

# ORAL PROSTHODONTIC REHABILITATION

THOMAS J. BALSBI, D.D.S., F.A.C.P.

Implant prosthodontic treatment has been available for the replacement of missing teeth for several decades. The benchmark of scientifically studied implants is the Branemark titanium screw, which has proven that osseointegrated fixtures (implants) provide excellent long-term favorable prognosis for fixed bone-anchored replacement teeth. The use of osseointegrated Branemark implants for patients who have sustained traumatic tooth loss takes on some very special considerations.

The entire procedure of osseointegration is based on a biocompatible coexistence between living tissues and titanium components that these tissues were never genetically coded to accept. Osseointegration relies on a situation where we create a predictable tissue to titanium interface through a very carefully controlled surgical procedure.

## ETIOLOGY OF TOOTH LOSS

Contact sports such as football, basketball, hockey, and boxing have produced a myriad of dental problems, the most serious of which is the loss of natural dentition. Other more genteel sports such as tennis, golf, horse back riding, and swimming have also led to inadvertent tooth loss. A recent review of our clinical data on sports related injuries indicate that 90% of tooth loss occurs in the anterior part of the mouth. In most of these situations the injury occurs on impact when the player is moving toward an inanimate object or receives a blow from an oncharging competitor.

## CHARACTER OF THE INJURY

A traumatic blow to the anterior part of the mouth creates a variety of hard and soft tissue lesions. Facial lacerations frequently cover deep seated fractures of the teeth and/or alveolar bone. If the impact is of sufficient magnitude, avulsion of anterior teeth is the most frequent form of permanent trauma. With severe impact, fractured roots and compound fractures of the

alveolar bone are more complicated and create biologic devastation and post-trauma prosthodontic challenges. Social implications are worthy of note in as much as unreplaced tooth loss is viewed as a social stigma.

## PROSTHETIC TREATMENT FOR LOST TEETH

There are five types of prosthetic approaches to replacing missing teeth (Table 1).

### Temporary Removable Partial Dentures (Provisional Restoration)

Traditionally the simplest form of tooth replacement has been the use of removable dental appliances (Fig. 1). Easily fabricated, light weight, temporary removable appliances provide the partially edentulous patient with immediate esthetic replacement. This form of treatment gives the athlete psychological and often physical comfort, but limited functional ability.

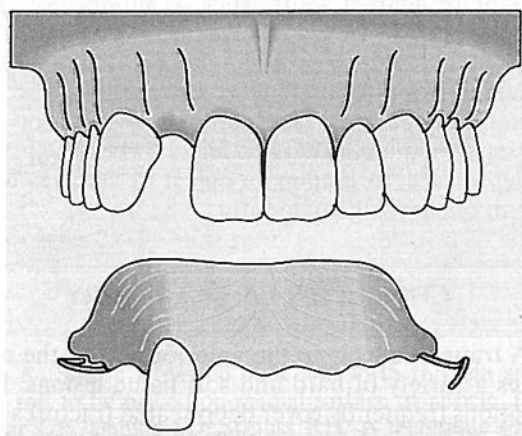
### Long-Term Removable Partial Dentures

When the hard and soft tissues have healed after traumatic tooth loss, a stronger removable prosthesis can be constructed using chrome cobalt castings to fasten the prosthesis to the remaining dentition. This is an inferior alternative form of treatment to "permanent" tooth replacement.

Another indication for the use of removable partial dentures is replacement of multiple missing teeth. When

**Table 1** Prosthetic Treatment for Lost Teeth

Temporary removable partial dentures (provisional restoration)
Long-term removable partial dentures
Fixed partial dentures (traditional crown and bridge)
Resin bonded fixed partial denture (Maryland bridge)
Osseointegrated implants (tissue integrated prosthesis)



**Figure 1** Temporary removable partial denture, constructed of acrylic, provides interim esthetics but limited function. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

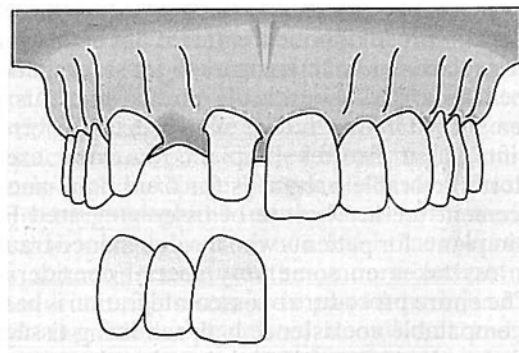
five or six consecutive teeth are avulsed, the adjacent abutment teeth are widely spaced. In this condition, the use of a traditional fixed partial denture may be contraindicated. For example, the loss of all of the maxillary anterior teeth (six teeth) would require the use of multiple posterior teeth for the construction of a fixed prosthesis. This prosthetic design would place the remaining abutment teeth under severe strain because of the forces applied to the anterior cantilevered pontic (tooth replacement) section. A removable partial denture may put less stress on these abutment teeth. Likewise it is not uncommon when large numbers of teeth are traumatically lost that portions of the alveolar ridge are also lost. When this occurs the removable partial denture also provides an esthetic replacement for the missing residual ridge tissue.

