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Preventing and Resolving Complications With Osseointegrated Implants

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North America was introduced to osseointegration via the Branemark method in the early 1980s. This marked a significant change in the philosophy, ideology, concept, and execution of treatment in prosthetic dentistry and implant prosthodontics. With this scientifically proved method of bone anchorage[15] for endosseous load carrying implants,[2, 4] a predictable prognosis based on critical surgical and prosthodontic precision began to change treatment for oral and facial reconstruction.[36] With the stability of the tissue-integrated prosthesis (TIP), came the added benefits of improved psychosocial attitudes and, for many patients, the resumption of normal daily activities.

Functional prosthodontics, for the edentulous and sometimes partially edentulous patients with severe residual ridge resorption and atrophic denture supporting areas, had been fraught with compromises and complications, which were frustrating for patients and prosthodontists alike.

The treatment of patients with TIPs resolved many of the problems that had been encountered with traditional prosthodontics. As prosthodontists and surgeons gained confidence in the Branemark method, more difficult conditions were treated. Although these patients were, and still are, the beneficiaries of complex yet successful treatment programs, the experiences of dealing with the osseointegration method of rehabilitation was not without complications.

With any biomechanical entity, difficulties can arise in the area of biologic function, as well as mechanical or engineering stability. This article will identify the fundamental complications that arise with osseointegration treatment and will examine the solutions to these problems. Complications may be divided into six major categories: (1) esthetic, (2) phonetic, (3) functional, (4) biologic, (5) mechanical, and (6) ergonomic.

Within each category, a variety of complications can exist. So too, can a host of solution possibilities.[6]

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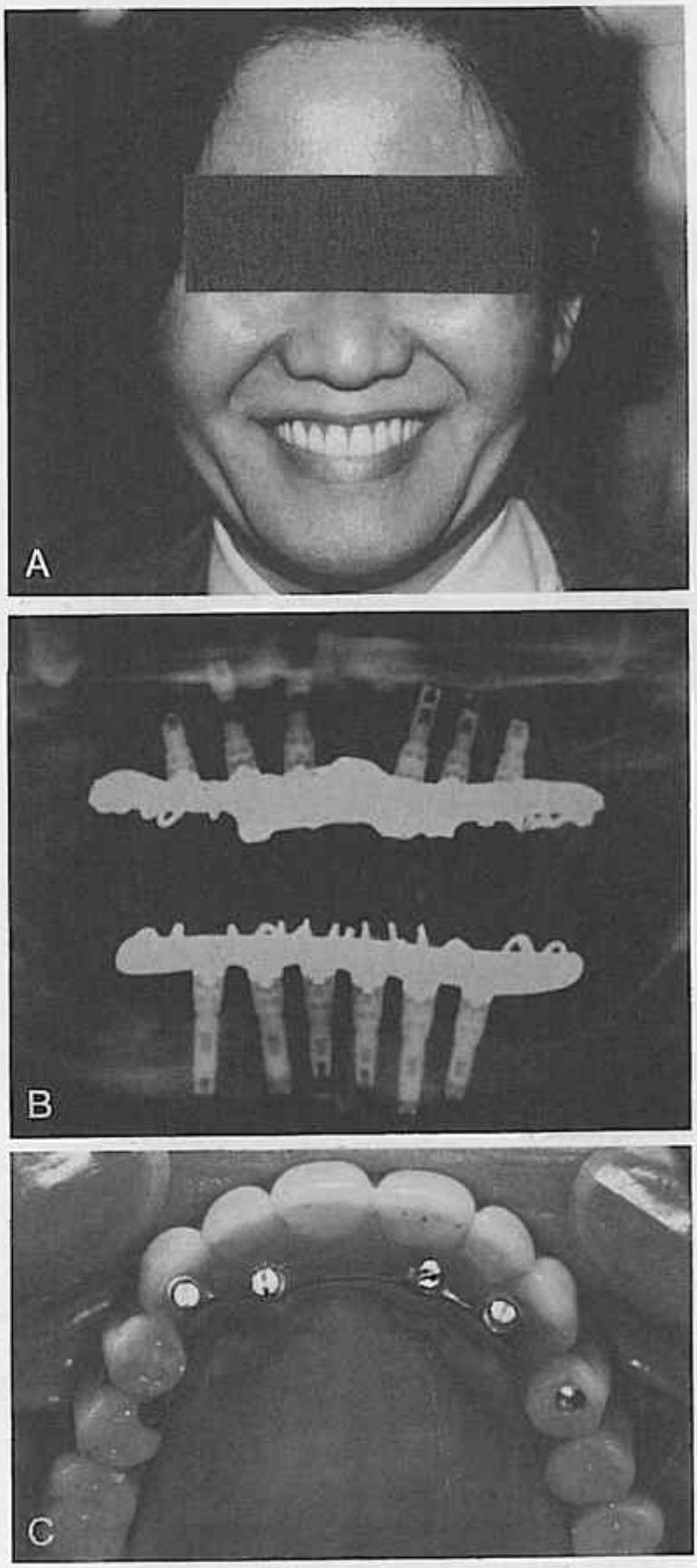

Figure 1. *A*, Optimal dental and facial esthetics achieved following maxillary and mandibular tissue integrated prosthesis. *B*, Panradiograph: Ideal placement of osseointegrated fixtures and completed prosthodontic rehabilitations. *C*, Palatal view: Note lingual and occlusal access screw holes.

ESTHETICS

When considering esthetics and osseointegrated implants, one should follow the philosophy of the great Philadelphia inventor-philosopher, Benjamin Franklin: "A stitch in time saves nine." Prevention is always the best medicine. Identification of potential esthetic problem areas prior to fixture (implant) installation frequently permits alternative planning and avoids more complex treatment or retreatment at a later date.

Using an organized and well structured tentative sequential treatment plan, phase 1 calls for presurgical prosthodontics.[9] Establishing an esthetic prototype of the final prosthesis provides information helpful in the design of surgical guide stints.[12] With careful planning[15, 23, 32] and equally careful surgical fixture installation[1, 3, 24] using guide stents,[13, 19] the most frequently encountered esthetic complication of facially angulated screw access holes is often avoided. When ample bone is available, guide stents assist the surgeon in angulating the endosseous fixtures so the prosthetic screw access will be centered within the facial-lingual dimensions of esthetically positioned prosthetic teeth (Fig. 1).[17, 20]

The use of diagnostic imaging, including panradiographs, lateral cephalometric films, as well as computerized tomography (CT) scans[26, 35] help determine ideal reception sites for the titanium fixtures. With less than ideal bone available, the divergent long axis fixture angulation tests the creative skills of the prosthodontist.

LABIALLY INCLINED FIXTURES

Labially inclined fixtures create the most frequently encountered esthetic problem in the fabrication of a fixed TIP (Fig. 2). Fixed prosthodontic solutions to labial access holes consist of two fundamental methods. One is the use of a double casting. The primary casting is fastened either directly to the fixtures or to the labially inclined abutment connectors. This casting contains a set of retentive screw threads positioned in parallel extensions from the framework to permit an overcasting with teeth to be securely fastened, hiding the second set of screw holes on the lingual or occlusal surfaces (Fig. 3).[8, 21]

The second method of avoiding facial access holes uses intermediary components designed to change the long axis fixture angulation. Examples of such components include the Robutment (Fig. 4)[30] and the Nobelpharma angled abutment (Fig. 5).

Secondary methods of managing this problem include the use of prefabricated or custom-made components fastened to either the fixture or abutment, that provide a solid conical abutment on which a conventionally constructed fixed partial denture (traditional crown and bridge) may be *cemented*. I view this as an undesirable method, as rigid cementation would be recommended to properly distribute the loading forces to each fixture and subsequently complicate easy recovery of the prosthesis without injury to the osseointegrated interface.

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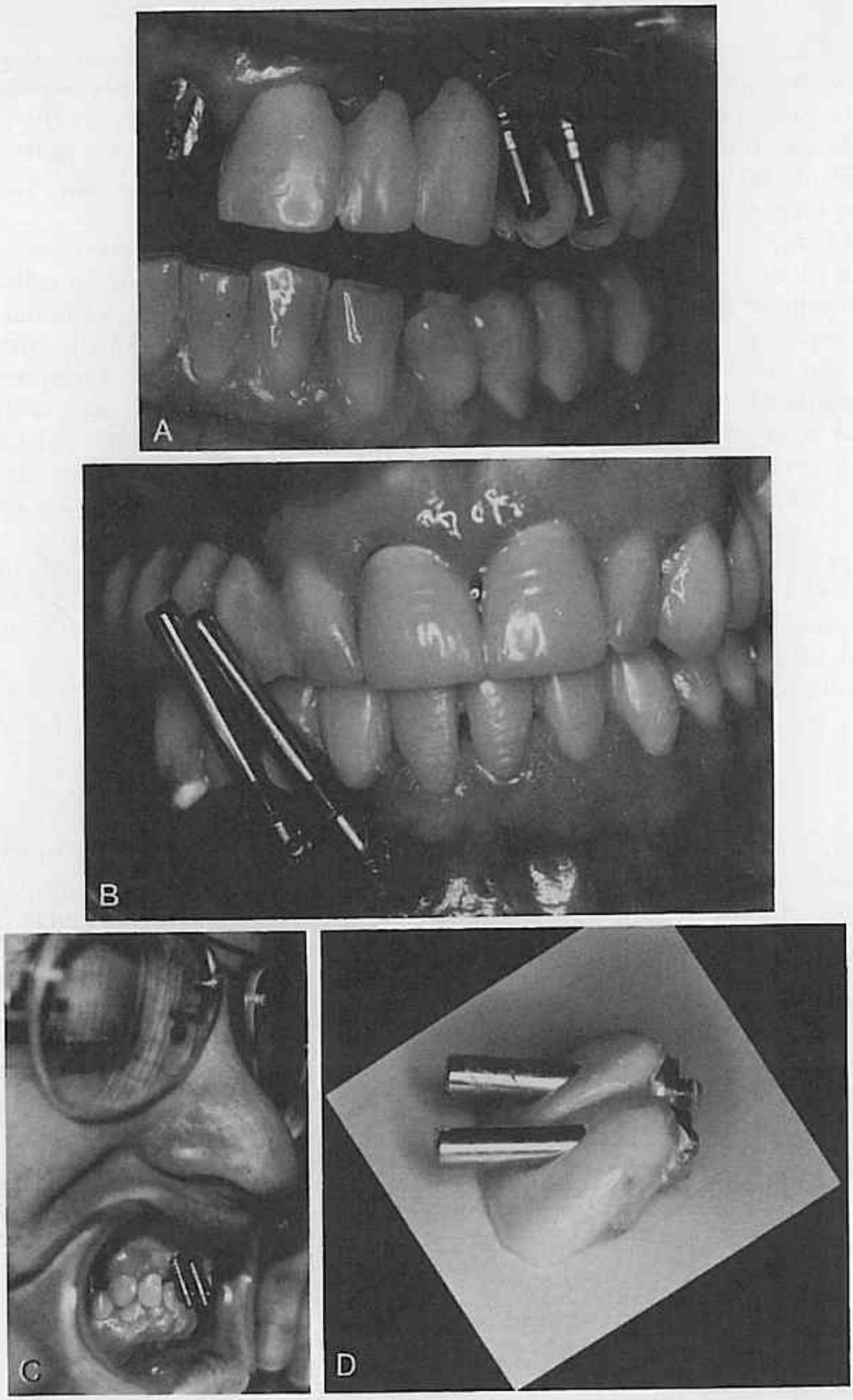
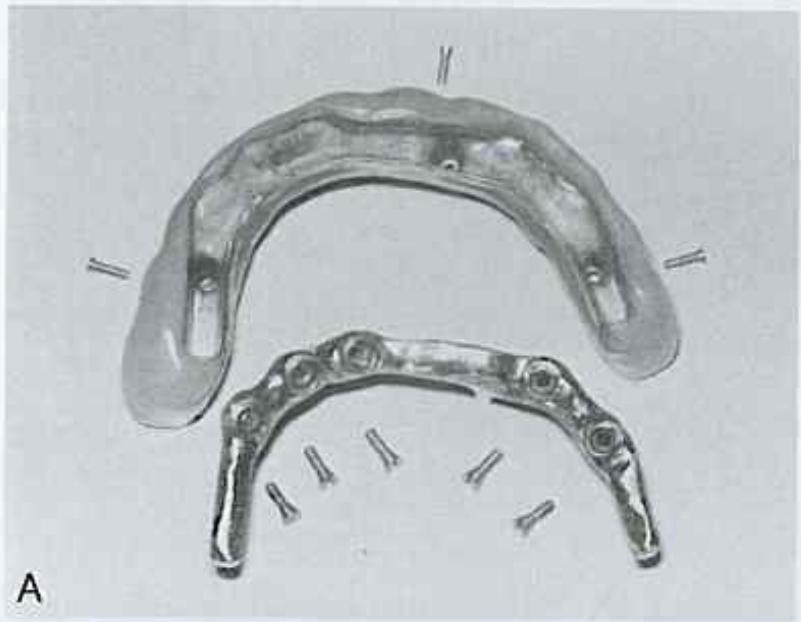
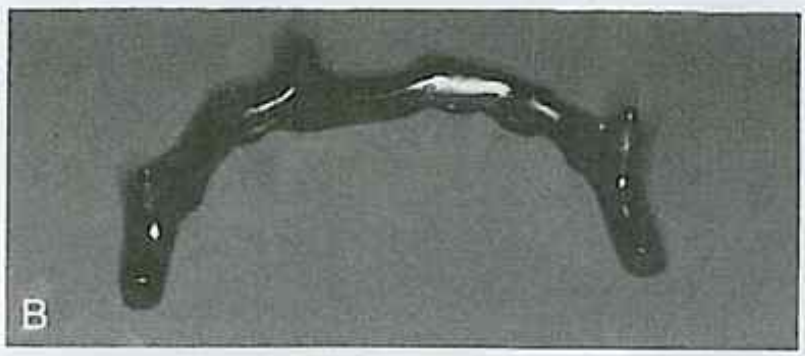


