Implant Prosthodontics - An Adjunct in Periodontal Prosthesis

Part I and II: Diagnosis, Treatment Planning, and Sequencing of Therapy

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ABSTRACT

Periodontal prosthesis can be defined as "those restorative and prosthetic endeavors that are absolutely essential in the treatment of advanced periodontal disease". The sequence of therapy is planned so that the basic contributing factors of inflammation and trauma from occlusion are brought under control.

Experimental and clinical research over the last decade has shifted the focus of periodontics towards increased use of guided tissue membrane techniques.

Today, as a result of the longitudinal studies on the viability of endosseous implantology,[5-12] implants used as an integral part of Periodontal Prosthesis now offer the patient and dentist a more stable and predictable restoration.

These articles focus on the comprehensive treatment of the partially edentulous situation. The first two parts address diagnosis, treatment planning and treatment sequencing in the overall management of the compromised dentition.

For decades, many dentists subscribed to a therapeutic dental philosophy called "Periodontal Prosthesis",[1,2] a term coined by M. Amsterdam and taught by himself, D.W. Cohen, G. Kramer, S. Schluger, R. Youdelis and others.

Periodontal prosthesis can be defined as "those restorative and prosthetic endeavors that are absolutely essential in the treatment of advanced periodontal disease".[1] The sequence of therapy is planned so that the basic contributing factors of inflammation and trauma from occlusion are brought under control.

This area of dentistry involved the very careful interplay of many dental disciplines, often times exhausting each to its limit in an effort to save or regenerate millimeters of attachment apparatus.

The overall concept is based upon the belief that, although individual teeth may demonstrate severe periodontal destruction wherein they could not withstand even normal forces of occlusion, these same teeth may be viable abutments when they are collectively splinted to one another.

In a broad sense, periodontal prosthesis has concerned itself with the correction of the mutilating factors of dental disease by attempting to restore alterations in form as they relate to function. On the whole, it has proven to be very successful in avoiding the alternative use of the full denture with its inevitable consequences.

In many cases however, the long-term prognosis remained guarded even after all of the most heroic of dental efforts.

"Definitive" periodontal therapy has been a critical aspect of the overall treatment plan. It involved ostectomy and osteoplasty procedures to recreate an anatomically normal hard and soft tissue topography. In so doing, the clinical roots were prepared to function within a healthy foundation upon which extensive fixed restorations could be utilized.

When one or more teeth is lost without replacement, there is a disruption in the integrity of the arch. This would frequently result in drifting, shifting and collapse with (or without) loss of the occlusal vertical dimension. The migration or over-eruption of teeth adjacent to, or opposite the edentulous site would create angular bony crests attendant the involved root surfaces. These angular crests often would lead to infrabony pocket formation in the presence of longstanding microbial plaque accumulation.

As a result, the value of orthodontic therapy took on new meaning for the adult patient. Its mechanotherapy has allowed us to move teeth through a healthy bony environment and thereby reduce and modify the size and shape of angular osseous defects.[3] The therapy is particularly valuable when a tooth is erupted or extruded. In these cases the bony crests can often be levelled with a concomitant improvement in the soft tissue anatomy.

The most important feature of this newer orthodontic awareness is that it offered us an opportunity for the first time to decrease the extent of osseous "take-away" surgical procedures. At the same time, we can create the proper periodontal environment for maintenance of health on the part of the patient and dentist.

Experimental and clinical research over the last decade has shifted the focus of periodontics towards increased use of guided tissue membrane techniques.[4] These approaches attempt to regenerate desired

attachment apparatus circumscribing the periodontally compromised root. Although there is some level of clinical unpredictability associated with this therapeutic approach, it once again represents a step in the direction of augmentation/regeneration versus resection.

Secondary occlusal traumatism, represented by moderate-to-severe loss of alveolar support and significant clinical mobility, results in a need to splint two or more teeth to recreate collective stability and functionality. This was and still continues to be predictably achieved with the use of partial or full coverage crowns. When the periodontal support from the remaining compromised teeth reached a point where a fixed prosthesis could not reliably be fabricated, the only option was a removable partial denture.

Today, however, as a result of the longitudinal studies on the viability of endosseous implantology,[5-12] implants used as an integral part of periodontal prosthesis now offer the patient and dentist a more stable and predictable restoration. Their relative immobility and load-bearing capacity, when secured in a qualitatively adequate bony housing, may allow for fabrication of a fixed prosthesis resistant to displacement. The damage pattern of primary and secondary occlusal trauma attendant many teeth may be reversed. Even teeth appearing to have a hopeless prognosis may be allowed to assume a useful prosthetic role.

In the comprehensive treatment of the partially edentulous situation, diagnosis, treatment planning and treatment sequencing continue to be difficult and troublesome areas for restorative dentists and surgeons.

In establishing a diagnosis, it is extremely important to ascertain the past history of tooth loss. A host of etiologic factors may have shared responsibility - caries, subsequent endodontic complications, traumatic injuries to teeth (and/or alveolus), periodontal disease (acute or refractory), trauma from occlusion, or iatrogenesis.

Clinicians who have been practicing periodontal prosthetic therapy for decades have been able to evaluate the success of these prostheses based upon their original diagnoses. All other factors being equal, we are now attempting to compare the various success rates of the osseointegrated prosthesis when used in patients with different original diagnoses.

It may truly be, for example, that the dentition compromised by trauma from occlusion has a similarly guarded prognosis when restored with endosseous implants as it may have had when restored at an earlier time with periodontal prosthesis. Further investigation and comparative analysis is necessary.

Diagnostic Aids:

A comprehensive dental/periodontal examination must first be performed. This will ensure that all members of the treating team have addressed their problem areas and have collated their respective treatments into the overall therapeutic scheme.

The clinical evaluation consists of caries, periodontal, endodontic, orthodontic, occlusal/TMJ and systemic examinations (Table 1).

To facilitate this diagnostic evaluation, a full-mouth series of periapical radiographs of teeth and residual ridges must be taken. A panoramic radiograph and the dental Cat Scan are suggested to help assess the bone quantity and density and may thereby supplement conventional dental radiography. The Cat Scan technology is often enhanced today by the use of barium-impregnated

TABLE 1.