### Fixed Partial Dentures (Traditional Crown and Bridge)

With technologic advances, nonremovable prosthodontics for the replacement of missing teeth is preferred over removable appliances. Using crowns and fixed bridges (Fig. 2) to replace avulsed maxillary anterior teeth can generally be considered after a preparatory treatment program.

A thorough diagnosis is required when considering a fixed prosthesis of this nature. A traumatic impact to the mouth, creating the loss of some teeth, may also have an impact on the remaining teeth. Teeth and bone adjacent to a trauma site may sustain fractures. Complete radiographic examination is necessary to determine the condition of the potential abutment teeth, their nerves, and surrounding bone. Testing these teeth for mobility will effect the number required as support for a nonremovable prosthesis.

Diagnostic pulp testing for nerve vitality in the proposed abutment teeth is also important after traumatic injury. If the supporting abutment teeth for a fixed prosthesis are traumatically injured or sustain partial fractures, root canal therapy for the abutment teeth and the use of a post and core restoration will be a necessary part of the prosthetic treatment.



**Figure 2** Traditional fixed partial denture firmly replaces a missing tooth but requires the removal of enamel from adjacent healthy teeth. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

Following trauma, the soft tissue morphology changes as the edema diminishes. Therefore, an interim restoration is recommended before the construction of a final fixed prosthesis. This healing time serves well to permit the patient time to accommodate to both the concept of a fixed prosthesis, as well as the physical change in the mouth. The complete reduction of edema in the healing edentulous ridge is necessary to establish a physiologic relationship between fixed replacement teeth and the remaining vital tissues. This period also provides the patient an opportunity to learn new oral hygiene methods required to maintain a healthy mucosal response to the prosthesis.

The *advantage* of a traditional fixed partial denture is the stability of the restoration and its esthetic value. The greatest *disadvantage* of this prosthesis is the biologic insult to the abutment teeth. Removal of enamel and dentin frequently lead to insult of the pulp requiring subsequent endodontic (root canal) treatment. In addition, the margins of the crowns, when placed subgingivally (below the gum lines), can lead to periodontal insult and subsequent gingival irritation and alveolar bone loss.

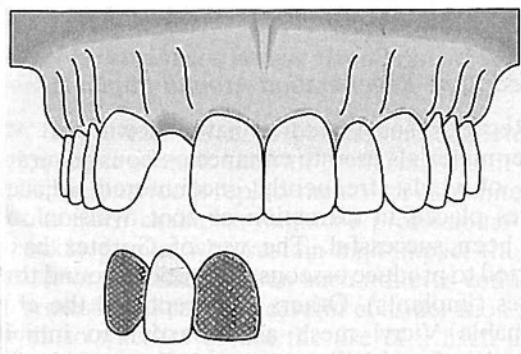
**Resin-Bonded Fixed Partial Denture (Maryland Bridge)**

Advancement in enamel bonding during the past 3 decades permits the replacement of small numbers of teeth with resin bonded retainers. These fixed bridges can be used as an interim form of tooth replacement, and, in some rare cases, as a long-term form of prosthetic treatment.

Resin bonded retainers rely on the ability to isolate healthy, clean enamel on the adjacent abutment teeth and produce a mechano-chemical bond between the metallic wings of the prosthesis and the abutment tooth enamel (Fig. 3).

**Bonded Strength**

Careful patient selection is essential for the effective use of a resin bonded fixed partial denture. Adequate occlusal (bite) clearance for the lingual retentive wings