Figure 2. *A*, Maxillary fixtures labially inclined. *B*, Mandibular fixtures labially inclined. *C* and *D*, Maxillary anterior fixtures labially inclined will require access openings through the facial surfaces of the central incisors leaving a "tell-tale" secondary composite restoration with poor long-term esthetics.





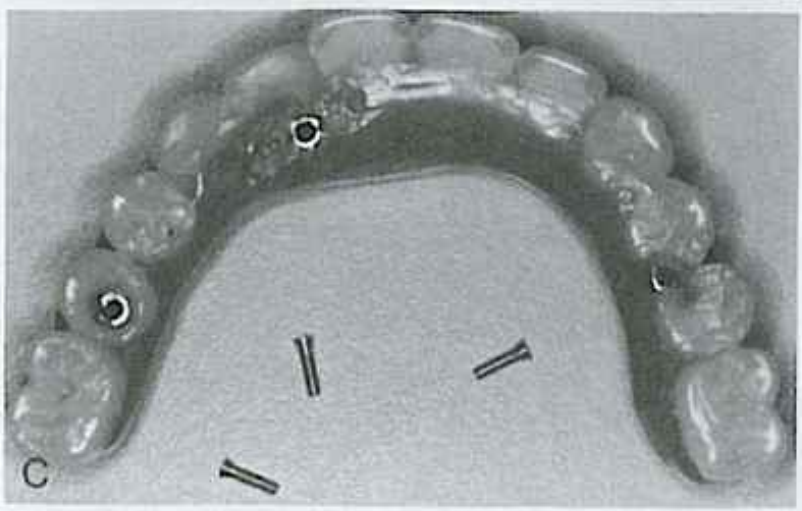
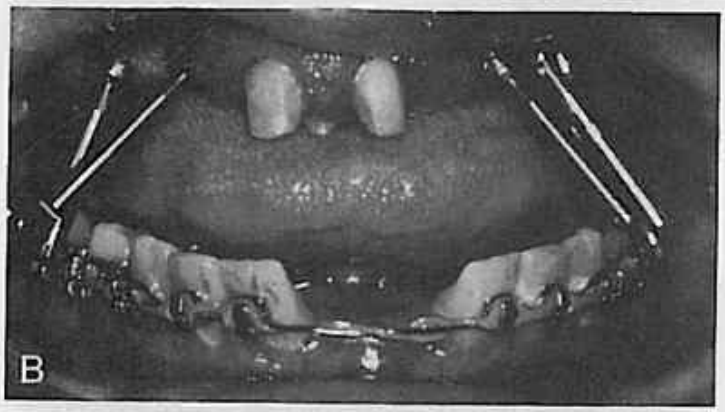


Figure 3. *A*, Double casting TIP reconstruction to correct screw angulations for a maxillary tissue integrated prosthesis. *Top:* Overcasting with tooth and gingival veneer. *Bottom:* Substructure casting. *B*, Substructure casting fastens directly to the titanium abutments. The three tall screw channels secure the overcasting using set screws. *C*, Occlusal view of the overcasting with denture tooth veneer and set screw position.



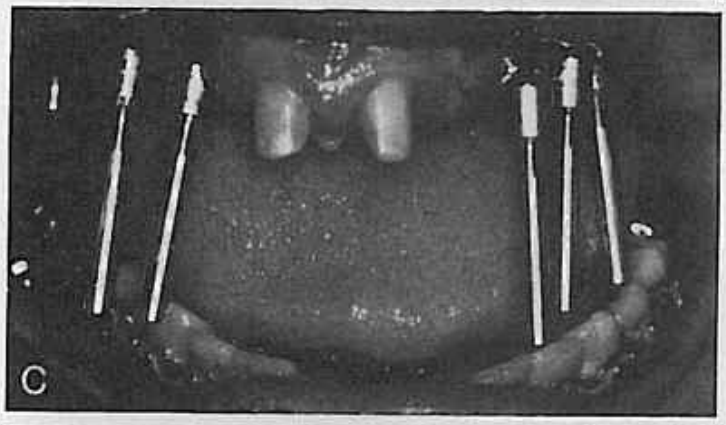


Figure 4. *A*, Preoperative: Partially edentulous patient to receive osseointegrated fixtures. *B*, Labially inclined fixtures, an esthetic complication. *C*, Robutments are used to change the long access angulation of the prosthetic access opening. *D*, Robutment consists of a ball and socket joint changing the long access 30°.

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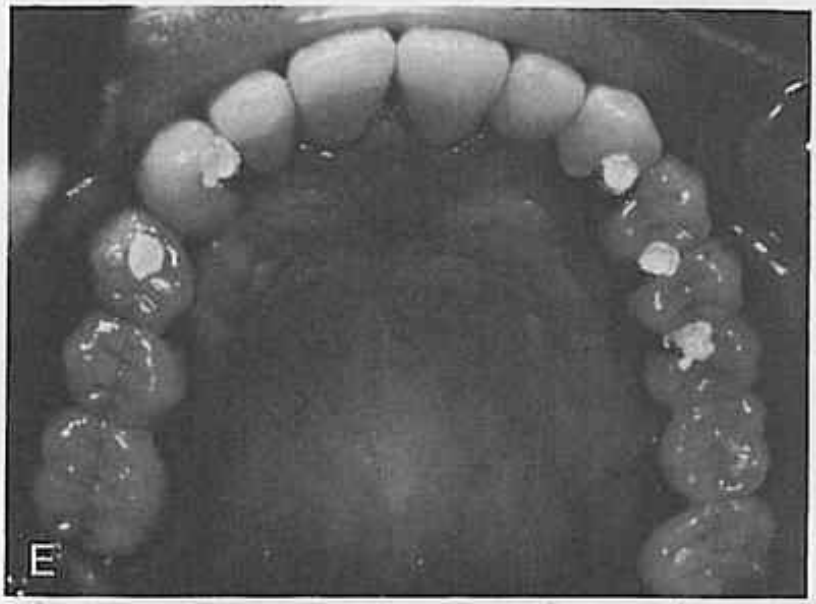

Figure 4 *Continued E*, Post-prosthodontic occlusal view: Note access holes in the lingual or occlusal surface of the prosthetic teeth. *F*, Final tissue integrated prosthesis with optimal esthetics.