DIAGNOSIS:

Caries:
- *Supragingival
- *Subgingival
- *Insufficient clinical crown height

Endodontic Considerations
- *Symptomatic teeth
- *Separated instruments
- *Dystrophic calcifications
- *Fractured roots
- *Apical & lateral zones of osseous destruction

Missing Teeth:
- *Without replacement
- *With delayed replacement

Traumatic Injury:
- *Clinical crown deformity
- *Soft and hard tissue deformities

Periodontal Disease:
- *Degree of bone loss
- *Topography of alveolar defect (Potential impact of bone loss on adjacent teeth)
- *Short clinical roots

Occlusal Traumatism:
- *Primary: Bruxism, Clenching, Retrograde wear
- *Secondary
- *TMJ considerations

Orthodontics:
- *Tooth shift or collapse

Bite Collapse:
as influenced by each of the above

Size and Shape of Residual Deformed Bony Ridge Areas:
the degree of resorption will influence the surgical and restorative ventures

Systemic Influences:
- *A host of systemic diseases - diabetes, cirrhosis.
- *Osteoporosis, osteopenia, osteomalacia
- *Liver or kidney dysfunction
- *Anticonvulsants
- *Antidepressants
- *Vitamin D deficiency
- *Parathyroid hormone
- *Aging; estrogen deficiency
- *Gastrointestinal problems

surgical templates,[13] to more precisely analyze all available bone sites.

Mounted study models will be of ongoing value. In most situations it is suggested that two sets of original models be taken - one set preserved diagnostically and the other to be worked on therapeutically.

After the clinical examination, radiographic imaging and study models, the next level of diagnosis can be performed. Many teeth may be strong viable abutments. Teeth substantially affected by periodontal disease, caries, or endodontic problems must be identified early on. These are teeth that may have minimal value as abutments for either individual crowns or splinted restorations. These are also teeth that may represent a serious periodontal liability to adjacent teeth or bony ridges.

In periodontal disease, as in dental caries, we may find that the mutilations of the disease create permanent scars that complicate therapy more than the active disease process itself. In many circumstances, anatomic deformities such as an altered residual ridge form[14,15] or close proximity of the sinus wall,[16,17] become propagating factors requiring even additional surgical correction. Often times these difficulties necessitate a staged approach of augmentation, regeneration[14] or onlay grafting first,[15] followed by a second surgical phase of implant installation and healing.

From a diagnostic standpoint, the dental team must try to anticipate the size and shape of the deformity that would be created by removal of the involved teeth. These judgements will play heavily in the restorative design.

From our periodontal prosthetic background, we know that many severely compromised teeth can still offer the patient short-term function. For this reason, the restorative dentist may strategically retain some of these teeth to facilitate an interim fixed provisional prosthesis rather than rely on a removable design.[18] This decreases the risk of prematurely loading the implant body, and inducing micromotion during initial stages of interfacial bony healing.[19]

These weak teeth may then be removed at a later stage in favor of additional endosseous implant support, as dictated by the biomechanical needs of the final restoration.

Height and Width of Bone - Hard Tissue Evaluation

A common error in implant placement is not planning for the final prosthesis. A sound rule to follow is that suggested by Bahat and Handelsman--"...plan the treatment in reverse".[20] That is, the steps to reach this goal should be simulated in reverse order. When such an approach is practiced, mishaps such as malaligned or misplaced implants and early implant failure can be avoided."

The hard tissue profile must be evaluated in various perspectives.[6] The width of bone should be at lease 4mm; the height at least 7mm. The quality and quantity (shape) must be studied in detail as these factors play a key role in the ultimate success or failure of the implant. Bone quality has been categorized into four types (I,II,III,IV); Type IV having the greatest amount of low-density cancellous (trabecular) bone.[21] This type of bone has been shown to have the highest failure rate. Jaw shape (quality) also plays a key role in ultimate prognosis.[22] Types A, B, and C demonstrate greater success rates than types D and E.

As a rule, shorter implants have a significantly higher failure rate than longer ones. In the posterior region of the jaws, shorter implants are generally used more than in the anterior regions. It is universally accepted by surgeons that it is always desirable for the fixture to penetrate two cortical plates so as to increase the resistance to torque. Often, however, in the posterior region of the mandible only one cortical plate can be engaged.

For the factors stated above, one can see why the prognosis of implants placed in the anterior region of the jaws are usually more successful. Greater bone height and width, and more favorable quality and quantity of bone allows for longer implants to be placed in more favorable bone. Furthermore, when one compares the edentulous jaw to the partially edentulous one, it is obvious that more implants can be placed in the former, thus allowing for a greater number of fixtures to succeed. Also, it should be mentioned that fixtures placed along a curve have a greater resistance to force than those placed along a straight line. Generally, the fully edentulous situation allows placement of the implants along a curve whereas in the partially- edentulous situation, more than likely the fixtures will have to be placed along a straight line. While recent reports appear to demonstrate similar success rates in both situations,[23-31] all other factors being equal, prognosis should be more favorable in the fully edentulous situation than in the partially edentulous one.

Occlusal Evaluation

As a rule, all the factors of occlusion in the natural dentition consistent with proper force reception and dissipation should be followed in implant prosthodontics. It is understood that axial forces are more favorably received than off-axis ones.[32] Often, because of the pattern of bone resorption which has previously occurred (especially in the maxilla), the jaw relationship will tend to simulate a Class III type. In these situations, it is usually suggested to set the teeth in a cross-bite relationship so as to direct the forces in a more axial manner.

Loading forces are generally greater in the posterior regions (about 70% higher that in the anterior regions). Unfortunately, the least favorable quality and quantity of bone is generally found in the posterior areas. Hence, using shorter implants in these areas may result in a greater chance for fixture failure. When cantilevers are used, bending forces come into play whereby the most distal implants will undergo compression and the more mesial ones have tension placed upon them. These bending forces on cantilevers also impact upon the prosthetic materials that are used. Often the metal substructure will undergo a slight amount of distortion resulting in fracturing of the veneering material or metal framework.

One might want to conjecture as to the prognosis of implants in posterior regions (especially the maxilla) in those patients who have bruxing and/or clenching habits with poor quality and quantity of bone. It would be interesting and informative if previous dental records reveal corollaries to when the natural teeth were present.

