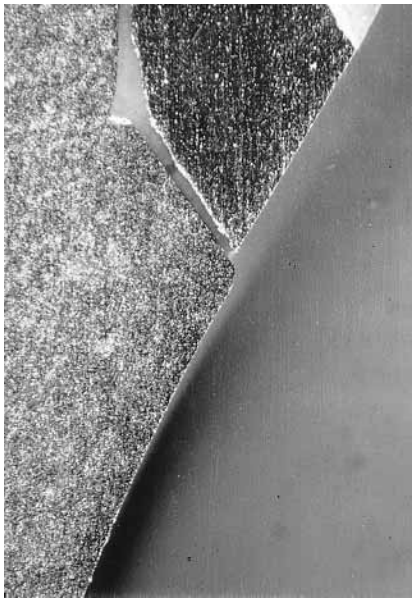

Fig. 6. Transverse section of cement-retained specimen of an ITI implant (*in vitro*) (original ×40). Courtesy of Scott E. Keith.

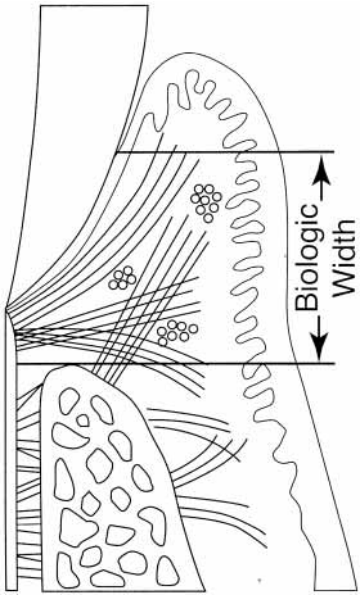

Fig. 7. The biological width is the dimension of the soft tissue from the alveolar bone to the apical extent of the junctional epithelium. In the average patient, this 2- to 3-mm distance remains constant in health and disease. Encroachment on the biological width by restorations often leads to a series of events that result in the formation of periodontal pockets.

previous restorations, caries, fractures, etc. have encroached on the biological width. The gingival tissues must attach to the tooth coronal to the alveolar bone and, in general, 2–3 mm of clean, healthy tooth surface is needed for this attachment. This gingival attachment is usually constant at all levels of probing depth, and has been termed the biological width (6) (Fig. 7). Encroachment on the biological width by tooth preparation, caries, fracture, restorative materials or orthodontic devices can lead to bacterial accumulation, inflammation, increased probing depths, gingival recession or a combination of these problems. To avoid encroachment on the biological width, the restorative dentist should measure probing depths before preparing the teeth. In normal (2–3 mm), healthy sulci with adequate bands of gingiva, margins can be placed 0.5 mm into the sulcus. In areas where there is insufficient tooth structure to allow adequate soft tissue attachment, crown lengthening may be necessary. This can be accomplished surgically (4, 8) or by orthodontic extrusion (Fig. 8–10). The surgical aspects of this procedure are covered by Wang & Greenwell in this volume.

Fig. 8. This patient was referred to expose caries that extended close to the alveolar bone on the facial surface of the lateral incisor.

A second indication for crown lengthening is in situations when short clinical crowns must be restored. This may require exposure of additional tooth structure for adequate retention of the fixed restoration. Short clinical crowns can be due to excessive coverage of the coronal portion of the tooth

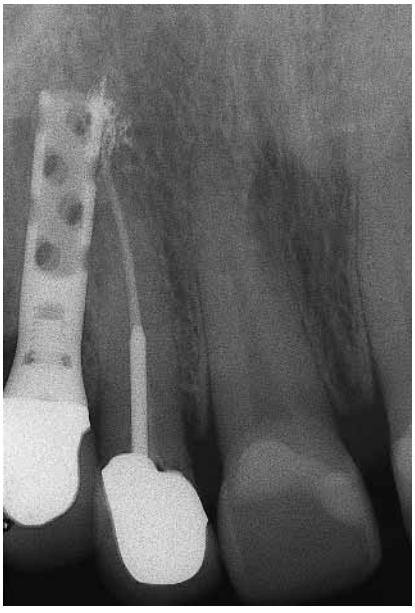

Fig. 9. Radiograph of tooth in Fig. 6 showing sufficient tooth length to allow orthodontic extrusion of the lateral incisor

by the soft tissues or may be associated with posterior bite collapse or excessive parafunctional patterns (bruxism, etc.) that have resulted in a reduced tooth height. In either instance, apical positioning of the gingival margin is usually accompanied by osseous resection to ensure a stable tissue level after healing.