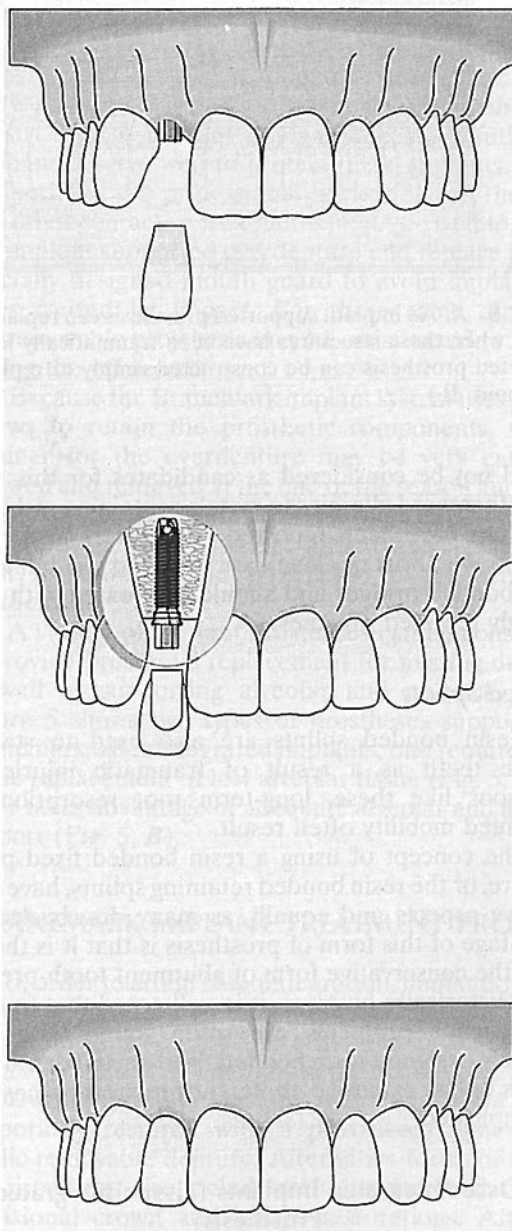


**Figure 3** A resin bonded fixed partial denture relies on the bond strength of resin between enamel and the base metal alloy. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

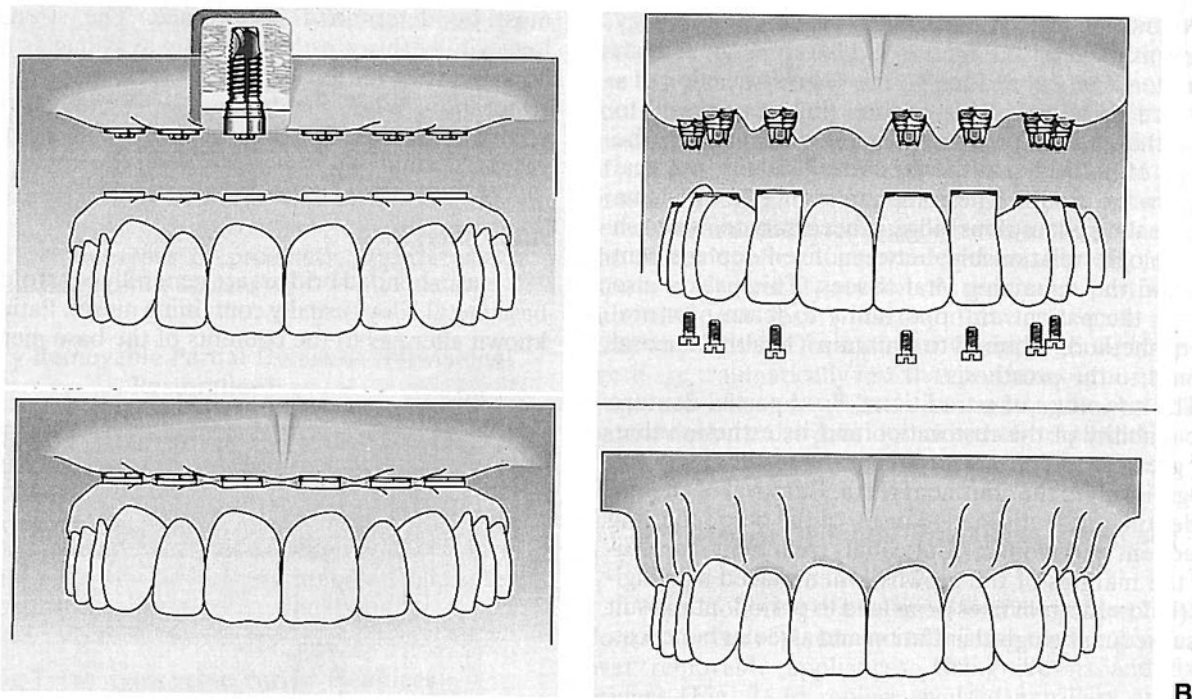
must be determined in advance. The strength and longevity of this prosthesis is only as strong as the resin bond between the enamel and the base metal alloy of the restoration. When the design relies totally on the bond strength, these bridges become loose and often fall out within 5 years.

**Alloy Allergies**

Resin bonded bridges are generally constructed with base metal alloys usually containing nickel. Patients with known allergies to the contents of the base metal alloys



**Figure 4** State-of-the-art replacement of a traumatically lost tooth relies on osseointegration of a Branemark implant in the alveolus followed by the placement of a ceramic crown. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)



**Figure 5** *A*, An implant supported prosthesis can replace not only missing teeth but missing alveolar bone and mucosal tissue (gum tissue) when these structures have been traumatically lost. *B*, When only tooth is lost and overlying mucosa retained, an implant supported prosthesis can be constructed simply to replace the missing tooth structure. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, IL.)

should not be considered as candidates for this treatment. Increased allergies to metals containing nickel and beryllium have been reported particularly in females. Patients who brux or clench are not good candidates for resin bonded bridges and should be treated with more strongly retained prostheses.

### **Bonded Splints**

Resin bonded splints are also used to stabilize mobile teeth as a result of traumatic injuries. In situations like these, long-term root resorption and continued mobility often result.