Soft Tissue Evaluation

The healthy periodontium can be divided into two basic architectural forms--the thin, scalloped type and the thick, flat type.[33] In the first category there is usually a distinct disparity between the height of the gingival margin on the direct facial and that which is interproximal. You also find thinness of the gingival tissue and underlying bone (dehiscences and fenestrations are often present), and a small amount of masticatory mucosa surrounding the emerging teeth. Tooth form is usually characterized by being quite flat (very slight facial convexity) with contact areas located toward the incisal or occlusal surfaces. With irritation, this type of periodontium usually reacts by receding.

The thick, flat type is characterized by the presence of a slight

disparity between the height of the gingival margin on the direct facial and that which is interproximal, thicker gingival tissues and underlying bone, and the presence of a greater amount of masticatory mucosa than is found in the thin, scalloped type. Tooth form is usually more bulbous with a squarer shape, resulting in a long contact area located more apically. With irritation, in this form of periodontium, pocket depth usually increases.

These two forms are innate to the individual and appear not to be able to be changed by dental endeavors, either periodontal or restorative. It is logical to assume that these basic prototypes will essentially remain the same when some or all of the natural teeth are lost and ultimately replaced by implants.

The length (height) of the implant abutment head is greatly influenced by the thickness of the soft tissue, thus impacting significantly on the ultimate esthetic result. In the situation where the overlaying gingival tissue is thick and flat, implantation to the level of the bone crest will offer the restorative dentist an adequate soft tissue dimension for placement of a transepithelial abutment of varying gingival collar length. This will generally allow for sufficient interproximal gingival height to simulate an interdental papilla.

When the periodontium is thin and scalloped, as frequently seen in the anterior region of the mouth, the tissue depth to the underlying bone is minimal, thus presenting a greater challenge to the restorative dentist. Subsequent to second stage exposure of the implant head, the overlying soft tissue may not allow for esthetic subgingival placement of the abutment and the implant crown. It is even likely that the interproximal papilla will be lost, and care must be taken to prevent this occurrence.

Additionally, surgeons must be very selective about employing a membrane technique in these situations. Too frequently a part of the mucoperiosteal flap may slough, further exaggerating the loss of the interdental papilla and creating an unesthetic restorative dilemma. As Bahat and Handelsman have suggested, it is often beneficial to converge the implants towards each other in the anterior region. This will result in a more incisal positioning of the gingival level, thus enhancing the esthetic result.

Biologic Dimension

Our observation has been that the radiographic image of the implant generally demonstrates complete bony coverage to its most coronal height at initial fixation. However, much controversy exists as to the radiographic findings of approximately 1 to 2 mm of crestal cupping or resorption occurring at the neck of the implant fixture during the first year of an applied occlusal load.[7] The implant generally demonstrates complete bony coverage to its most coronal height at initial fixation. Within a short period of time after second stage exposure of the implant head and placement of a titanium healing component or abutment, the crestal cupping becomes evident radiographically, even if the implant remains unloaded.

We have equated part of this observation with the findings commonly related to a tooth restoration that has been extended deeply into the sulcus in an attempt to secure sound tooth structure. A tooth restored in this manner usually results in a poor gingival response because the connective tissue and epithelial attachment have been violated. This combined dimension averages several millimeters and has been described as the "biologic-width".[34]

Lisgarten has described the histologic configuration covering the healing implant, as a picture very similar to that of a natural tooth, without a periodontal ligament.[35] Essentially there is a proportional dimensional relation between the crest of bone, the connective tissue, and the epithelial attachment.[36] It is reasonable to assume that any infringement of this dimension by a transepithelial component will result in an apical shift of the complex to recreate normal proportional dimensions of these tissues.

Angle of Emergence of Implant

Ideally, the implant should emerge through the cingulum of an anterior tooth and the central fossa area of a posterior tooth. This is most easily achieved when there are optimal jaw and ridge relations. Unfortunately with ridge resorption, resultant deformities such as knife edge ridges, ridge concavities, dehiscences, etc. are commonplace. In these situations it is frequently necessary to alter the inclination of the fixture even though it may not follow the greatest dimension of the ridge. This is done in order to prevent the fixture from exiting through the facial surface of the anterior tooth, or to the facial or lingual of the central fossa of the posterior tooth. Under extreme situations where facial ridge resorption is excessive, the restoration will be overcontoured facio-lingually. From an esthetic standpoint the patient may need this overcontouring to support the lip. However, this will make cleansing of the implant/gingival interface quite difficult at times. The underlying metal framework must also be designed in such a way that porcelain is not "cantilevered" from the metal, which could result in porcelain fracturing.

The angulated abutment has become quite popular. There are those who feel these devices should be used sparingly because the forces of occlusion on the underlying fixture will not be in an axial direction, thus resulting in potential loss of the implant(s).

One can look at the angulated abutment in a manner similar to that of the telescopic undercasting used with natural teeth in fixed restorations. When the natural teeth are severely out of position and telescopic copings are used to parallel these abutment teeth, the end result is often an occlusal and esthetic compromise. Forces are received off the long axes of the teeth. Also, as the telescopic shoulder is moved incisally to bring it in line with the other abutments, often a display of metal is apparent on the facial surface. When implant fixtures have a severe angulation, and an angulated abutment is utilized, similar occlusal and esthetic problems can often be seen.

Unfortunately, most implant angulation and emergence problems are really only seen when the restorative phase begins, long after the implants have been placed. This points to the importance of pre-surgical and prosthetic planning among the surgeon, restorative dentist, and dental technologist.

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Part II: Treatment Planning and Sequencing of Therapy

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Our ultimate therapeutic goal as dentists is to achieve maximum health, masticatory function, speech, esthetics and comfort for our patients.

The general concept to be followed in treatment may be divided into three levels. 1. Emergency care for relief of pain or sudden dysfunction; 2. removal of the causative factors of the disease processes; and 3. removal of the effects of the disease or traumatic insult. Phase one, emergency treatment, must be accomplished before any other level of therapy is instituted (Table 2).

The second phase is to control inflammation. A basic tenet of periodontal therapy is the mechanical debridement of all accretions adherent to the clinical crowns and roots of teeth or restorative materials, both supragingivally and subgingivally. This is performed by scaling, root planing and curettage procedures in concert with plaque control instruction. For dental caries, it is self evident that early placement of restorations prevents the need for more extensive intervention later.