Endodontically treated teeth often require full-coverage restorations. Regardless of the type of core build-up or reinforcement, whether it be preformed or custom post, bonded or cemented, forces may be imparted to the tooth that predispose it to fracture. To avoid or minimize this potential problem, crown preparations should extend apically beyond the margin of the core and engage approximately 2 to 3 mm of sound tooth structure. If there is less than 2 mm of sound clinical tooth beyond the post or core, then either surgical crown lengthening or orthodontic super-eruption is indicated so the required amount of tooth structure may be engaged by the restoration.

Crown lengthening may also be done for aesthetic reasons. This may sometimes be associated with the so-called gummy smile or excessive display of gingival tissue (see Wang & Greenwell in this volume). Wear patterns, restorations that have been artificially widened to close diastemas or tissue levels that are in an abnormal coronal position may create a situation in which teeth are disproportionately wide relative to their height. The “golden proportion” has been recommended as a guide for an aesthetic tooth/restoration: the mesial-distal width of a tooth is approximately 75% of its height (20). Even in a natural dentition where no restoration is planned, crown lengthening may be indicated to establish this proportion. Where excessive suprabony gingival tissue is present (more than 3 mm during sounding with a periodontal probe following local anesthesia); gingivoplasty of up to 1.5 mm can be performed. Following normal tooth eruption, excessive gingival tissues in aesthetic areas are uncommon. Reflection of a full-thickness mucoperiosteal flap followed by judicious bone removal and apically positioning of the flap is often required (Fig. 11–15).

Several months of healing are necessary to re-establish a normal sulcular depth after crown-length-

Fig. 10. To preserve the aesthetics of the area, orthodontic extrusion was chosen over crown lengthening surgery. This moved the soft tissues coronally allowing an apically positioned flap (performed after this photograph was taken) to move the tissues into a normal relation with tissues on the contiguous teeth.

Fig. 11. This patient had worn away her anterior dentition through years of bruxing.

Fig. 12. After placing provisional restorations, it was determined that crown lengthening was needed to establish improved aesthetics by increasing the length of the clinical crowns.

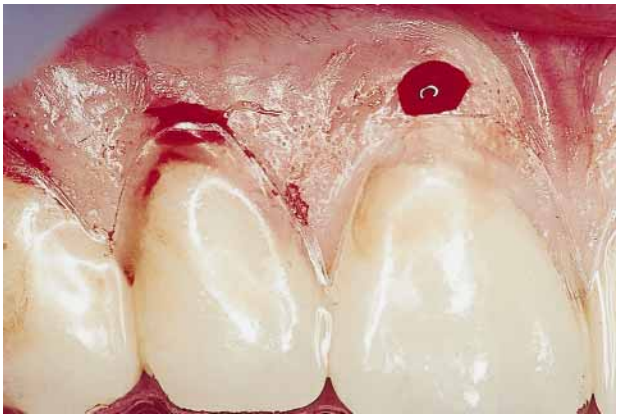

Fig. 13. A surgical template was constructed to guide placement of the soft tissues.

ening procedures. It is, therefore, suggested that final tooth preparation and restoration be delayed until adequate time for healing has occurred. On average, this takes about 90 days (2). The use of provisional restorations that mimic the proposed shape of the final restorations allows the clinician to preview the response of the soft tissues to subgingival margins and the contours of the restoration. It also provides an optimal environment for performing procedures such as surgical tissue modification prior to fabricating the final restoration.