The concept of using a resin bonded fixed partial denture, or the resin bonded retaining splints, have many positive aspects and equally as many drawbacks. The advantage of this form of prosthesis is that it is thought to be the conservative form of abutment tooth preparation. Historically, however, it is well noted that frequent maintenance problems are often found with inadequately designed resin bonded fixed partial dentures or splints unless extensive abutment preparation has been accomplished.

### **Osseointegrated Implants (Tissue Integrated Prosthesis)**

Osseointegration is the long-term intimate relationship of ordered living bone fusing to the surface of a load bearing titanium implant. The use of osseointegrated implants today may be considered the most biologically

conservative form of replacement for patients who have sustained traumatic tooth loss (Fig. 4).

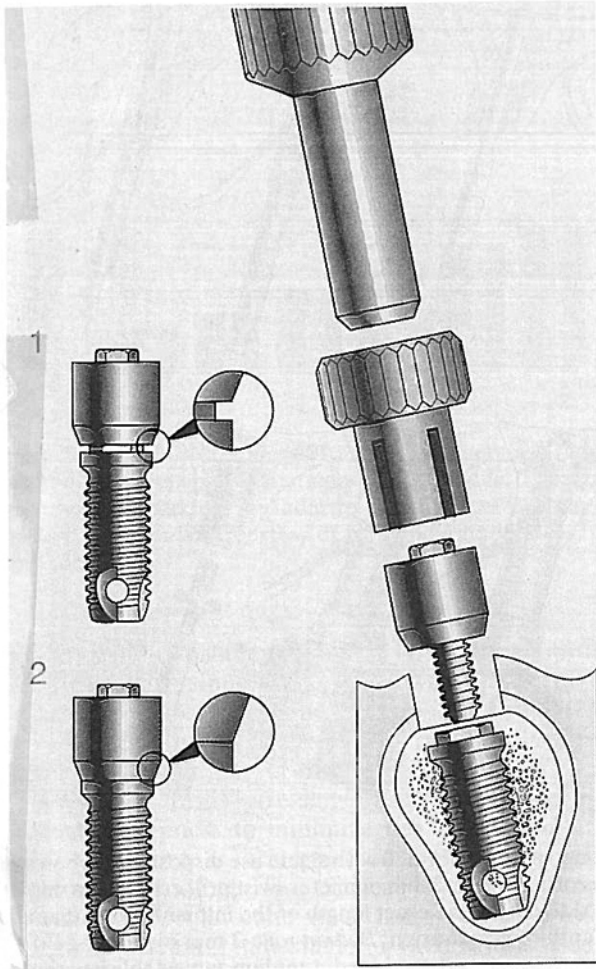
### **Implant Placement Secondary To Alveolar Ridge Healing**

Following severe traumatic loss of numerous teeth and the alveolar ridge, as often seen in high speed impact accidents, the edentulous ridge should usually be allowed to heal initially before fixture (implant) placement. This permits complete mucosal closure over the remaining alveolar bone. Careful treatment planning is necessary to determine precise fixture position, long axis angulation, and implant distribution relative to the potential loading forces created by the implant supported prosthesis.

### **Guided Bone Regeneration Around Implants**

Recently some studies have shown that various barrier materials used to enhance osseous generation in areas of voids, frequently encountered adjacent to fixtures placed in extraction or root avulsion sockets, have been successful. The use of Goretex has been reported to produce osseous generation around titanium fixtures (implants). Others have reported the effect of resorbable Vicryl mesh as a barrier to inhibit the ingrowth of epithelium around Branemark fixtures where osseous voids are encountered at the time of initial fixture placement.

Generally sports injuries to the teeth are nonrepeti-



**Figure 6** After the appropriate healing time the fixture is reexposed and the titanium abutment securely fastened after aligning the interlocking hex between the cylinder and the top of the implant. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

tive and permit the patient to proceed with complete prosthodontic rehabilitation after a normal course of healing. In light of this biologic conservatism, however, one must also consider the professional athlete where the potential for repeated injury does exist.

### **Removable Protheses Versus Fixed Implant Supported Protheses**

In some circumstances professional athletes who have lost some of their anterior teeth can benefit greatly from permanent tooth replacement with osseointegrated implants. Such examples might be professional boxers and hockey players who sustain high-impact trauma to the anterior dentition. When such athletes continue in their professional careers, careful consideration should be given to whether or not the use of a fixed implant supported prosthesis is advisable. Because osseointegration by definition is the intimate contact of ordered living bone on the surface of a load carrying implant, without a soft tissue interface, there is absolutely no mobility to

the implant fixture. Without a ligament, any impact to the implant supported bridge will convey the same impact to the underlying bone. A sudden blow to the prosthesis can create microfractures to the bone, thereby destroying osseointegration, leading ultimately to the failure of the bone anchored unit through the development of fibrous encapsulation.

When professional athletes continue to compete, the clinician may consider the use of osseointegrated implants to support a removable appliance with a resilient interface between the prosthetic teeth and the osseointegrated fixtures. Such appliances can be constructed in the form of overdentures with soft tissue liners. Gold clip bars frequently serve as one of the best mechanisms for overdenture retention.