The third level of care is the focus of this article - attempting to correct alterations in form and function.

The Established Periodontal Prosthetic Treatment Approach:

Convention in periodontal prosthetic therapy subdivides this approach into a periodontal, orthodontic, occlusal and restorative phase. These phases are very much interdependent even if one may initially have precedence over another. In some cases there may be direct overlapping (Table 3).

The objective of periodontal therapy is gingival health, alveolar repair and restoration of normal anatomic form. Treatment is directed at decreasing the inflammatory response by improving the osseous topography and the relationship of the overlaying soft tissue - to decrease probeable depth. Amsterdam has noted that this has been most predictably accomplished for teeth of normal anatomic root lengths with probeable depths not exceeding 4 - 7 mm measured from the CEJ. The added advantage with this osseous surgical approach has been to increase the clinical crown length and thereby provide a final crown design with sufficient biomechanical retention.

For teeth treated with full coverage restorations employing subgingival preparation, it is important to evaluate the mucogingival environment and determine the value of recreating or enhancing the masticatory mucosa. Autogenous gingival grafts, subepithelial connective tissue grafts and repositioning of an existing gingival complex are approaches commonly employed.

The orthodontic phase strives to improve tooth alignment, erupt fractured or impacted teeth or facilitate the extrusion of teeth with infrabony defects. Here, it is often prudent to consider a mucogingival procedure prior to tooth movement should a minimal zone of gingiva exist on the facial, lingual or palatal surface. This will

TABLE 2.

Emergency Treatments

PROBLEM	TREATMENT CATEGORY	TREATMENT
Deep caries	Sedative restorations	"direct-fillings" or temporary crowns
Symptomatic teeth/ Abscess	Endodontic	drainage, antibiotics, conventional or surgical treatment
Occlusal trauma or Myofacial pain syndrome	Occlusal Therapy	selective adjustment, appliance therapy, anti-inflammatory medication
Large circumscribing periodontal/periapical lesions	Extraction of hopeless teeth	Interim fixed or removable restoration as necessary
Broken Appliances	Prosthetic repair	re-establish masticatory function and esthetics

avoid a concern about recession if the tooth must assume a position not directly over its basal support.

Advanced periodontal disease frequently necessitates provisional splinting of individual teeth or groups of teeth to restore or maintain masticatory function. Severe loss of periodontal support of one or more of these teeth may suggest that the tooth best be extracted early in treatment or at the surgical phase. Where bite collapse has occurred, the restoration is even more difficult. To this end, a provisional acrylic restoration is utilized as a replacement for the extracted teeth, to restore lost occlusal vertical dimension and to establish or re-establish anterior guidance, allowing for disarticulation of posterior teeth during excursive movements[1].

In the majority of periodontal prosthetic case treatments, when orthodontic intervention would be indicated, it generally precedes the provisional acrylic restorative phase. When the protocol is reversed, the clinical team may be involved with significant additional repairs and recementations. Cement washout places teeth at greater risk for development of caries and the patient may often require a new provisional restoration prior to the impression phase of therapy.

Once the provisional restorations are fabricated and tooth stability is achieved, the restorations can be removed to better access the surgical field for correction of any residual hard and soft tissue inconsistencies. After tissue maturation and after the prognosis is established for all remaining teeth on both an individual and collective basis, subgingival preparation may be finalized and the acrylic restorations relined, followed by completion of the fixed or fixed-removable prosthesis. (Figure 1, A-M)

The Implant-Assisted Prosthetic Treatment Approach

The implementation of osseointegration technology[23-31], osseous regenerative technology,[38-42] onlay grafting from the mandibular symphyseal region[15] (or other locations), sinus elevation procedures[16,17] and nerve repositioning techniques[43] has significantly changed the sequencing and lengthened the timing of prosthetic treatment for the partially edentulous case. (Table 4)

It is preferable to temporarily restore the dentition with a fixed provisional restoration prior to endosseous implant installation[19]. This enhances patient comfort and confidence and prevents the risk of premature loading of any implant fixtures by an interim, removable, tissue-borne prosthesis.

Periodontal surgical therapy is then performed for all teeth which have a favorable prognosis. Either regenerative approaches[4] or pocket reduction and clinical crown exposure procedures should be rendered before endosseous implant installation.

When orthodontic treatment is considered, it may require early tooth positioning to create adequate space prior to fixture installation. In some situations, such as a flared maxillary anterior segment with few or no posterior teeth, implants may be placed first and employed as the anchorage mechanism to retract and align the remaining teeth at an acceptable occlusal vertical dimension. For these situations, we are only limited by the treatment planning creativity of the dental team.

Figure 1A. Pretreatment: 55 year old male. Missing teeth (partial denture replacement). Severe periodontitis. Complete bite collapse.

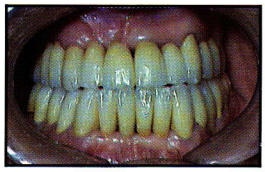


Figure 1B. Post-treatment: Ceramo-metal fixed-splinted restorations.

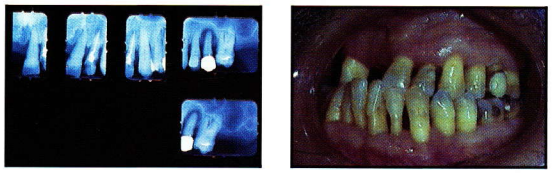


Figure 1C-D-E. Pretreatment: Upper and lower left view. Periodontal and periapical pathology. Class III malocclusion. Primary and secondary occlusal traumatism.

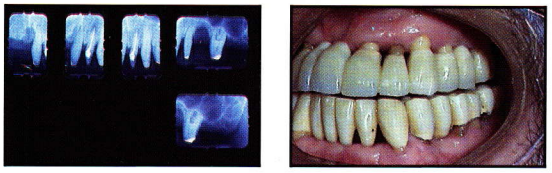


Figure 1F-G-H. Provisional acrylic restoration: Post-surgery (before final tooth preparation.) Restored occlusal vertical dimension. Established anterior guidance. Replaced missing teeth. Facilitated periodontal surgery.