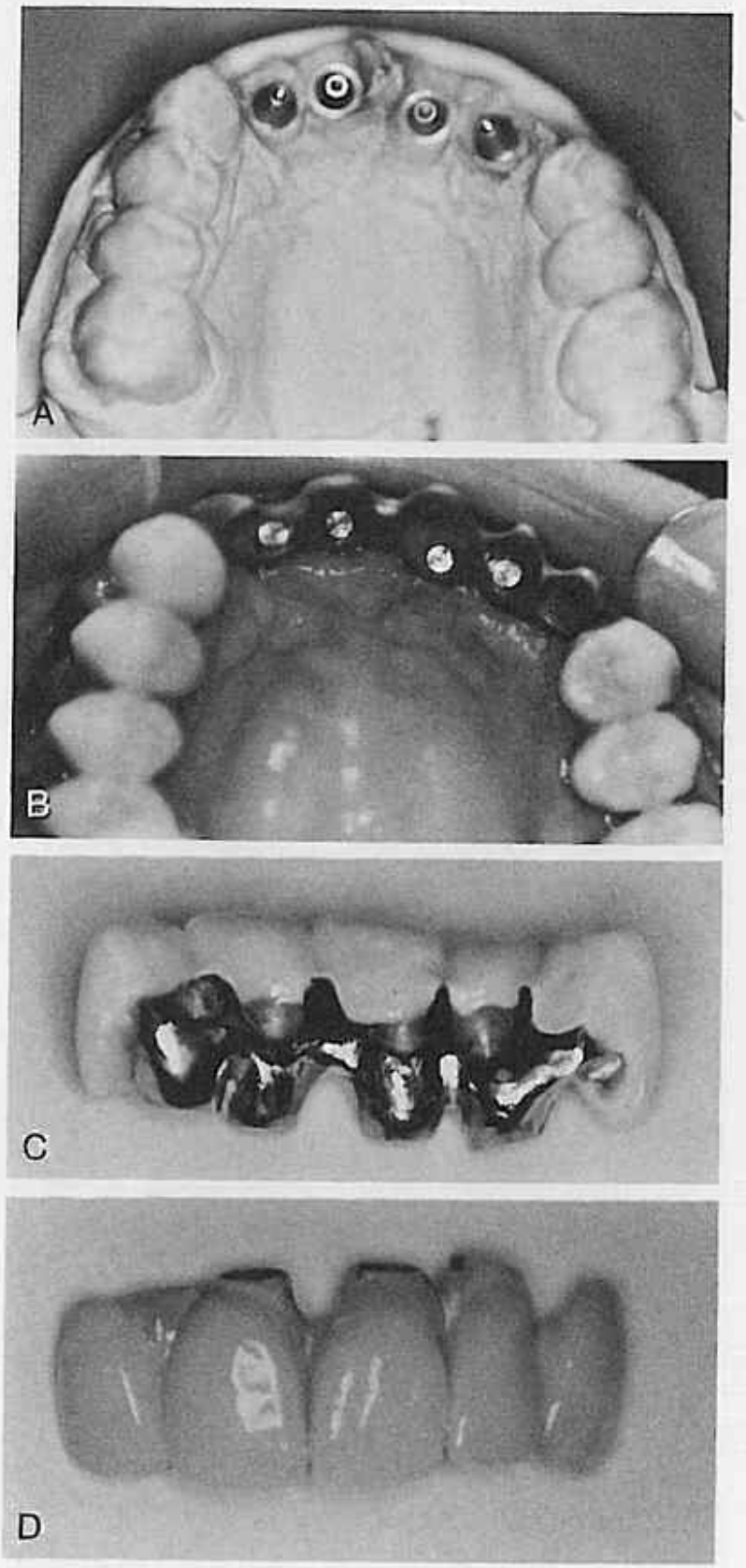

Figure 5. *A*, Master cast with brass analogues of the Nobelpharma angled abutment show a prosthetically acceptable base for an esthetic restoration. (These abutments change the long access fixture angulation from labial orientation 30° to the lingual.) *B*, Occlusal view casting try-in shows the screw access position on the lingual surface of the teeth. *C*, Final prosthesis with lingual access screw holes. *D*, Final prosthesis: labial view.

LIP LINE EFFECTS

Maxillary high and mandibular low lip lines may present an esthetic compromise created by either advanced horizontal and vertical bone loss necessitating a space between the TIP and the mucosal tissue or abutment, framework, and other metallic component visibility. In addition, uneven residual ridges associated with extractions following osseointegration of previously implanted fixtures require esthetic masking.

Use of either extended fixed acrylic (Fig. 6) or porcelain gingival facades[11] (Fig. 7) provide improved esthetics but often make oral hygiene more difficult for the fixed TIP. An alternative solution to esthetic complications due to both fixture alignment high lip line may be the use of an implant-supported overdenture.[33]

ANTERIOR PARTIALLY EDENTULOUS AND SINGLE TOOTH REPLACEMENT

When the TIP is employed to replace a small number of teeth in visible areas, management of the interdental papilla becomes a concern. Even with a single missing tooth, the flattened papilla adjacent to the edentulous area may require careful surgical reconstruction following the second-stage abutment connection. This esthetic plastic surgery may include onlay or inlay connective tissue grafting to rebuild the missing papilla tissue. In areas where soft-tissue reconstruction is impossible, prosthetic tissue replacement will be required (Fig. 8).

FACIAL SUPPORT

Lips and Cantilevers

Lip support is best determined by the presurgical prosthesis. Traditional guidelines for the tooth position in the construction of complete removable dentures suggest teeth be set over the crest of the residual alveolar ridge. Because of the resorptive process following tooth loss, the crest of the ridge and the spacial position of those teeth will usually create

Figure 6. Extended labial flange compensates for a high lip line.

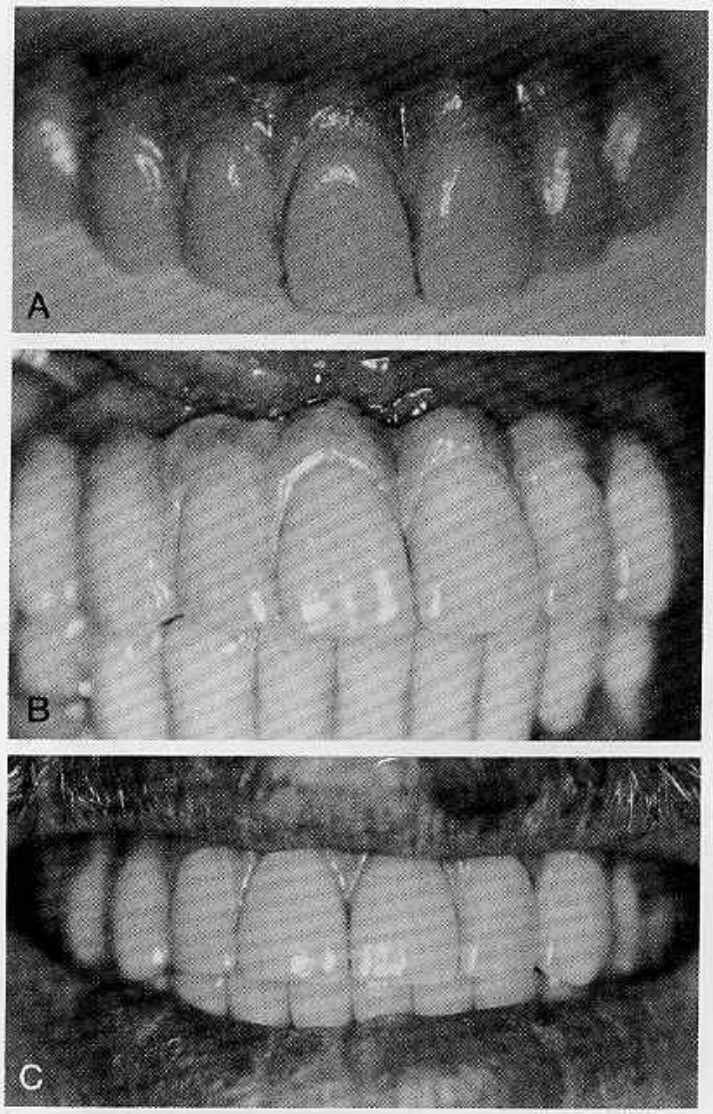

Figure 7. *A*, Maxillary anterior TIP with porcelain flange. *B*, Maxillary anterior porcelain flange hides titanium abutments, even with lips retracted. *C*, Porcelain interdental papilla and flange extension provide excellent esthetics for patients with a high smile line.

a smaller arch and be positioned more lingually than the anatomic orientation of the natural dentition. In contrast, the bone-anchored stability of the TIP allows the prosthetic teeth to be positioned off the crest of the severely atrophic residual ridge. With restoration of the occlusal vertical dimension and facial cantilevering of the teeth, appropriate lip support may be attained. The result is better facial esthetics.[7]

In edentulous or partially edentulous patients who require esthetic facial plastic surgery or who may be contemplating such treatment at a future date, completion of the TIP treatment prior to the face-lift surgery is essential. The rigid security of the bone anchored bridge is a dependable skeletal extension for support of the surgically repositioned facial tissues (Fig. 9).[27]

Lips and Complications

Facial cantilevers of the TIP can create complications when the cantilevered distance is excessive or when occlusal forms exert loads exceeding the biomechanical limits of the osseointegration interface. An example of this condition is illustrated later (see Fig. 21) in the section on biologic complications: *load, angulation, and bone.*

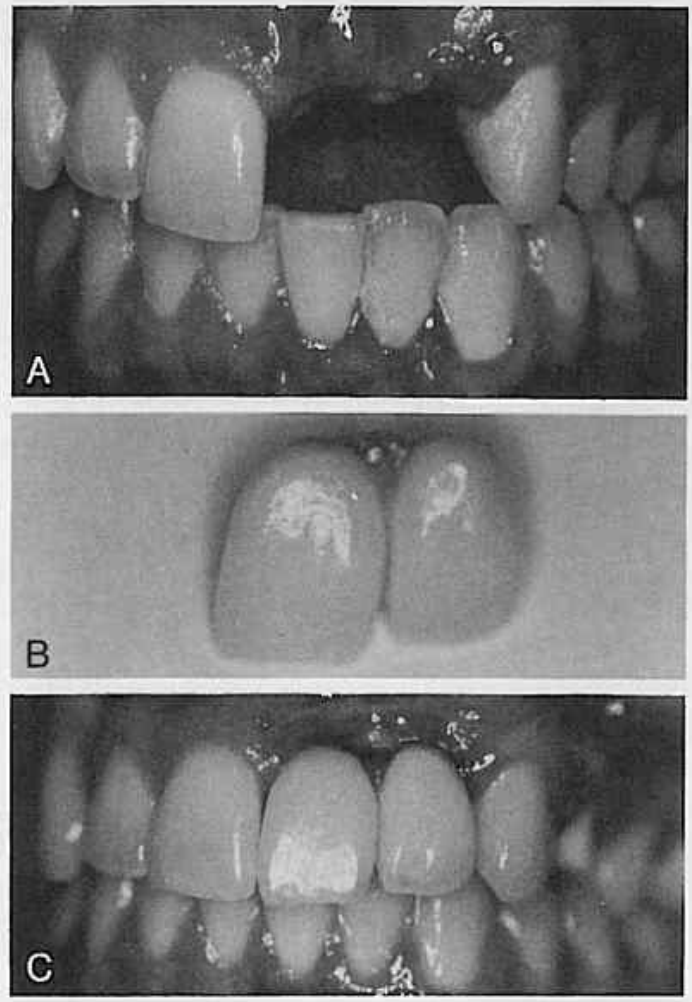

Figure 8. *A*, A preoperative condition requiring prosthodontic treatment for the replacement of teeth Nos. 9 and 10. *B*, Small TIP includes porcelain interdental papilla between teeth Nos. 9 and 10. *C*, Clinical view shows surgical scars apical to the porcelain papilla and the tissue integrated prosthesis.

Figure 9. *A*, A preoperative lateral view showing facial collapse, loss of occlusal vertical dimension and lack of lip support with ill-fitting dentures. *B*, Restoration of facial features and appropriate lip support are the results of TIP treatment followed by esthetic plastic surgery (Face lift surgery: Dr. C. E. Pappas, Fort Washington, Pennsylvania).

The solution to this complication is multifaceted and includes accurate treatment planning, assessment of the quality and quantity of bone, and appropriate load distribution through optimal placement of numerous and long fixtures.

PHONETICS

Phonetic complications may occur if the spacial position of the prosthetic teeth are different from the natural dentition or if patients experience long-term accommodation to a prosthesis with poor tooth position. Previously existing speech impediments, such as lisps or hissing sounds, should be noted in the records and pointed out to the patient. It may also be advisable to record the speech difficulty prior to treatment. These records reduce the anxiety level for both patient and doctor following the delivery of a final prosthesis and the continuation of a phonetic abnormality.

If presurgical diagnostics will predict an emergence of the bone-anchored unit in a palatal position, additions may be made to the presurgical prosthesis to stimulate the added bulk of prosthetic material a patient may experience with the final TIP in the area of its connection to the osseointegrated fixtures. Phonetic difficulties may also be experienced by patients when the space between the maxillary TIP and the residual ridge is excessive (Fig. 10). Using shorter abutment connections or adding material to the prosthesis to close the space often improves this phonetic difficulty.