Athletes should be warned that severe impact to the implants can destroy the bone implant interface. Under these circumstances, a secondary appliance should be constructed to prevent implant impact. Mouth guard appliances serve well to protect these implants. During competition, the professional hockey player, the boxer, and other contact sport athletes might do well to remove the implant supported overdenture and replace it with a specially designed mouth guard to avoid implant fractures caused by impact. For these same athletes a nonremovable prosthesis may be constructed to be used during the off season.

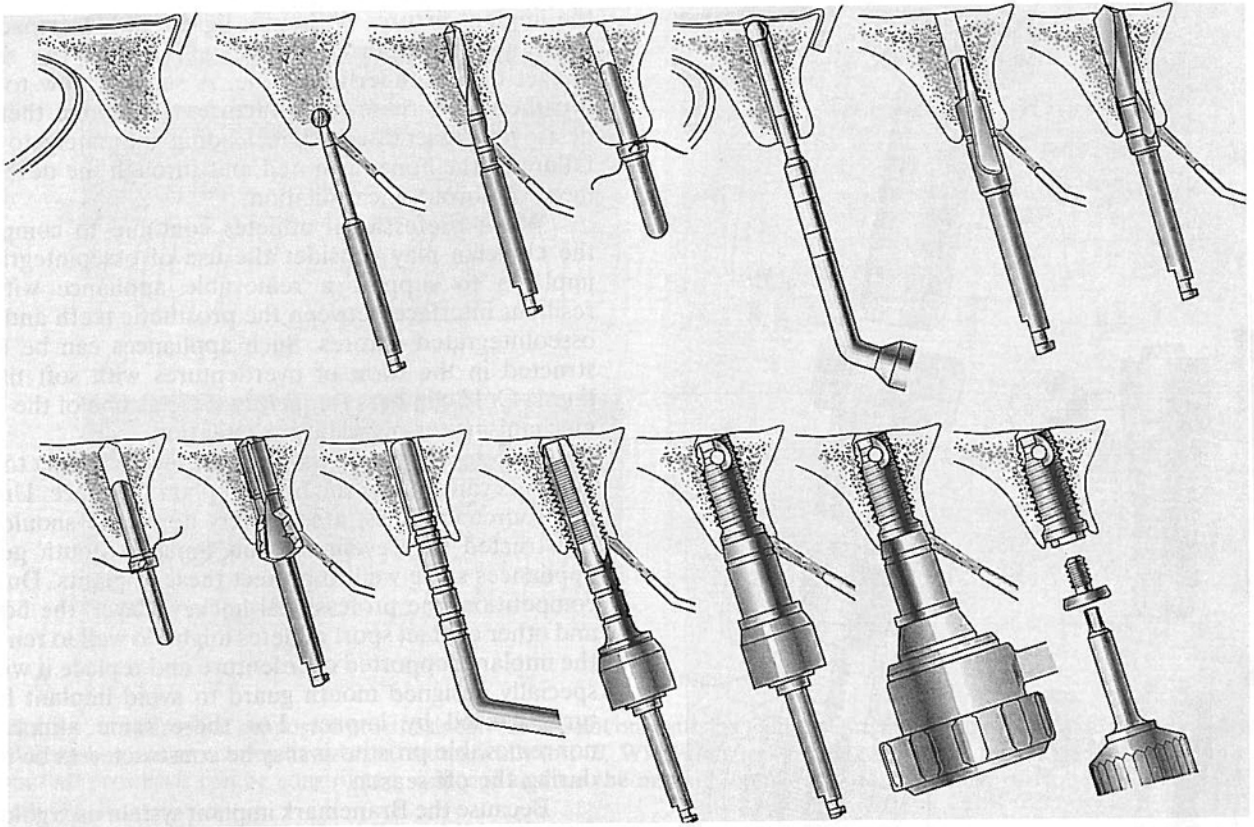
Because the Branemark implant system uses gold set screws to retain the prosthetic components, the bar retainer for the overdenture may be very easily unscrewed and removed at the end of the season and a fixed prosthesis secured with the same fastening screws. At the end of the off season, the athlete may again change from a nonremovable prosthesis to the removable overdenture.

A variety of implant prostheses can be constructed to provide prosthetic replacement for missing dentition as well as supporting alveolar and mucosal tissues. Figure 5 shows two types of prostheses supported by Branemark osseointegrated implants; one requires prosthetic replacement of lost alveolar tissue (Fig. 5, A), the other takes advantage of adequate alveolar and mucosal support (Fig. 5, B).

### **BRANEMARK IMPLANT TREATMENT PROCESS**

In order to attain osseointegration, implants must be placed in the alveolar or basal bone and allowed to remain undisturbed for 5 to 6 months in the maxillary (upper) jaw and 3 to 4 months in the mandibular (lower) jaw. During this initial healing stage the patient can be temporarily restored with a provisional light weight acrylic removable denture. Alternative forms of temporary prosthesis also include resin bonded teeth or fixed provisional crown and bridge restorations. After the prescribed healing period, a second stage surgery is performed to re-expose the implant and add an extension called the abutment, to which the permanent teeth are ultimately fastened (Fig. 6).