Crown contour and emergence profile

Crown contours are normally determined by tooth anatomy, periodontal condition, margin placement, and access for oral hygiene. However, compromises must occasionally be made in the interest of aesthetics or to reduce food retention. Proper restorative contours require adequate tooth reduction to allow proper thickness of restorative materials, while allowing easy access for personal oral hygiene.

The emergence profile of a restoration is the shape of the restoration in relation to the gingival tissues. The emergence profile of a restoration in aesthetic areas has two aspects: subgingival form and supragingival form. The subgingival form should follow the contours of the cementoenamel junction and support the gingival tissues. Within limits, increased thickness of interproximal subgingival contours leads to increased papillary height, while increased facial contours lead to apical positioning of the gingival tissues.

Fig. 14. The area 3 months after periodontal surgery

Fig. 15. The final clinical appearance following an apically positioned flap. Bone removal was needed to establish an adequate biological width (compare with Fig. 11).

Tissue retraction for impressions: displacement versus resective procedures

The extension of preparations below the free gingival margin and the use of elastic impression materials necessitate the exposure of gingival margins of preparations to allow for their accurate duplication (11). Gingival retraction may take one of two forms. The first involves the displacement of the gingival tissues (such as retraction cords, copper bands, etc.). A two-cord technique is an effective way of providing gingival retraction. The initial tooth preparation is completed to the level of the free gingival margin. A small diameter cord (lightly braided with minimal memory and usually impregnated with a chemical agent) is gently placed slightly below gingival level circumferentially around the tooth. The preparation is then refined and, where dictated by aesthetics or the need for additional retention, the margins of the preparation are extended approximately 0.5 mm below the tissue level. A second and larger diameter cord is then gently packed over the first cord to expose the margins. An impression can then be taken after removal of only the larger diameter cord. The use of bands as a displacement technique, whether with impression compound or elastic materials, is an accurate and effective method of gingival retraction. However, trimming and fitting of such bands must be done with great care because excessive pressure or extension of the band may sever or traumatize the gingival attachment and lead to irreversible gingival recession.

The second major method of gingival retraction involves the surgical removal of tissue to form a trough around the preparation, thereby exposing the margins for the impression material. This is most commonly accomplished with electrosurgery or lasers. While recognized as an effective method of retraction, injudicious use of either of these instruments can cause excessive necrosis of the gingiva and, in extreme cases, the underlying bone. Electrosurgery works by concentrating an electrical current at the tip of the electrode, thus generating enough heat to volatize the tissues. If care is not taken to keep the electrode in constant motion and to allow recovery time between passes, irreversible damage may occur (33). The same is true for the use of the laser for retraction. Therefore, tissue resection has the potential of reducing soft tissue height and causing bone destruction. This may lead to exposure of margins or compromised aesthetics and resective procedures should be avoided in areas where the gingival architecture is thin or over prominent teeth such as in anterior segments of the mouth.

Prosthetic design

As is the case with natural teeth, implants function best and withstand occlusal forces optimally when loaded in a vertical direction. This is especially true in the posterior regions of the mouth, where the potential forces are increased in relation to the proximity of the temporomandibular joints and musculature. For this reason, planning and placement of implants with proper angulation is critical. In posterior partially edentulous situations, where three or more implants are placed, an attempt to keep implants from being in a straight line (that is, tripodization) is recommended for one style of implant (17). This establishes a more optimum foundation to better withstand subsequent loading for this particular system.

In fully edentulous patients, an attempt should be made to extend the implants over as large an arc as possible. If possible, a straight-line arrangement of implants in the anterior region should be avoided because it results in excessive and unfavorable torque when loaded with prosthesis. Such a prosthesis will transmit forces that may ultimately result in loosening or breakage of implant components. The forces may even jeopardize osseointegration of the implants themselves. Proprioception is greater around natural teeth than around implants. Consequently, whenever possible, in partially edentulous patients, it is suggested that natural teeth be used to guide the occlusion. If natural canine guidance in excursive movements cannot be achieved, group function of splinted implants should be considered in order to maximize support.