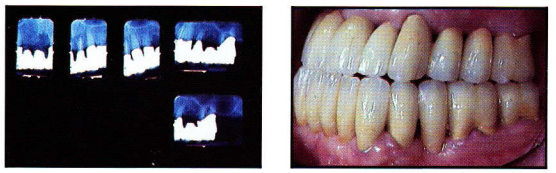


Figure 1I-J-K. Completed ceramo-metal fixed restorations.

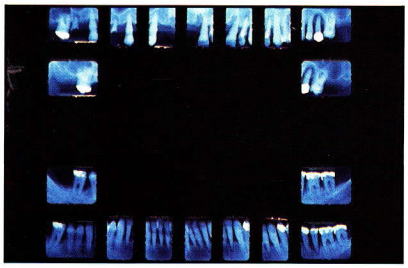


Figure 1L. Pretreatment full mouth radiographic series.

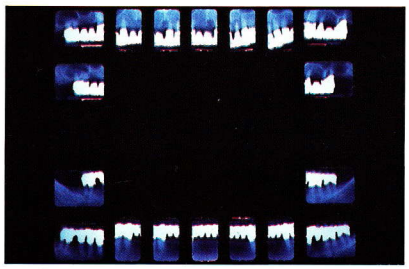


Figure 1M. Post-treatment full mouth radiographic series.

TABLE 3.

Periodontal Prosthetic Sequence of Treatment:

I. Emergency treatments: (Table 2)

II. Scaling, root planing, curettage, oral hygiene instruction:
- A. Closed flap curettage:
  1. Mechanical debridement of calcareous and plaque deposits adherent clinical crowns and roots of teeth or restorative materials both supra- and subgingivally.
- B. Open flap curettage:
  2. Debride intrabony defects.
  3. Explore topography of questionable teeth.
  4. Debride fresh extraction sockets.
- C. Microbiologic testing:

III. Operative dentistry:
- A. Restoration:
  1. Conservative control of dental caries.

IV. Orthodontic treatments:
- A. Level and align teeth.
- B. Erupt fractured or impacted teeth.
- C. Extrude teeth with infrabony defects.

V. Fabrication of provisional restoration:
- A. Guidelines:
  1. Replace missing and/or recently extracted teeth.
  2. Maintain inter- and intra - arch harmony.
  3. Assess adequacy of tooth reduction.
  4. Determine the clinical crown profiles.
  5. Develop therapeutic occlusal scheme.
  6. Control occlusal forces and assess function.

VI. Periodontal surgical treatments:
- A. Osseous therapy:
  1. Regeneration/augmentation:
     a) Regenerate attachment apparatus for teeth and for deformed ridges.
  2. Ostectomy/osteoplasty:
     a) Improve alveolar topography.
     b) Achieve minimal sulcular depth.
- B. Mucogingival management:
  1. Autogenous gingival grafts.
  2. Subepithelial connective tissue graft.
  3. Apically positioned gingival complex.
     a) Reconstitute or enhance the gingival complex around teeth or implants.

VII. Re-evaluation:
- A. Establish prognosis of the remaining teeth.

VIII. Prosthetic phase of treatment:
- A. Fixed prosthesis.
- B. Fixed-removable prostheses.

IX. Maintenance and recall

The Interim Provisional Restoration:

The interim restoration may be designed in several different ways. One possibility is to modify an existing bridge or splint, relining the crowns on selected natural teeth and converting other crowns to pontics as necessary. With a paucity of strong, well distributed natural teeth, the existing rigid metal framework can better resist normal occlusal forces and avoid fracturing of the prosthesis.

The removable interim prosthesis is the least desirable measure to preserve masticatory function. Unfortunately, it must be employed when the support provided by the remaining teeth is too compromised and the number and distribution of teeth is insufficient to allow the use of a fixed prosthesis. In these situations it is imperative that the restorative dentist observe the edentulous areas at regular clinical intervals and replace the soft liner material of the saddle areas when it becomes hard or brittle, or elicits a pressure (decubitus) ulceration in the soft tissue.

Ideally, a new fixed provisional restoration, with or without a rigid metal reinforcement, should be made. It is made from a diagnostic wax-up and incorporates all of the esthetic, functional and phonetic characteristics being considered in the case, removing any pre-existing limitations. This restoration is, therefore, essentially a blueprint of the final prosthetic outcome. It can be employed as a guide, allowing us to plan the case construction from the desired end point in reverse order. (Figures 5E, 5K)

The surgical template, a guide to surgical implant installation, is fabricated from either a diagnostic wax- up or, preferably, a stone model of the functioning provisional restoration.

After placing the provisional restoration intraorally, impressions are taken of both the prosthesis and the underlying edentulous ridges and tooth preparations. Stone models are made and an acrylic shell of the restoration is cured on a model of the prepared teeth. Access locations and axial alignments are carefully planned with the surgeon and are carved into the acrylic form to anticipate all future implant placements.

Although a lingual or palatal approach is commonly used in designing the surgical guide, a facial approach should also be considered. It provides the surgeon with an accurate visualization of the ideal implant sites, the desired path of abutment emergence and the axis relation to the final prosthesis. (Figure 5M)

The ability to perform surgical procedures demands excellent access, which is provided by temporary removal of the provisional interim restoration. The surgeon will then orient the surgical template by securing it to the prepared and/or unprepared teeth, and then penetrate into the bone to effect proper positioning of the implants.

Considerations at the Surgical Phase:

The well-designed treatment plan may require one of a host of scenarios to deal with the installation of endosseous implants into bony sites that either still house teeth, or are areas of ridge deformity.

Where implant installation is anticipated, the most common approach is to extract teeth at the time of provisional restoration (Figure 2). Full maturation of the bony socket may then take anywhere from three to six months. The newly formed bone in these recent extraction sites has proven to be an excellent reservoir of pluripotential cells to promote successful osseointegration.

An alternate approach may considerably shorten the duration of treatment. Here the effort is to first achieve soft tissue coverage over the recent extraction site. The interim prosthesis may then be

retrieved and the implant submerged several millimeters below the bony crest to reduce the risk of dehiscence formation. In these situations, the ability to achieve primary flap closure will decrease the risk of post-operative complications, especially if a cell-occlusive membrane is indicated.