The hardware consists of very special sharp instru-



**Figure 7** Fixture installation. Sequential drilling to prepare the osteotomy site is performed with single use disposable carbon steel drills and taps. *Top row:* Mucoperiosteal flap, round pilot drill perforates cortical plate, 2 mm diameter twist drill establishes implant depth, guidepin confirms long axis angulation, measuring instrument used to determine exact length of the implant, 3 mm diameter pilot drill starts the final preparation, 3 mm twist drill completes the depth of preparation. *Bottom row:* 3 mm diameter guidepin confirms angulation, counter sink prepares the crestal bone, the final measurement determined, titanium tap establishes threads in areas of dense bone, implant placed at 15 to 20 RPM, final hand tightening of implant in bone, removal of carrying device and placement of cover screw prior to mucosal closure. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

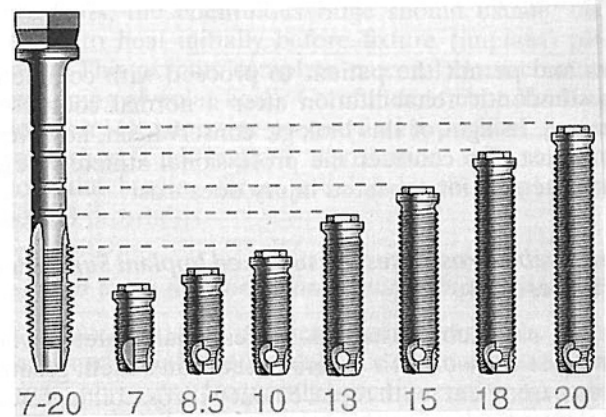
ments (Fig. 7) and noncontaminated, commercially pure titanium implants (Fig. 8) and abutments (Fig. 9) with a particular surface microarchitecture. These components must be manufactured from a correct bulk metal (CP titanium) and must have an oxide cover with the right characteristics down to the molecular level. Even minor deviations in the titanium oxide can result in the incorrect attachment or arrangement of the early proteins in the wound as it heals.

The software consists of procedures that assure a very gentle tissue handling and careful preparation, recognizing the fact that we are dealing with a wound and that we are creating a defect in the bone that is similar to a fracture. We have to respect that the tissue needs undisturbed healing until the young bone tissue can be made to remodel under functional load (see Fig. 7).

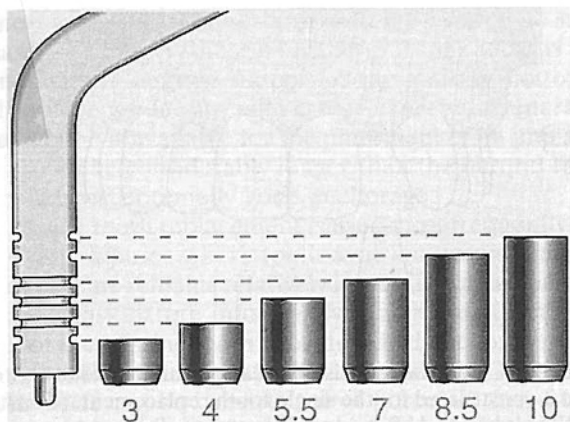
## SURGICAL PROCEDURE

### Stage I: Implant Installation

A mucoperiosteal flap generally in the labial fold permits access to the area of the jaw bone where the



**Figure 8** Proper depth for different fixtures is indicated on the screw taps as well as various measuring instruments used during stage I surgery. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)



**Figure 9** Standard abutments. At stage II surgery, a variety of both standard and special abutments are available. The depth gauge has six markings to indicate the different heights for standard abutments. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, IL.)

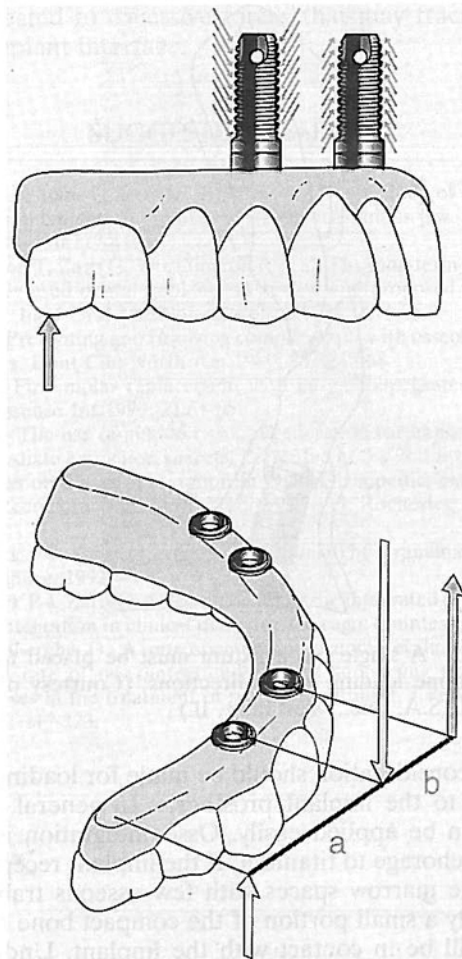
implants will be installed (see Fig. 1). Anterior borders of the maxillary sinuses and the lower border of the piriform aperture should be identified. Evaluate any concavities on the buccal aspect of the alveolar crest, especially in the region of the lateral incisors.