TONGUE PROBLEMS

The mandibular TIP may also provide opportunity for phonetic compromise. Patients with longstanding edentulism, especially in the mandibular posterior, often experience an enlargement of the tongue. Early recognition of this condition, with pretreatment discussion with the patient, minimizes the potential for frustration when the confining rigidity of the TIP restricts freedom of the tongue. Excessive enlargement of the tongue may require surgical reduction of the tongue following delivery of the TIP if patients cannot adapt to the confining feeling of the prosthesis (Fig. 11). Reduction of anterior tongue space or impingement on the lingual muscle

Figure 10. Maxillary TIP with excessive space between the prosthesis and residual ridge tissues creates phonetic complications.

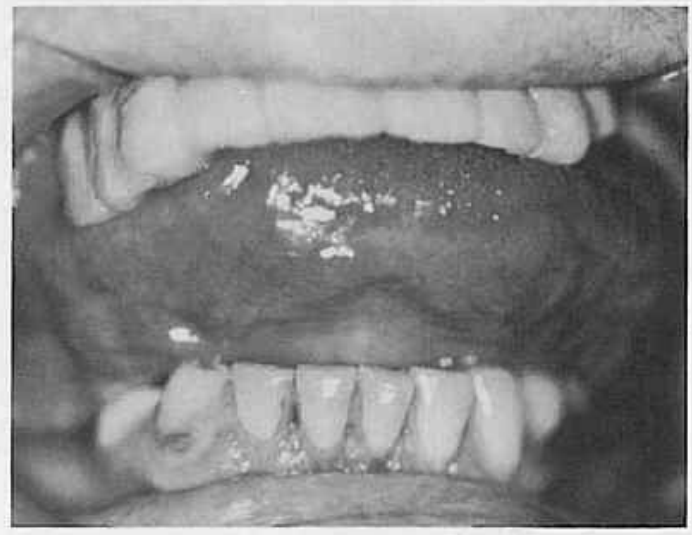

Figure 11. Severely enlarged tongue, due to long-term posterior edentulism in both the maxilla and mandible may require surgical reduction following delivery of the TIP.

attachments has been experienced by patients with lingually inclined fixtures. Alteration of the emergence alignment of these fixtures helps reduce this impingement (Fig. 12).

FUNCTIONAL COMPLICATIONS

Lip, Cheek, and Tongue Biting

Functional complications are minimal yet should be noted, as their occurrence is annoying for the patient. Lip, cheek, and tongue biting are

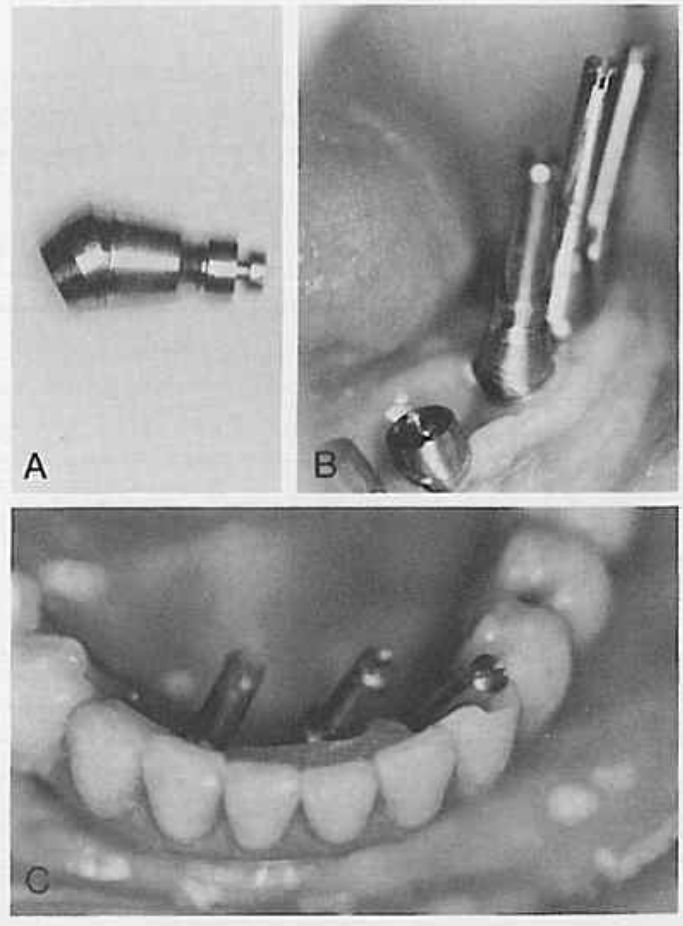

Figure 12. *A*, Rigid angled titanium abutment. *B*, Three angled abutments replacing straight abutments move the prosthetic screw access hole 5 mm facially. *C*, With access holes in the cingulum or lingual surface of the teeth, more space is available for tongue movement.

the most common functional complication with patients who have experienced long-term edentulism without the benefit of prosthetic replacement.

Increased buccal overjet for cheek or lip biting may be necessary. Widening of the posterior arch form decreases biting the posterior lateral border of the tongue; however, this solution is limited by occlusal considerations, facial appearance, and smile line parameters.

TMJ Dysfunction

Functional disabilities, such as TMJ dysfunction, often benefit greatly from restoration of occlusal vertical dimension and posterior dental support provided by a fixed TIP. However, with longstanding severe joint dysfunction, dental replacement itself may be inadequate in providing total comfort. The solution to this complication may be additional occlusal appliance therapy or joint surgery.

Parafunctional Habits

Parafunctional habits, such as bruxing and clenching, may produce added muscle exertion or even spasm when returning patients go from the edentulous state to bone-anchored dentate function via a fixed TIP. Relaxation techniques, physical therapy, and time are often the most appropriate and conservative treatments for this condition.

Parafunctional habits may also create mechanical and biologic complications related to the prosthetic components, materials, and bone-anchored hardware or the state of osseointegration, respectively (Fig. 13).

BIOLOGIC

Preventing biologic complications depends on the *establishment and long-term maintenance* of a healthy implant bed, surrounding mucosal tissue, and the integrity of the osseointegration interface.[28]

Bone Grafts

Establishing a suitable osseous receptor site for titanium fixtures depends on a critical analysis of the quantity and quality of the available bone. When severe atrophy prohibits fixture placement, augmentation of the ridge through a variety of autogenous bone grafting procedures may be used. Generally 6 months[16, 18] to 1 year[22] may be necessary for adequate bone healing and maturation following graft placement.

Alloplastic Grafts

Patients previously treated with alloplastic ridge augmentation materials such as hydroxylapatite (HA) should be carefully evaluated prior to finalization of the TIP. A significant increase in the number of osseointegration failures were noted when attempts were made to place fixtures through areas of HA augmentation (Fig. 14). The highly predictable success levels as previously described[15] can be obtained, however, if fixtures are correctly placed following the removal of all the HA material in the implant receptor site (Fig. 15).[14, 25, 34]

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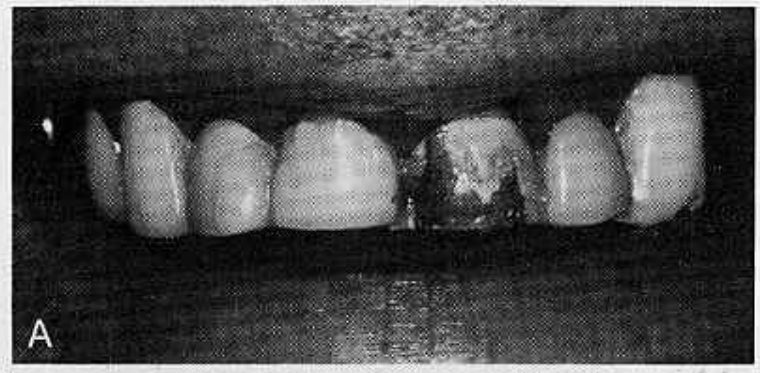

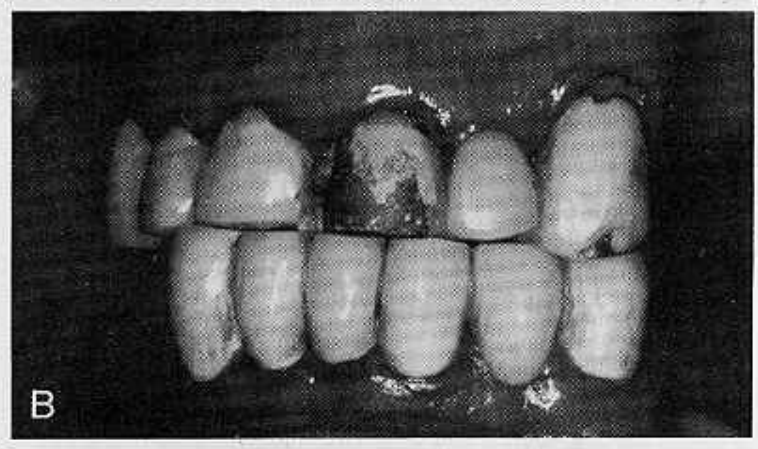

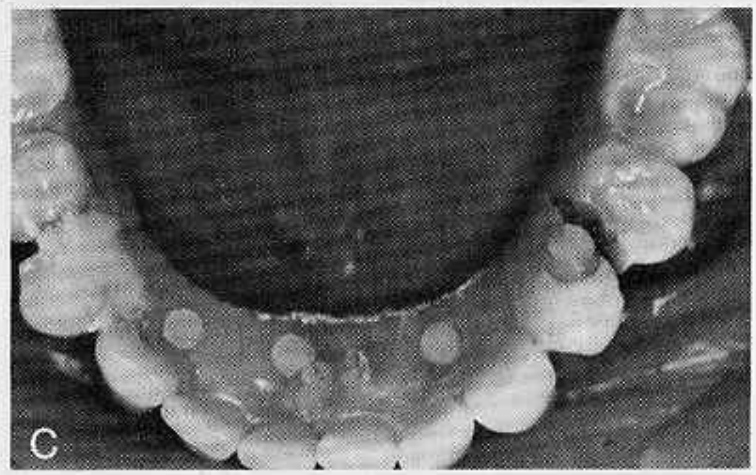

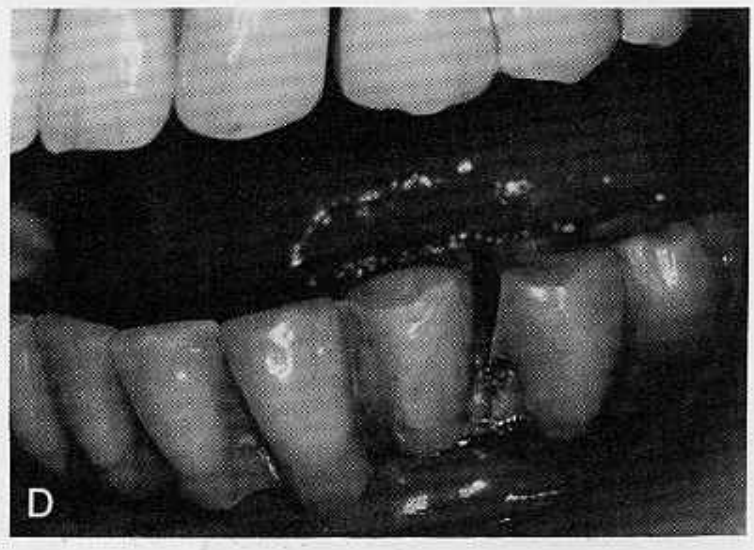

Figure 13. *A*, Preoperative smile; fractured porcelain and reverse incisal edge creates poor smile line esthetics. *B*, Edge-to-edge occlusion and severe bruxing led to fractured facial and cervical porcelain on the conventional anterior splint. *C*, Occlusal view of the mandibular TIP after 6 months of use shows the development of an occlusal crack line at the junction of the cantilever between teeth No. 20 and No. 21. *D*, Labial view of fractured mandibular and posterior cantilever. Note also the small diastema developing between the maxillary, canine and first bicuspid. The bicuspid, being part of a bone anchored bridge has no movement. The anterior component is supported by the natural dentition which was parafunctionally moved anteriorly 1 mm in the 6 months following delivery of the bone anchored bridges.