Cantilevers incorporated in restorations placed on natural teeth, while often eliminating the need for removable prostheses, are fraught with potential problems. As a result of pressure being placed on a largely unsupported restoration (the pontic), it is not uncommon to see complications such as fractures of solder joints or porcelain, cement washout and caries of the adjacent retainers, breakdown of the periodontium (in the presence of inflammation) or fracture of roots. Cantilevered implant restorations are subjected to similar loads. Therefore, the decision to use cantilevered pontics with implants should be made only after a careful consideration of forces that are associated with their use. In general, in patients with a history of parafunctional habits,

cantilevers in posterior segments should be used sparingly and, if used, should be suspended only from multiple-splinted implant restorations. The occlusal contacts of cantilevers should be light and to minimize the chance of occlusal overload, cantilevered units can even be modified to consist of a facial aspect with little or no occlusal surface. As a matter of course, these restorations should be protected with a physiological bite appliance.

The role of occlusion in periodontal disease

Bacterial plaque is necessary for the initiating and sustaining marginal periodontal inflammation (12) and the clinical course of the periodontal disease can be influenced by risk factors such as genetic influences, smoking, and diabetes. The location and composition of bacterial pathogens are important local factors that can be affected by compliance with suggested oral hygiene procedures and periodontal maintenance. Some have downplayed the role of occlusion as a risk factor for patients with periodontitis (16), but the opposite view can also be supported. Pihlstrom et al. showed that teeth exhibiting movement in function (fremitus) have less bone support than teeth without fremitus, even when matched for comparable levels of inflammation and clinical attachment loss (15). Other work has related increased tooth mobility to increased loss of periodontal support (5). Still other studies have shown a positive relation between tooth movement and increased levels of interleukin-1 (7). Interleukin-1 is an inflammatory mediator that is found in higher levels in inflamed than noninflamed gingiva.

The role of occlusion in implant failure

Implants and the prostheses they support are vulnerable to excessive forces. The design of an individual implant may influence its long-term success. Overloading, often from occlusal forces, can result in loosening or breakage of implant components and, in extreme cases, of the implants themselves. However, the judicious selection of appropriate implants, proper treatment planning, careful implant placement and prosthetic reconstruction can virtually eliminate breakage. The use of narrow implants should be restricted to areas of minimal loading (usually in anterior segments), and increased use of wide-bodied implants in posterior areas can help avoid these problems.

The role of occlusion in the failure of implants without fracture is more controversial. Bone loss around failing implants has been blamed on traumatic forces of occlusion, improperly fitting restorations, bacterially induced inflammation, or a combination of these factors (14). The use of more and larger diameter implants, offset placement (17), or structurally stronger implants with greater bone affinity (3) have been suggested as possible ways to reduce the probability of implant failure from occlusal trauma.

Splinting teeth can increase patient comfort and improve mastication. It can also be indicated in patients with increasing tooth mobility (26). In most cases with early to moderate tooth mobility, the decision to splint should be made following resolution of inflammation, fabrication of occlusal guards, and occlusal adjustment. In some advanced cases, splinting may be needed early in treatment to improve function or enhance aesthetics or to allow placement of implants under provisional restorations. Splinting has not been shown to reduce tooth mobility once the splint is removed (21). Implants may be splinted to provide additional stability to the prosthesis and increase support. Cross-arch stabilization has been suggested for immediately loaded full arch implants (27). The relative contraindications to splinting implants include reduced access for oral hygiene or possible aesthetic compromises.

Temporization

Temporization (Fig. 12, 16, 17) provides a template for tissue healing and a diagnostic tool for successful restorations. Fabrication of a fixed provisional restoration, whether it be for a single unit restoration or full-mouth rehabilitation, and whether for natural teeth or implants, is a critical phase of restorative dentistry. The provisional restoration serves as a diagnostic tool and is essential in establishing a precursor to the permanent restoration. By using provisional restorations, an evaluation of the proposed final restorations can be done in the early stages of treatment. Corrections or alterations can then be performed prior to making a commitment to the final restoration. The following are some of the functions of provisional restorations.

- They maintain space and protect the teeth while a final restoration is being fabricated.