All of the "drills" are single use carbide steel with maximum sharpness to minimize heat of friction. The entire procedure is accompanied by copious saline irrigation for cooling. The cortical layer and a small amount of trabecular bone are penetrated with a round guide drill. Then a 2 mm diameter twist drill is used to prepare the initial long axis angulation for implant placement. The implant site is then widened with a pilot drill and finally a 3 mm twist drill prepares the receptor site (see Fig. 7, top row). Assuming there is sufficient cortical bone, countersinking the fixture site should be performed. If the maxillary bone is dense, pretapping threads into the bone may be necessary (Fig. 7, bottom center). The implant with attached fixture mount is picked up with the drill machine and rotated into the alveolar bone at 15 to 20 RPMs. When the fixture is fully seated, the fixture mount is disconnected and removed. A cover screw is then manually tightened onto the top of the fixture to prevent bone from growing into the internal threads (see Fig. 7, bottom right). The area is then thoroughly cleansed and the mucoperiosteal flap sutured closed.

### Stage II: Abutment Connection

After the prescribed healing period for osseointegration, generally 5 to 6 months in the maxilla and 3 to 4 months in the mandible, the second stage surgery is performed to expose the implant. The cover screw is removed and the appropriate titanium abutment placed.

A variety of abutments are available for various prosthetic purposes. Standard abutments, however, are most commonly used (see Fig. 9) and are available in sizes ranging from 3 to 10 mm in height depending on

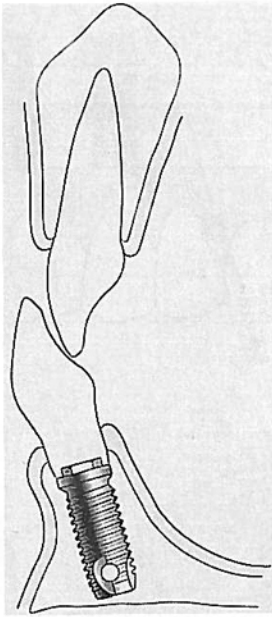


**Figure 10** Spreading the implants across the edentulous area is important for load distribution to the underlying alveolar bone. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, IL.)

mucosal thickness. The titanium abutment is retained to the fixture with a titanium abutment screw. Interlocking male and female hexagonal components must be aligned to fit on top of the fixture properly (see Fig. 6). Before final tightening an abutment clamp should be used to rotate the abutment cylinder to ensure the appropriate interlocking of the hexagonal faces. After the abutments are installed the mucosal tissue is sutured, if necessary, to achieve a close adaptation between the soft tissue and the titanium abutments. The precision fit of the implants to the abutments must be verified radiographically. The prosthetic reconstruction can then be carried out. The final prosthesis is retained using small gold set screws as illustrated (see Fig. 5, B).

### BIOMECHANICAL CONSIDERATIONS

Biomechanical considerations for construction of a tissue integrated prosthesis are important for patients who have sustained traumatic injuries to the alveolar bone. When alveolar bone is weakened through trauma, fracture, or because of the nature of the bone itself,



**Figure 11** A single tooth fixture must be placed to permit optimal bone loading in all directions. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

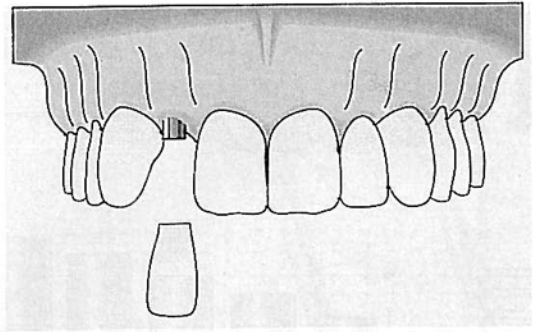
special consideration should be made for loading forces applied to the implant prosthesis. In general, several rules can be applied easily. Osseointegration is direct bone anchorage to titanium. If the implant receptor site has large marrow spaces with few osseous trabeculae, then only a small portion of the compact bone (trabeculae) will be in contact with the implant. Under such circumstances multiple fixtures should be used to attempt to increase the bone volume in contact with the titanium fixtures. The more fixtures, the more bone surface will be osseointegrated in that arch.