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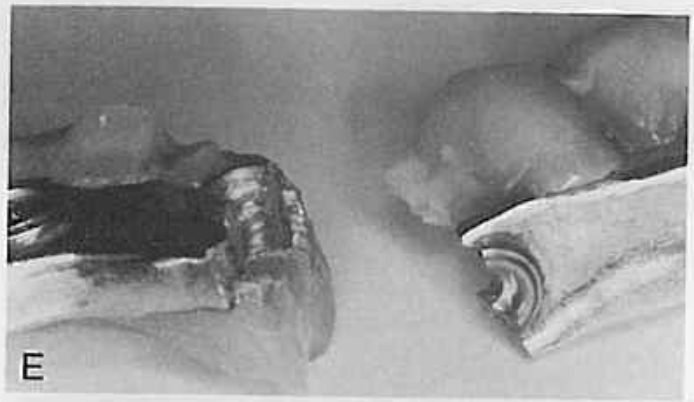

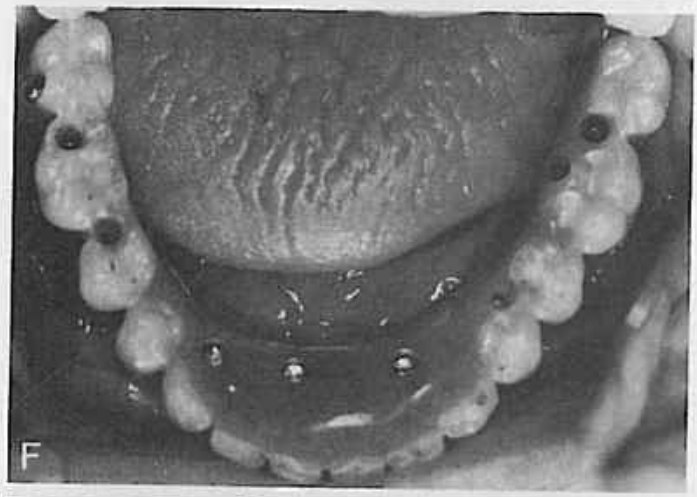

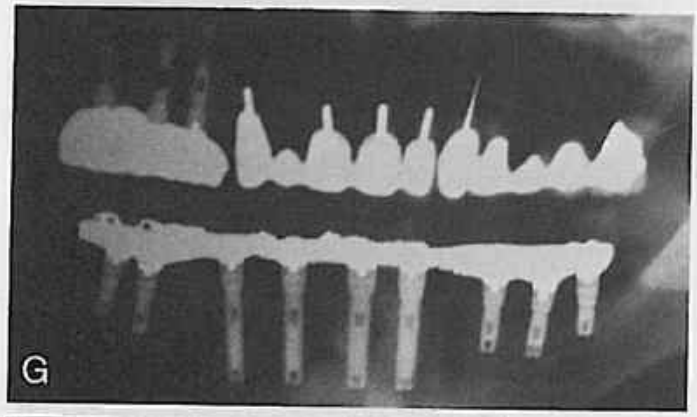

Figure 13 *Continued* Total fracture of the cantilever portion split the prefabricated gold cylinder, as well as the custom cast gold framework. *F*, Following the placement of posterior fixtures, a new TIP without cantilevers provided a stable resolution for this patient's severe bruxing and clenching patterns. *G*, Postoperative panradiograph shows the addition of five posterior fixtures eliminating the need for cantilevered pontics. *H*, Postoperative satisfaction.

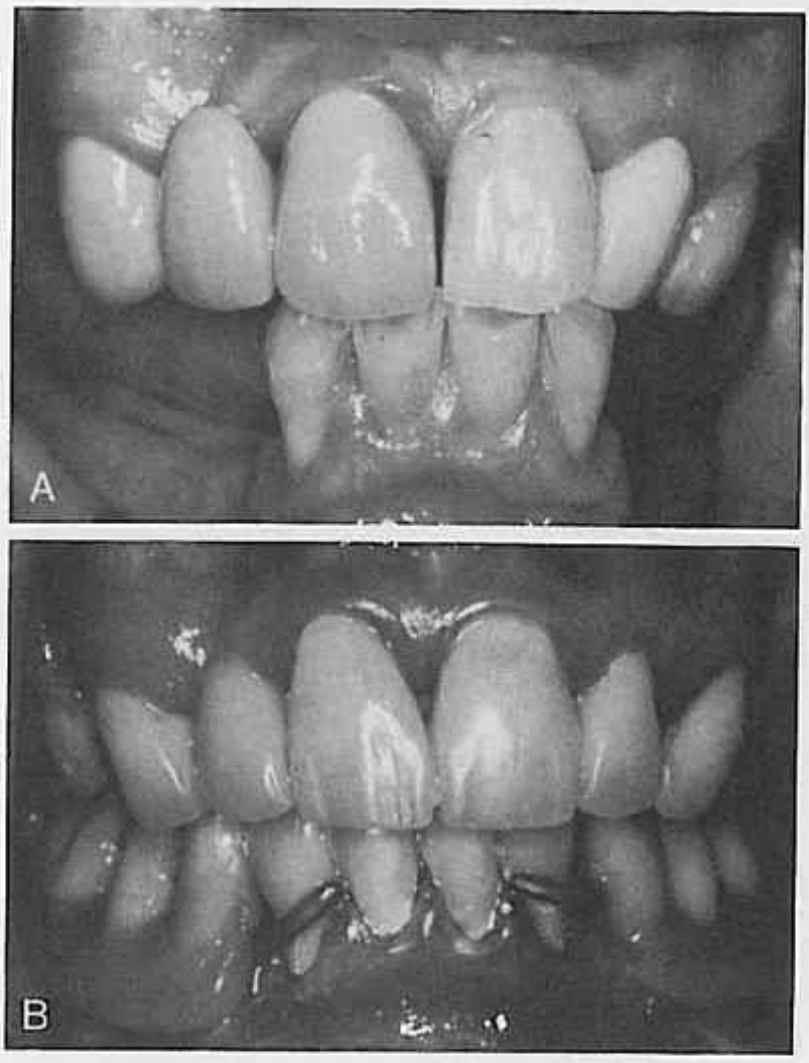

Figure 14. *A*, Preoperative mandibular incisors stand well above a severely atrophic posterior ridge. *B*, A provisional removable partial denture replaces the posterior dentition following hydroxylapatite ridge augmentation later mucosal inflammation and response to pressure prevent the patient from wearing a posterior removable partial denture in the areas of the hydroxylapatite ridge augmentation.

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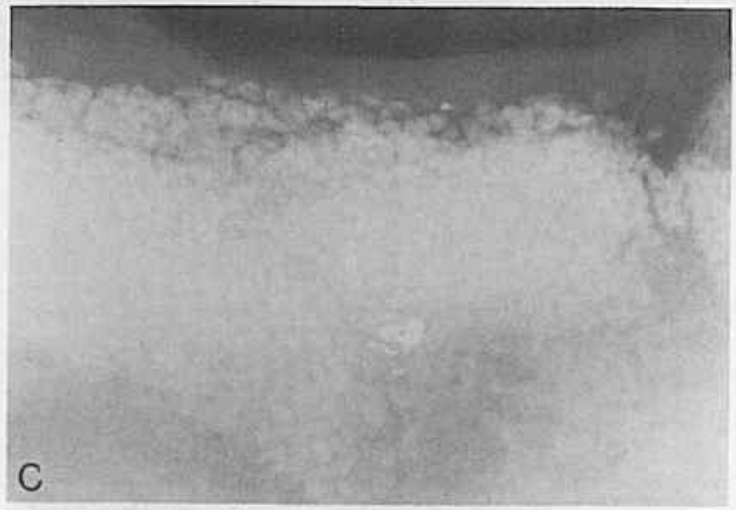
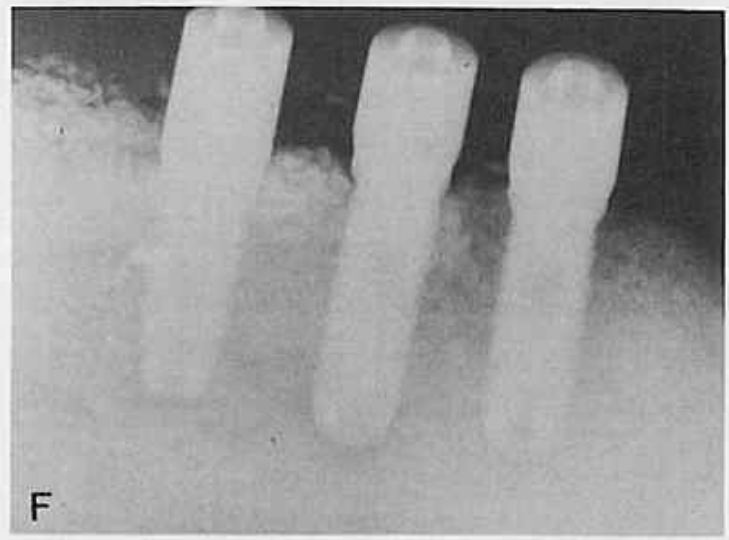
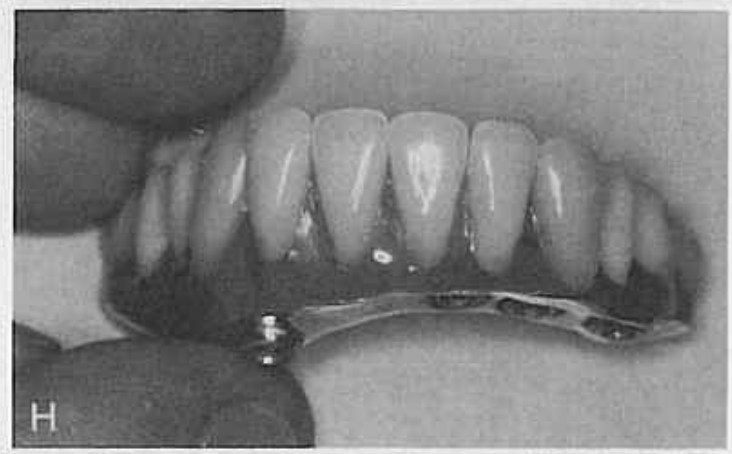


Figure 14 *Continued C* and *D*, Radiograph: hydroxylapatite particles in the edentulous areas. *E*, Removal of the mandibular anterior teeth followed by placement of Branemark titanium fixtures. Fixtures were placed through the hydroxylapatite on the patient's right side. On the left side, portions of the hydroxylapatite were removed at the time of fixture placement.