In an effort to more precisely determine the quality of the bony housing for possible immediate implant placement and minimize the overall maturation phase, the teeth may be sectioned horizontally at their gingival margins. The pulp should be extripated, the canal medicated and sealed and provisional restorations fabricated leaving these tooth roots for the surgeon to extract at the time of implant installation. This avoids the need to interfere with early socket healing and precludes the risk of additional crestal bone resorption of the healing socket.[44] (Figure 5F, 5L)

When an edentulous ridge is modestly damaged and the site has been planned for implant placement, the surgeon may elect to position the implants at an angle that corresponds to the ideal final restoration. Any possible fenestration over the implant may be corrected by placement of a physical membrane barrier (based on the principles of guided tissue regeneration).[42] Here adequate space must be achieved to promote complete reformation of the bone complex.

To correct a major ridge deformity, use of a membrane technique or an onlay graft technique will generally involve two or more surgical interventions. First, it requires the reconstruction of the ridge to a more normal anatomic shape and size, followed by the implant installation. (Figure 5H, 5I) Frequently, onlay grafting[15] and sinus elevation procedures are being performed simultaneously with implant installation, when there is enough available bone to immediately immobilize the fixtures for the healing period.

After the bony ridge has been reconstructed and endosseous implants installed, a sufficient healing period must be observed to ensure a satisfactory "take". Bone remodelling adjacent to implant fixtures occurs over a period of at least a year, leading to a more mature bone (lamellar compacta) within which the implant may better tolerate the forces of occlusion.[45]

Figure 2A-B. Pretreatment: 53 year old female: Bicuspids have been stabilized via introcoronal splinting. Progressive loss of alveolar support.

Figure 2C. After extraction of biscuspids/incisors and removal of provisional restoration.

Figure 2D. Exposure of underlying bone prior to implant placement.

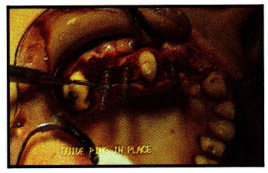


Figure 2E. Surgical guide pins in healed extraction sockets.

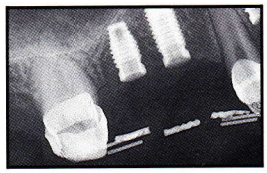


Figure 2F. Periapical radiograph of endosseous implants in position; interim provisional acrylic restorations recemented on natural teeth.

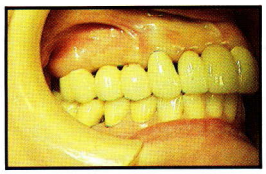


Figure 2G. Ceramo-metal restoration.

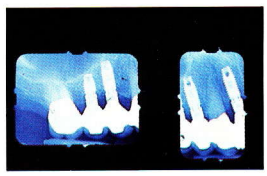


Figure 2H. Post-operative radiograph of completed ceramo-metal restoration.

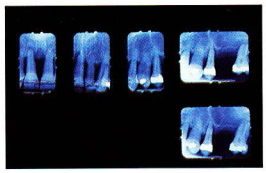


Figure 3A-B. Pretreatment: 50 year old female. Severe periodontitis with minimal bone support attendant all remaining teeth.

Figure 3C. Prepared teeth prior to extraction of #'s 10 and 12.

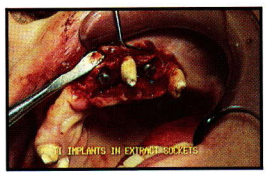


Figure 3D. Extraction of teeth #'s 10 and 12 with immediate implant placement.

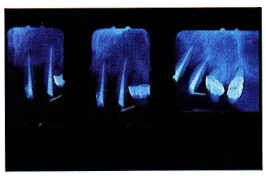


Figure 3E. Periapical radiograph of prepared teeth.

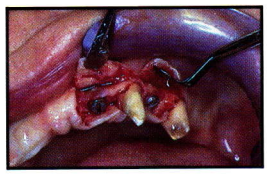


Figure 3F. 2nd stage uncovering of implants: note bone formation to crest of both sites #'s 10 and 12.

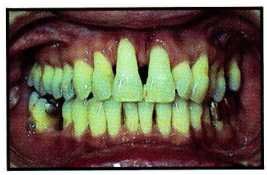


Figure 3G. Pretreatment:

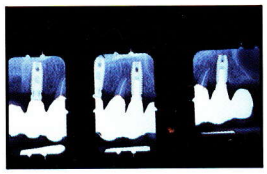


Figure 3H. Post-operative radiograph:

Figure 3I. Post-treatment: Ceramo-metal fixed bridge.

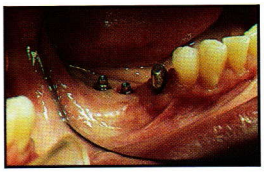


Figure 4A. Transepithelial implant abutments. Installed 4 weeks following 2nd stage implant exposure.

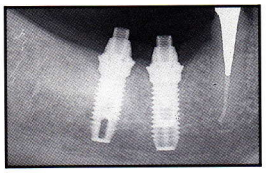


Figure 4B. Periapical radiograph; showing well-seated implant abutments.

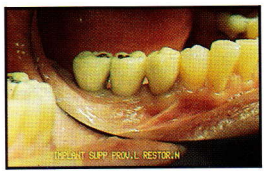


Figure 4C. Transitional restoration: combining tooth #29 with implants in position of former teeth # 's 30 and 31.

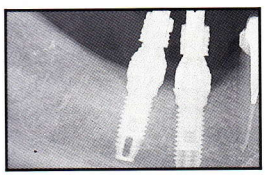


Figure 4D. Periapical radiograph: with temporary crown cylinders on implant abutments.

Second Stage Implant Exposure and the Transitional Implant-Assisted Restoration:

It is extremely important to coordinate the schedules of the surgeon and restorative dentist for the timing of second stage uncovering of the implants.

The surgeon will perform a small gingival punch procedure or a more extensive mucoperiosteal flap procedure, repositioning the gingival complex around the implants. A transepithelial healing component is then fastened to each implant body. After soft tissue and periosteal maturation, a high or low-profile transepithelial abutment may be selected and a provisional acrylic restoration can be made to restore form and function. (Figures 4A, 4B)

When multiple implants are exposed and it is anticipated that angulation may be a concern, it is of value to make an impression recording the orientation of the fixture heads after early soft tissue healing. A new provisional restoration may then be fabricated in the laboratory, utilizing titanium temporary cylinders that are designed to mate directly with the implant body or to a selection of available abutment heads.