### BONE REMODELING

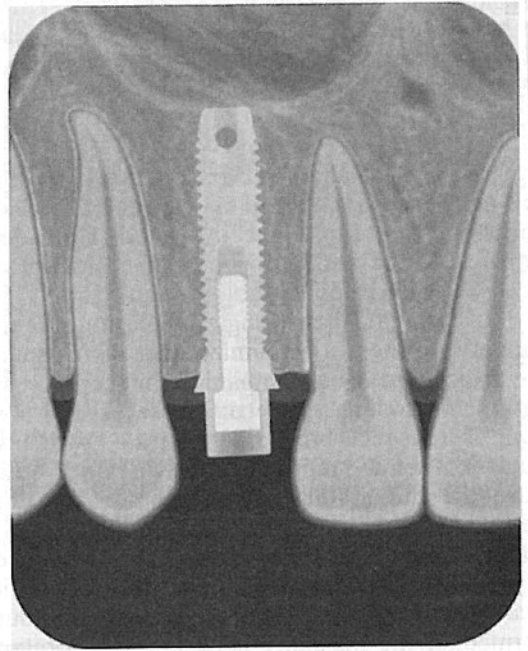
The concept of gradual loading is combined surgical/prosthetic methodology. Knowledge of the bone quality and quantity is integrated in an empirical formula with the number of fixtures used to support any given prosthesis.

Should a patient present with evidence of parafunctional habits, such as bruxing and clenching, soft loading of the newly uncovered implants with a soft denture liner will limit the amount of force applied to the fixtures. Gentle loading creates a remodeling stimulus to the bone surrounding the implants. As the remodeling increases the density and amount of cortical bone around the fixtures over the loading time, other more rigid prosthesis attachment methods may be employed.

In the large prosthesis used to replace multiple missing teeth, the implants constitute bridge posts that share the applied functional loads as axial forces between them. Spreading implants evenly along the arch enables this axial load distribution (Fig. 10). In smaller restorations with shorter spans, this geometric implant



**Figure 12** A crown consisting of an aluminum oxide ceramic core is constructed for the single tooth replacement. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)



**Figure 13** Radiographic illustration of the ideal implant position with the titanium abutment in place. (Courtesy of Nobelpharma U.S.A., Inc., Westmont, Il.)

spread is not always possible. In such cases, it is appropriate to look at the implant as being an artificial tooth root rather than a bridge post, because it may have to withstand load in all directions from the connected prosthesis. A small implant supported partial prosthesis, or a single tooth implant (Fig. 11), is more sensitive to the precise and detailed placement and anchorage of the fixtures than are full arch, or large multiple fixture supported prostheses.

### SINGLE TOOTH REPLACEMENT WITH TITANIUM IMPLANTS

A single tooth replacement in the maxillary anterior part of the jaw means the replacement of a missing natural tooth with a fixture approximately the same



dimension as the missing tooth root. If the fixture in such a case is as long as the missing natural root and has the same amount of bone support as the natural root once did, sufficient bone strength can be expected. Generally, ample bone is available for the placement of an implant, which can be considerably longer than the natural root, providing exceptionally good anchorage.

Single tooth replacement is used most frequently for traumatic injuries where tooth avulsion occurs and the alveolar bone remains relatively intact. The placement of a Branemark fixture into the alveolar ridge beyond the apex of the missing tooth provides ideal anchorage for a single tooth replacement (Figs. 12 and 13). The prosthesis itself can be constructed of porcelain fused to a high gold content substructure or to high strength ceramic core.

In the posterior part of the jaw, a single fixture does not correspond to the lost root support of a molar, which ordinarily has multiple roots of approximately the same dimension as the implants. In this situation, if space is available, multiple implants should be used to replace a single molar. Considering these factors, in combination with the fact that loading forces are at their greatest in the posterior region of the mouth, it is easy to understand that a single fixture used in the molar region may

be subjected to excessive forces that may fracture the bone/implant interface.

## SUGGESTED READING

- Adel R, Lekholm U, Rockler B, et al. A 15 year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg* 1981; 10:327-416.
- Albrektsson T, Zarb G, Worthington P, et al. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. *Int J Oral Maxillofac Implant* 1986; 1:11-25.
- Balshi T. Preventing and resolving complications with osseointegrated implants. *Dent Clin North Am* 1989; 33:821-868.
- Balshi T: First molar replacement with an osseointegrated implant. *Quintessence Int* 1990; 21:61-65.
- Becker B. The use of guided tissue regeneration for implants placed in immediate extraction sockets. Presented at the 2nd International Congress on Tissue Integration in Oral, Orthopedic, and Maxillofacial Reconstruction. Mayo Medical Center, Rochester, MN, Sept, 1990.
- Branemark P-I. Surgical procedure manual. The Branemark system. Gothenburg, 1992.
- Branemark P-I, Zarb G, Albrektsson T. Tissue integrated prosthesis—Osseointegration in clinical dentistry. Chicago: Quintessence, 1985.
- van Steenberghe D. A retrospective multicenter evaluation of the survival rate of osseointegrated fixtures supporting fixed partial prostheses in the treatment of partial edentulism. *J Prosthet Dent* 1989; 61:217-223.