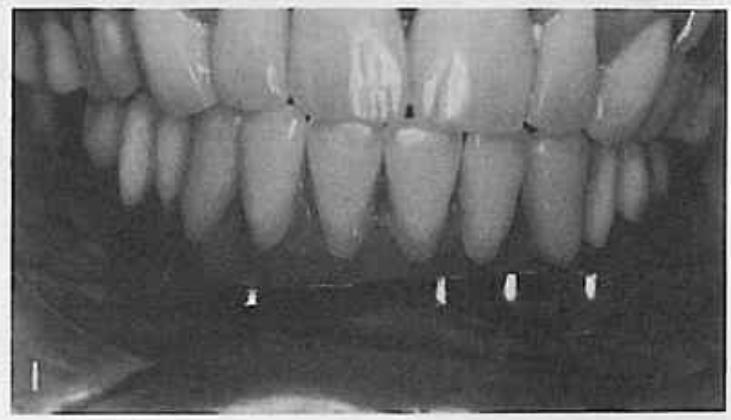


Figure 14 *Continued* *F*, Radiograph following abutment connection. Three fixtures placed through hydroxylapatite in the mandibular right side failed to osseointegrate. *G*, At the abutment connection left side, three fixtures placed where hydroxylapatite was removed are well osseointegrated. *H*, Following removal of additional hydroxylapatite on the right side, one additional fixure was placed. This fixture osseointegrated in 3 months and the TIP fabricated. *I*, The TIP supported by four Branemark fixtures in a patient with hydroxylapatite ridge augmentation complications.

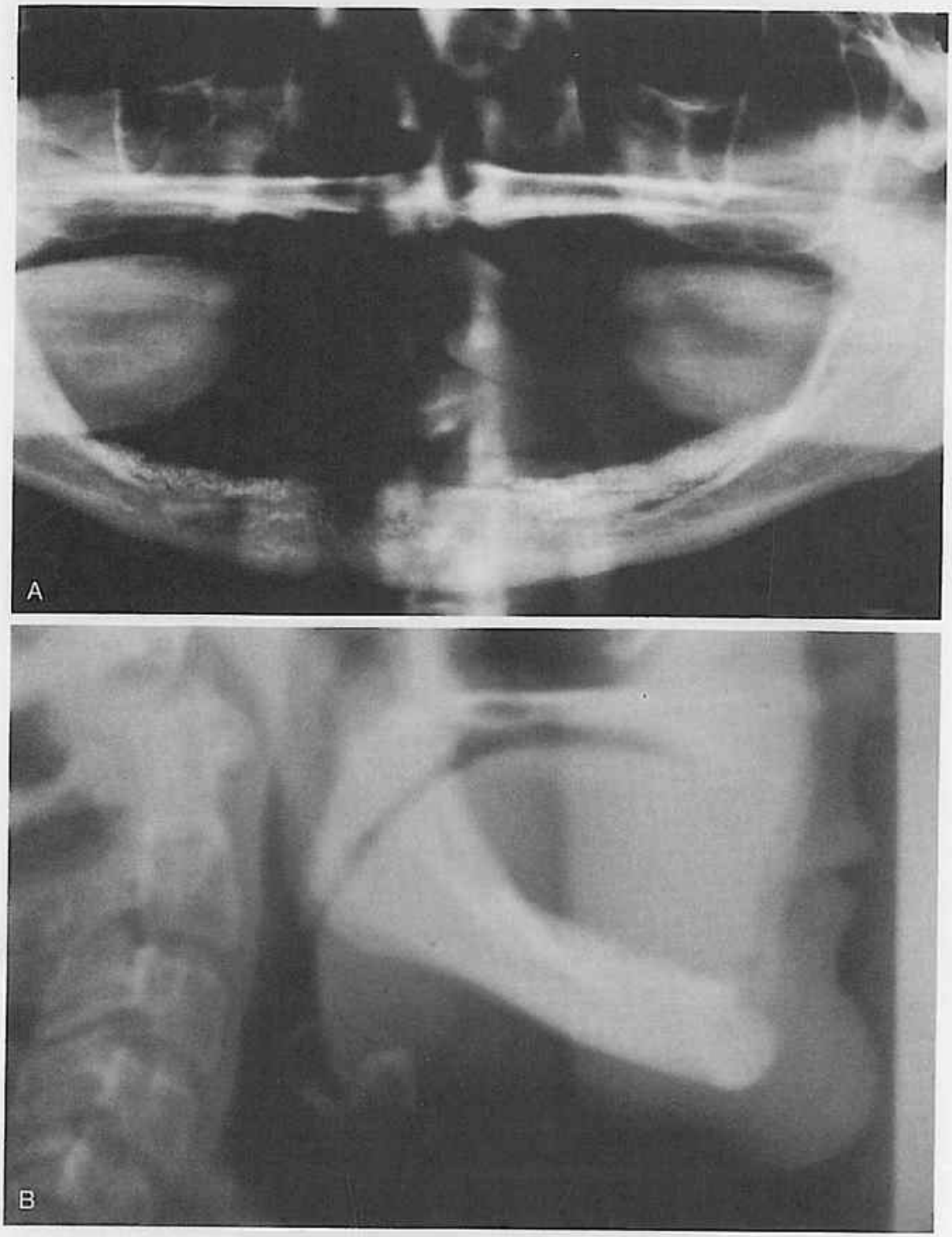


Figure 15. *A*, Preoperative panradiograph: mandibular hydroxylapatite ridge augmentation. Note the exposed mental foramen and inferior alveolar canal covered by hydroxylapatite. Denture pressure creating movement of the granules over the neurovascular structures produced excruciating painful response. *B*, Preoperative lateral cephalometric hydroxylapatite ridge augmentation 2 years postoperatively. Patient has had chronic pain and inability to tolerate the mandibular denture.

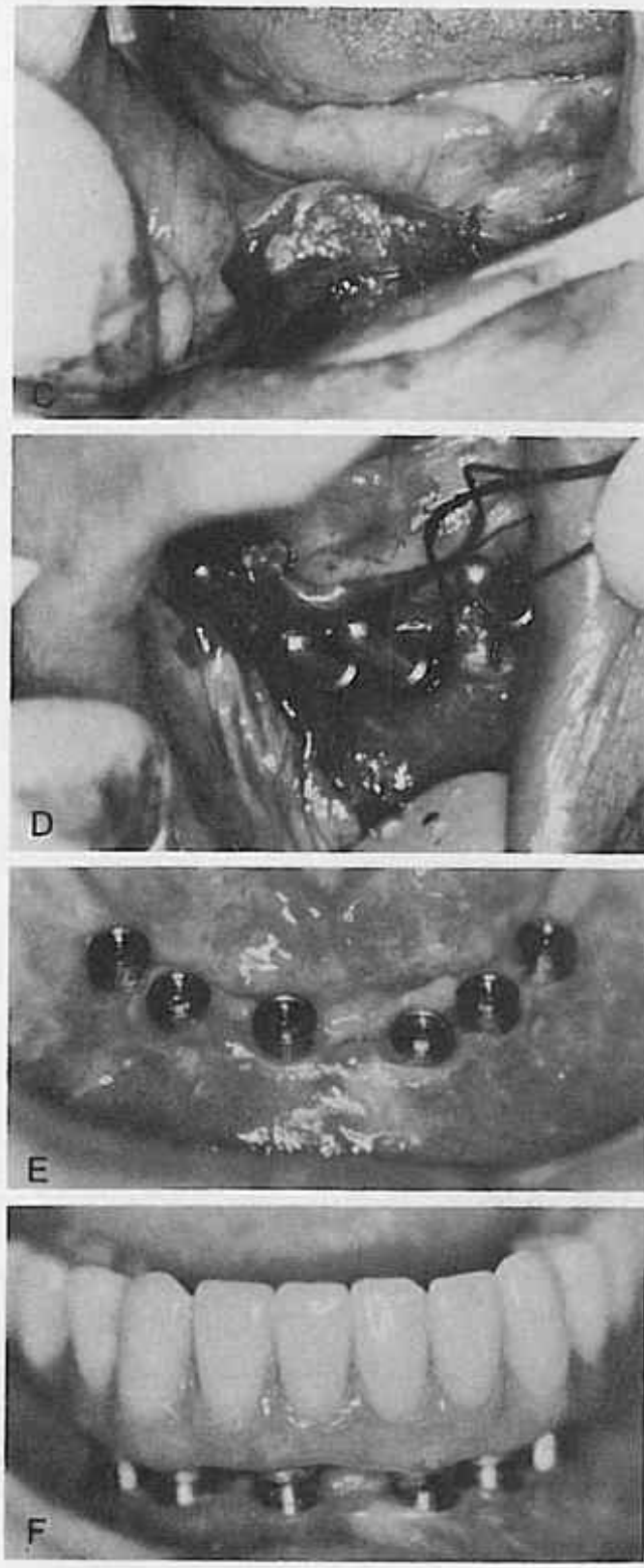


Figure 15 *Continued C*, Surgical removal of most hydroxylapatite particles from the fibrous connected tissue and periosteum. *D*, Following thorough cleansing of the mandibular bone, fixture installation sites area prepared. *E*, Five weeks postabutment installation shows well healed mucosal tissues in an area previously inflamed with underlying hydroxylapatite. *F*, Final tissue integrated prosthesis suspended above the mucosal tissues and the exposed mental foramen and inferior alveolar canal.

Previous Dental Implants

Implant beds may also be severely compromised by the previous placement of other endosseous or even subperiosteal implants.

In the case of failing endosseous implants, such as blade or blade-vent implants, complete removal of the soft-tissue encapsulation, the low differentiated scar tissue, the fibrous connective tissue, and associated granulation tissue permeated with inflammatory cells and suppurative material, is critical not only to immediate healing but the long-term condition of the healed residual bone. Depending on the dimensions of the osseous defect created by the removal of a failed endosseous implant, 4 to 12 months healing may be necessary prior to fixture installation in the same site (Fig. 16).

Following the removal of failing subperiosteal implants, recuperation time is required. This healing is primarily associated with superficial osseous cells, the associated periosteum, and mucosal tissues. Removal of excessive granulation tissue, suppurative material, and complete mucosal closure and healing should be accomplished 4 to 6 weeks prior to fixture installation (Fig. 17). When subperiosteal implants are removed, an added complication of heavy scarring and altered muscle attachments make both surgical procedures and prosthetic reconstructions more difficult.

In selected circumstances, placement of Branemark fixtures in areas of healthy bone adjacent to failing endosseous implants can be successfully accomplished, if the failing implants are required to temporarily maintain esthetics and limited function while osseointegration of the non-loaded fixtures occurs (Fig. 18). A minimal distance of 2 mm from any area of radiolucency identified in conjunction with a failing endosseous implant must be maintained to obtain predictable osseointegration results. Constant patient observation and often antibiotic therapy may be required to maintain a controlled and checked condition of an inflammatory response in areas of recent surgery (Fig. 19).

Inferior Alveolar Neurovascular Bundle

Anatomic structures may also compromise the potential for a successful TIP. The posterior mandible in particular presents a significant challenge when severe atrophy leaves little, if any, bone superior to the inferior alveolar canal. The solution to limited space for posterior mandible fixture placement includes detailed initial treatment planning and careful surgery to unroof the canal and move the neurovascular bundle prior to fixture installation.