Frequently at second stage, the existing interim provisional prosthesis must be modified by shortening the undersurface of the pontics to provide room for the healing components. Later these components are removed, abutments of proper height are screwed into position and temporary cylinders are seated, shortened to contact the opposing occlusion, and incorporated into the existing provisional restoration.

If there is any doubt as to the feasibility of accomplishing functional and esthetic alignment of the implant abutment, there are temporary crown cylinders that can be secured directly to the implant body. It is noteworthy that these metal cylinders are available from most implant manufacturers. They ensure intimate fit to the titanium abutment or fixture head and allow us to start developing our anticipated contours. Of course, should we need to modify the form, the acrylic itself offers us ample opportunity without jeopardizing any accuracy of fit.

A transepithelial collar of minimal height, shallow sulcular depth and a circumscribed border of bound-down keratinized tissue are essential ingredients in allowing for conventional plaque control measures.

Chiche has pointed out that due to "surgical and anatomic limitations, implant placement may not correspond to the initial expectation set at the presurgical phase, and over-contouring the final restoration could create esthetic and functional liabilities."

"The path of emergence of the fastening screw through the prosthesis may compromise part of the facial or occlusal morphology, especially if it passes through a primary centric occlusal contact, an interproximal embrasure" or the facial veneer. "Even minor discrepancies between an implant and crown axis may result in eccentric screws, since such deviations are magnified at the level of the occlusion."[46] Here the transitional prosthesis is invaluable in diagnosing these prosthetic limitations. With this early awareness, we can better anticipate and plan for the fabrication of an auxiliary substructure to facilitate the prosthetic result.

Some have conjectured that the implant-assisted provisional restoration may provide a shock-dampening effect that may be beneficial during the first year of bone maturation adjacent to the implant fixtures. Of possibly greater value is the role of the provisional restoration in establishing the esthetic, phonetic and functional needs for the final prosthetic design.

At this stage, a radiographic and clinical evaluation of the stability of the implant fixtures is made. The weak teeth that were held strategically to support the interim prosthesis are extracted at this time.[19] (Figure 3). Some of the natural teeth may be removed in favor of additional implants or retained as indirect retainers in situations where fewer implants are utilized in the overall support of the prosthesis. If a new transitional prosthesis has recently been fabricated, there may have been a change in the occlusal vertical dimension or the esthetic form, both of which would require further acrylic modification. Additionally, it may be necessary to consider mucogingival treatment to enhance the complex of masticatory mucosa around selected teeth or implants.[47]

Final Prosthetic Phase of Treatment

Now that the final prognosis for all teeth and implants has been established, the restorative dentist can employ crown and bridge techniques to construct the fixed or fixed-removable prosthesis. He may proceed with final impressions of the natural teeth, relate them to the proper position of the implant fixtures or abutments, and fabricate a master mold. To initate the laboratory procedures, the case is carefully mounted on an appropriate articulator by a series of occlusal registrations.

An exciting, but often overlooked value of the implant-assisted provisional restoration, is its ability to check the accuracy of the master model. First, by removing any natural tooth dies in the master model the prosthesis may be screwed to place and tested for its fit. Now, assuming you have successfully restored the occlusal vertical dimension with the existing provisional restoration, it will serve to mount the master models for final prosthetic construction.

On the master model, a soft tissue marginal profile should be constructed around each natural tooth die and implant analogue to simulate the gingival condition in the oral cavity. This allows for predictable abutment head selection in terms of proper height, angulation and emergence profile.

Technical choices are now made concerning case design, case construction, the use of telescopic copings on retained natural teeth, or the use of precision dovetail slide attachments to interlock sections of teeth and implants.

The primary substructure is fabricated and tried in; the fit of the copings is tested individually then collectively soldered and the final ceramo-metal restoration is completed. Upon delivery of the final case, a hard cement is used to secure the telescopic copings on the remaining teeth. The fixture-assisted dental reconstruction is then seated with a temporary cement to create

a hermetic seal at the interface of the metal abutment and superstructure. Retention and resistance to displacement are provided by securing the prosthesis with set-screws.[48]

Implant prostheses are carefully followed on a hygiene recall maintenance program, alternating visitations between the periodontist and the restorative dentist. Any tissue changes or prosthetic mechanical problems[49,50] can thereby be detected early and addressed accordingly. Although conventional periodontal indices such as plaque index, sulcus bleeding and probing depth are not directly related to the success or failure of implant osseointegration, they may be appropriate for assessment and monitoring of the health of the peri- implant tissues. Periapical and panoramic radiographs are taken at 12 to 18 month intervals to ascertain any changes that may take place in the osseous configuration around implants or natural teeth.

The authors would like to express thanks to Drs. Garry Miller, Karl A. Rose and Michael Stiglitz for their surgical management in the cases pictured. An additional thank you goes to Sylvie Rupple-Bozilov for her technical assistance in the preparation of this manuscript.

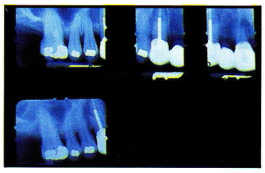


Figure 5A. Maxillary right quadrant: large zone of rarifaction circumscribing root of tooth #6. 7mm probing depth mesio-palatal of tooth #5. 8 mm probing depth distal of tooth #3 with furcation involvement. Apical root resorption of tooth #8.

Figure 5B. Clinical pretreatment view.

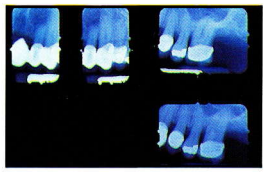


Figure 5C. Maxillary left quadrant: trifurcation involvement of tooth #14. Apical root resorption of tooth #10. 7mm probing depth mesial of tooth #12.

Figure 5D. Maxillary right quadrant: pretreatment.

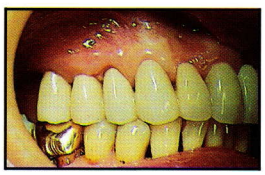


Figure 5E. Interim provisional restoration.

Figure 5F. Upon removal of the provisional restoration: roots of selected teeth have been sectioned to their gingival margins in readiness for extraction.