- They facilitate elimination of caries and faulty restorations as well as facilitate healing and oral hygiene.
- They provide improved access and visibility for periodontal surgical procedures or implant placement.
- They serve as a trial method for re-establishing vertical dimension and occlusal schemes in cases of posterior bite collapse or tooth migration. As such, they allow the practitioner to evaluate whether or not prosthetics alone will be sufficient or whether other treatment such as pre-prosthetic surgery, dental implants or orthodontics will be needed to achieve the desired outcome.
- They can provide anchorage for orthodontic tooth movement.
- They may be used to stabilize mobile teeth and to evaluate the periodontal and pulpal status of individual teeth.
- They serve as a template to evaluate aesthetics and phonetics, as well as to assess the form and function of the final restoration.
- Provisional restorations provide patients with a preview of the end result. This can have tremendous psychological benefits and build patient confidence in the dentist. It also helps patients to become more comfortable with plans for future treatment. This may be especially true for patients who are new to a dental practice or for those who are having complex treatment because the final restoration may be months or even sometimes, years away.
- In implant dentistry, the provisional restoration can be used to facilitate and guide soft tissue healing by establishing ideal contours.
- The provisional restoration can be utilized to facilitate the transition from a tooth-supported prosthesis to one that is implant-borne.
- Provisional restorations can be used to avoid removable appliances during the osseointegration phase of implant placement, and thus eliminate premature loading of the fixtures.

There are numerous methods of fabricating provisional restorations. They can be made by using direct intraoral procedures, by utilizing an impression and a vacuum formed shell from the existing dentition or by a diagnostic wax-up. Provisional restorations may also be prefabricated as a heat-processed shell in the laboratory prior to tooth preparation. The heat-processed provisional, whether for the single tooth or full arch, has the advantages of improved aesthetics and durability. When teeth with questionable prognoses or excessive mobility are being maintained, or when a minimal number of teeth are being utilized to support a provisional restoration during osseointegration, the incorporation of metal reinforcement for extra strength is advisable.

Fig. 16. Provisional restorations in place following initial stabilization of implants that replace the maxillary central incisors

Fig. 17. Care was taken to provide supragingival and subgingival contours that would support and shape the gingival tissues seen around natural teeth.

The importance of the temporization phase cannot be overemphasized. It provides both the dentist and the patient with a preview of the end result. It also serves as a trial and error method of evaluation that is often necessary to create a successful and long lasting restoration. If a satisfactory provisional restoration cannot be fabricated, the practitioner should not expect the final restoration to magically eliminate any unresolved difficulties.

Summary

The successful integration of periodontal and restorative dentistry for both natural teeth and implants requires knowledge and application of both mechanical and biological principles. In areas of aesthetic concern, an adequate band of attached gingiva can increase patient comfort, reduce the probability of gingival recession following tooth preparation and simplify restorative procedures. While some restorative margins need to be placed at or below the margin of the free gingiva, this should be considered to be a compromise, and margins should not be placed more than 0.5 mm into a healthy gingival sulcus. Approximately 2–3 mm of healthy, natural supra-alveolar tooth surface is needed for attachment of the gingival tissues to the tooth. This dimension is called the biological width. If adequate biological width does not exist, surgical or orthodontic procedures to expose healthy tooth structure are recommended before final restorations are placed. Retraction of soft tissues for impressions is best accomplished with mechanical methods rather than lasers or electosurgery because of the potentially harmful effects of these devices to the cementum, bone and soft tissues surrounding the teeth. Implants function best and withstand occlusal forces optimally when loaded in a vertical direction. Therefore, planning implant placement is critical for success. Because of increased proprioception, it is suggested that natural teeth be used to guide the occlusion in partially edentulous patients. Cantilevers should be used with caution and with appropriate attention to occlusal forces. While occlusal trauma does not cause periodontal disease, it may contribute to bone loss around teeth and implants. In the opinion of the authors, provisional restorations are an integral part of dental and periodontal therapy. They can be used to establish aesthetic and physiological contours that can be easily cleaned by patients and they can also be used as a guide for any needed surgical tissue modification.

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