The risk of paresthesia always accompanies mandibular posterior fixture placement or treatment associated with the neurovascular bundle. Fixtures placed near the inferior alveolar canal may traumatize the area sufficiently to create a transient or long-lasting paresthesia (Fig. 20). The use of CT scans with reformatted images, such as those provided by the Dentascan software, may be helpful in identifying the position of the mandibular canal or other anatomic landmarks restricting fixture placement.

Loads, Fixture Angulation, and Available Bone

The severely atrophic and highly resorbed residual maxillary ridge presents many challenging problems when TIP treatment is considered.

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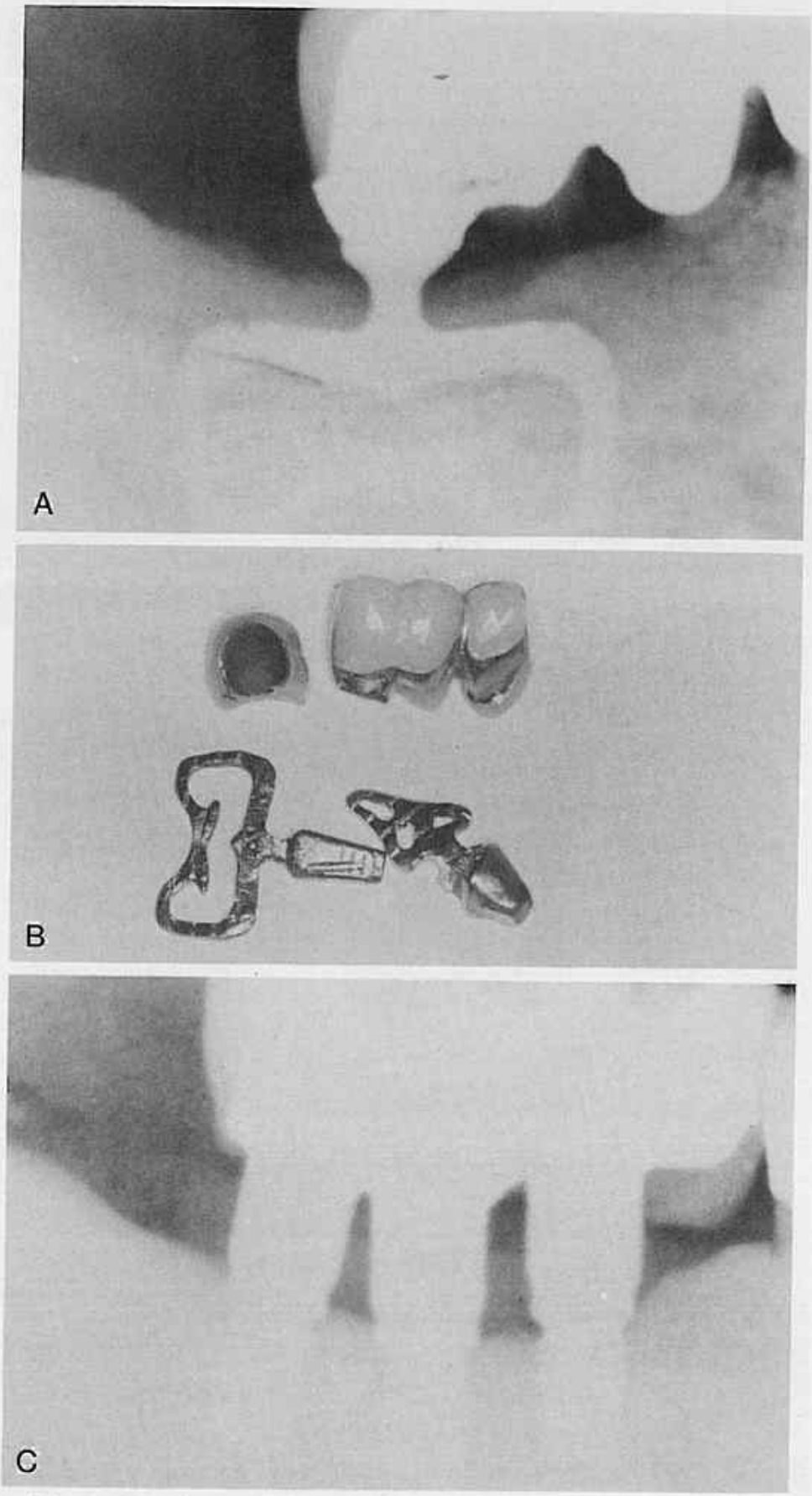


Figure 16. *A*, Panradiograph: Note failing maxillary and mandibular posterior blade implants. *B*, Blade implants and encapsulating soft tissue removed to permit osseous healing in preparation for future osseointegration. Cantilevered pontics are also removed. *C*, Sectional TIP supported by three Branemark fixtures replaces failed blade implant bridge.

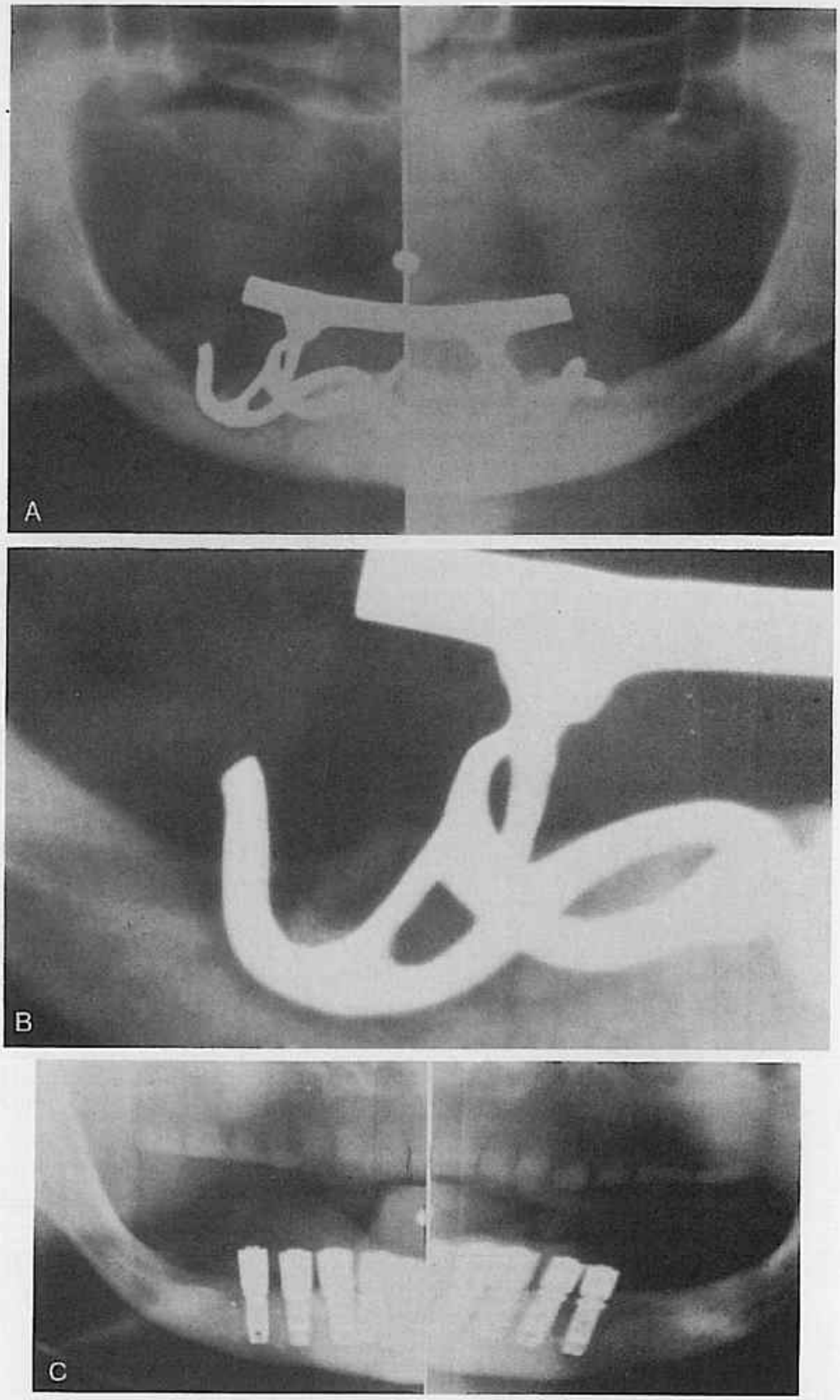


Figure 17. *A*, Panradiograph: Failing mandibular subperiosteal implant. *B*, Radiographic close up of right posterior shows advanced bone loss associated with the failing subperiosteal implant. *C*, Panradiograph showing six Branemark fixtures replacing the subperiosteal implant. Implants placed 6 weeks following the removal of the subperiosteal implant.