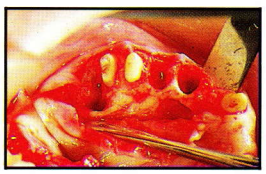


Figure 5G. Extraction of distobuccal and palatal roots of #3; Root #5 and #6. Note large palatal defect.

Figure 5H. Implant placement in extraction socket of palatal root #3. DFDBA packed into extraction sockets and filling the palatal defect. The sites were subsequently covered with GTAM.

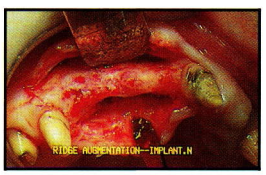


Figure 5I. Augmented maxillary ridge (6 month post-operative) in readiness for implant installation.

Figure 5J. Maxillary left quadrant: pretreatment.

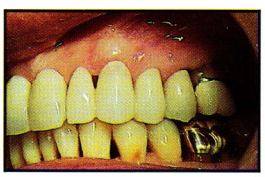


Figure 5K. Interim provisional restoration.

Figure 5L. Roots of selected teeth in readiness for extraction.

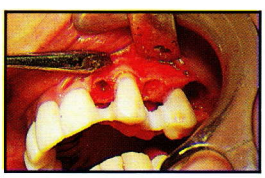


Figure 5M. Surgical template prosthetically guiding implant installation following immediate extractions.

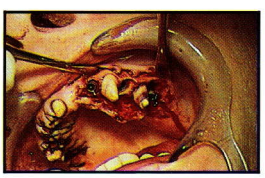


Figure 5N. Endosseous implants submerged below crestal bone. The implant sites were then packed with DFDBA and covered with GTAM.

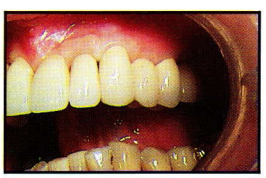
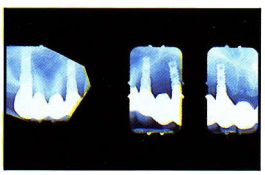
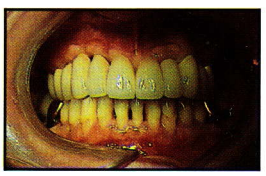


Figure 5O. Ceramo-metal restoration.





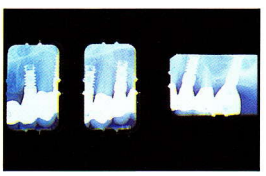


Figure 5P-Q-R. Completed implant and tooth-supported ceramo-metal restoration. (Clinical and radiographic.)

TABLE 4.

Implant Prosthodontic Sequence of Treatment:

I. Emergency Treatments:

II. Scaling, Root Planing, Curettage, Oral Hygiene Instruction:
- A. Closed Flap Curettage:
  - 1. Mechanical debridement of calcareous and plaque deposits adherent clinical crowns and roots of teeth or restorative materials both supra- and subgingivally.
- B. Open Flap Curettage:
  - 1. Debride intrabony defects.
  - 2. Explore topography of questionable teeth.
  - 3. Debride fresh extraction sockets.
- C. Microbiologic Testing:

III. Operative Dentistry:
- A. Restoration:
  - 1. Conservative control of dental caries.

IV. Orthodontic Treatments:
- A. Level and align teeth.
- B. Erupt fractured or impacted teeth.
- C. Extrude teeth with infrabony defects.

V. Fabrication of Interim Provisional Restoration:
- A. Guidelines:
  - 1. Allow for extraction of hopeless teeth and their replacement.
  - 2. Maintain inter and intra - arch harmony.
  - 3. Assess adequacy of tooth reduction.
  - 4. Determine the clinical crown profiles.
  - 5. Develop therapeutic occlusal scheme.
  - 6. Control occlusal forces and assess function.

VI. Periodontal Surgical Treatments:
- A. Osseous Management:
  - 1. Regeneration/Augmentation
    - a) Reconstruct lost alveolar support for retained teeth and for deformed ridges.
  - 2. Ostectomy/Osteoplasty:
    - a) Minimize sulcular depth.
- B. Mucogingival Management:
  - 1. Autogenous Gingival Grafts.
  - 2. Subepithelial Connective Tissue Grafts.
  - 3. Apically Positioned Gingival Complex.
    - a) Reconstruct gingival complex around teeth.

VII. Onlay grafting or Sinus elevation procedures:
- A. Anticipating future implant placement.

VIII. Fabrication of Surgical Template:
- A. Guide implant placement.

IX. Implant Installation:
- A. Into available bone sites or healed extraction sites.
- B. Into fresh extraction sockets.
- C. Into fresh extraction sockets covered with Guided Tissue Augmentation Material (GTAM).
- D. Into fresh extraction sockets with decalcified freeze-dried bone allograft (DFDBA) and covered by GTAM.
- E. Onlay graft with implant placement.
- F. Sinus elevation procedure with implant placement.
- G. Nerve repositioning procedure with implant placement.

X. Interim Maintenance: to facilitate healing.
- A. For surgical sites:
  - 1. Control the exposure of: membrane filters and loose cover screws.
- B. For interim provisional prosthesis:
  - 1. Repair broken acrylic joints.
  - 2. Replace soft reline materials.

XI. Second Stage Implant Uncovering:
- A. Preservation or augmentation of gingival complex.
- B. Placement of transepithelial healing components and allow for soft tissue maturation.

XII. Transitional Provisional Restoration:
- A. Selection of implant abutments.
- B. Conversion of existing provisional to implant-assisted restoration.
- C. Fabrication of new implant or new implant and tooth-assisted provisional restoration.

XIII. Re-evaluation:
- A. Stability of fixtures and remaining teeth.
- B. Occlusal vertical dimension.
- C. Esthetics.
- D. Phonetics.
- E. Proper emergence profiles of crowns for teeth and implants.

XIV. Prosthetic Phase of Treatment:
- A. *Implant-assisted:
  - 1. Fixed Prosthesis.
  - 2. Fixed-Removable Prosthesis.
- B. *Implant-supported:
  - 1. Fixed Prosthesis.
  - 2. Fixed-Removable Prosthesis.

XV. Maintenance and Recall:

*Classification of implant prostheses will be a subject of Implant Prosthodontics: Part III, to be published.

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