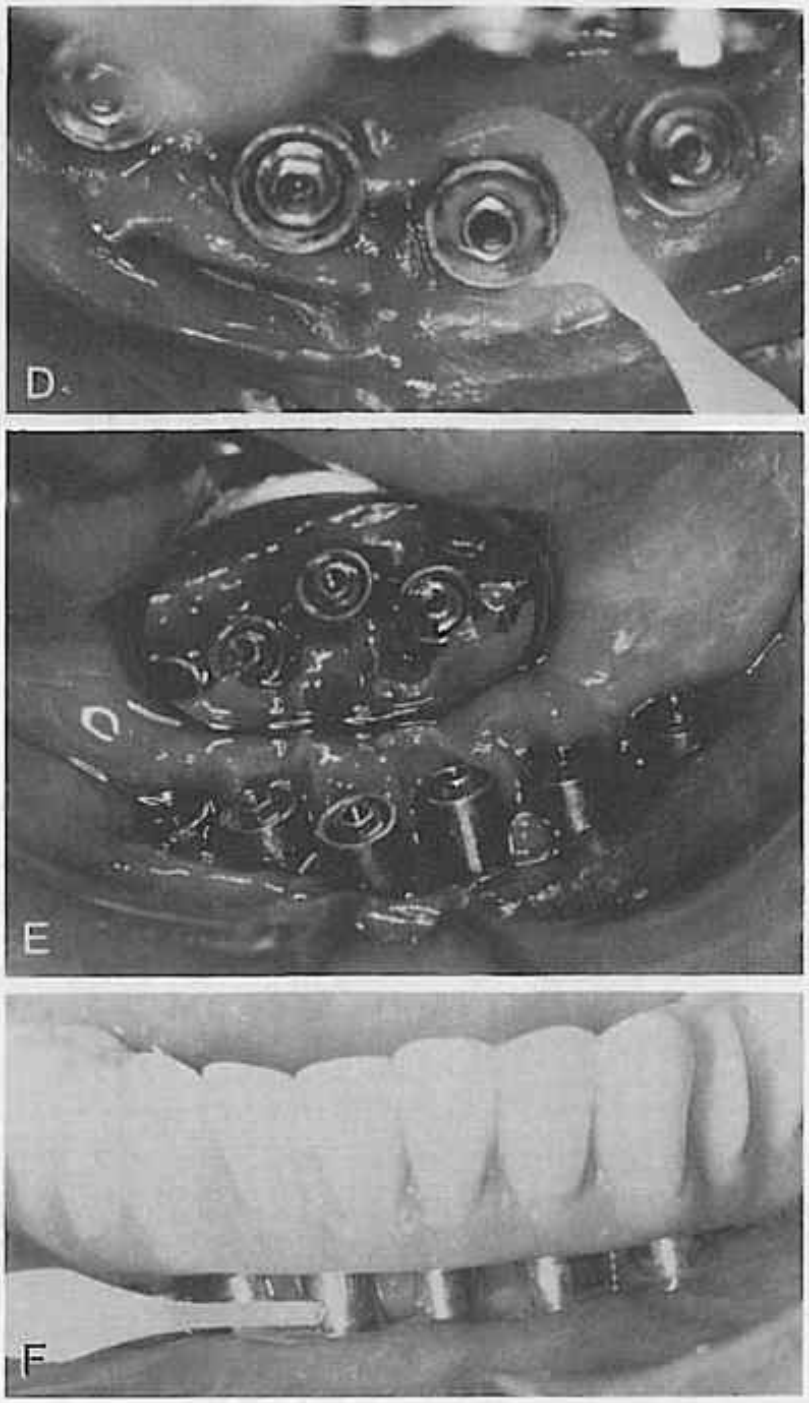


Figure 17 *Continued D*, Titanium abutments retained the lingual musculature. Floor of the mouth muscles tend to evulse anteriorly in extreme cases of mandibular anterior ridge atrophy. *E*, The impinging lingual musculature complicates conventional oral hygiene. Use of the Balshi Abutment Scaler with its circumferential cleansing ability permits easy access to the lingual surfaces of the abutment connectors. *F*, The final tissue integrated prosthesis 2 years postoperatively shows continued excellent mucosal health with frequent use of the abutment scaler.

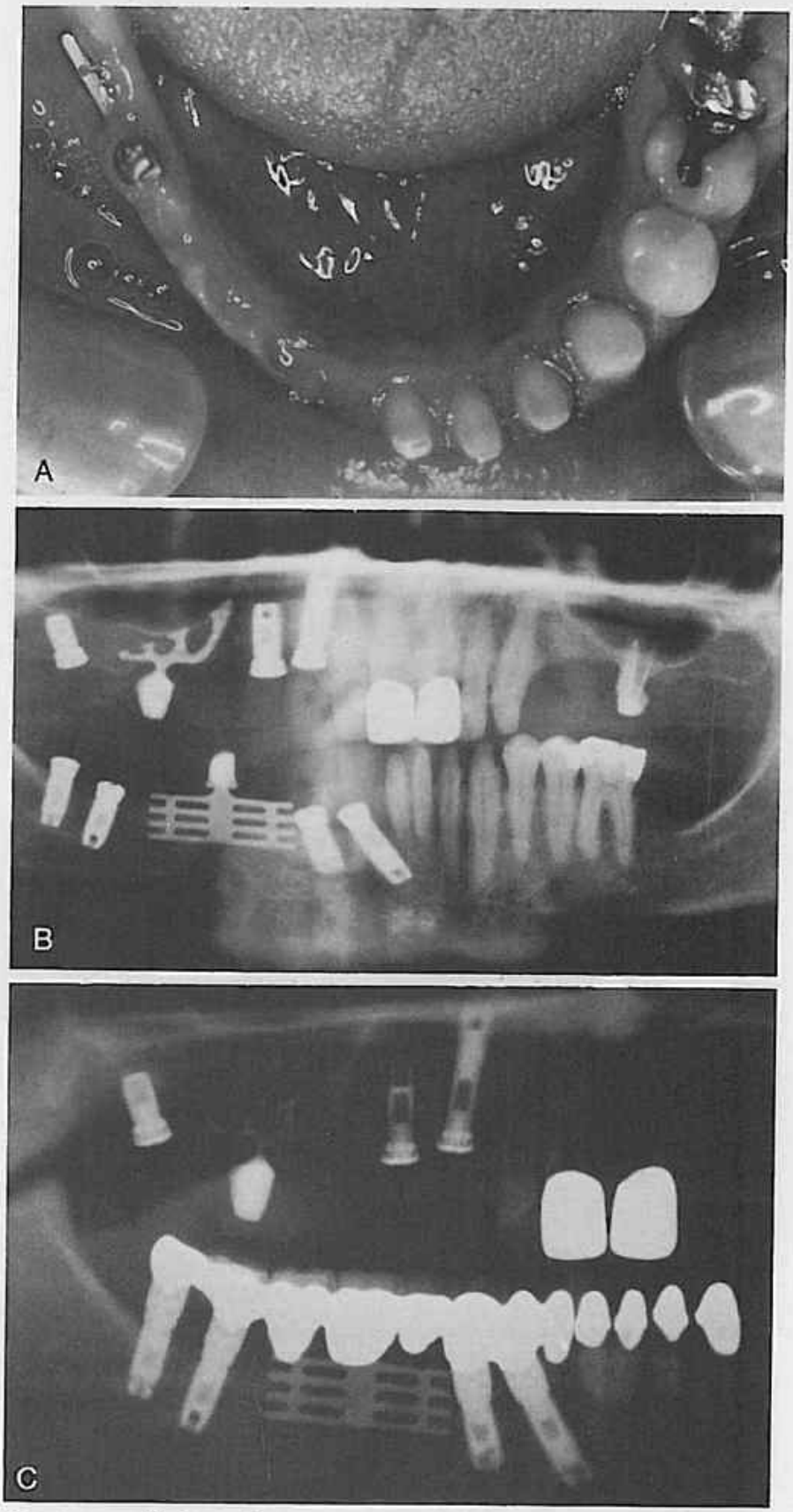


Figure 18. *A*, Mandibular right posterior with failing endosseous blade implant. Note the implant shoulder protruding through the mucosal tissues distal to the head of the implant. *B*, Branemark fixtures have been placed anterior and posterior to both maxillary and mandibular failing implants. Blade implants are allowed to remain in place to temporarily support provisional restorations and maintain esthetics during the osseointegration healing. *C*, Mandibular final tissue integrated prosthesis is fabricated prior to the removal of the blade implant, permitting the patient to continuously wear a fixed prosthesis throughout treatment.

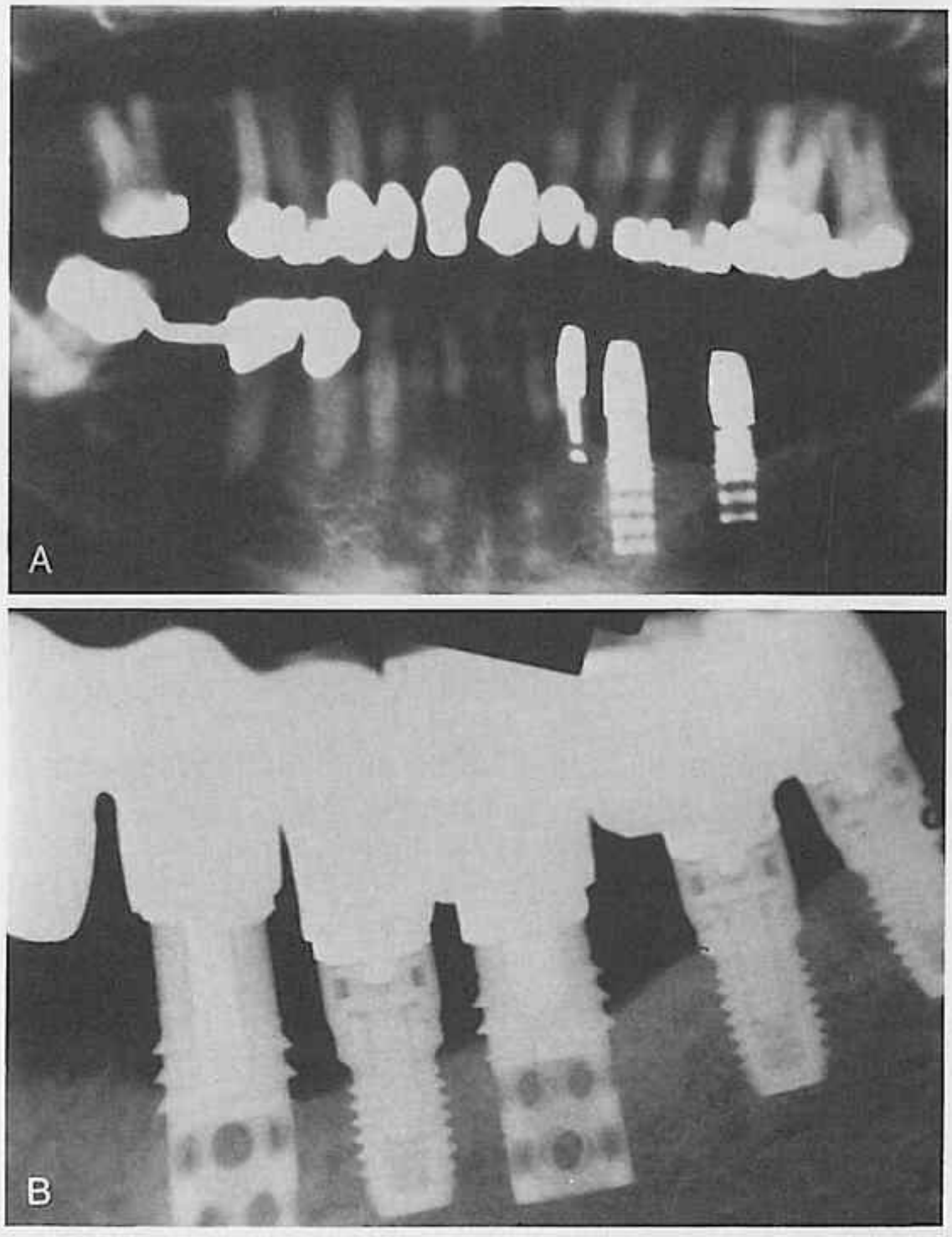


Figure 19. *A*, Rapid advanced bone loss suppuration is found around the failing hollow basket endosseous implants. *B*, Branemark implants are osseointegrated between the failing hollow baskets implants to support a tissue integrated prosthesis. The hollow basket implants will require removal in the near future in an effort to prevent further bone loss.

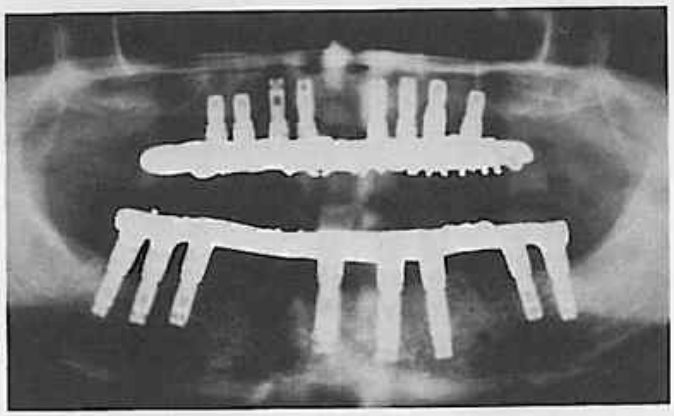


Figure 20. Carefully placed mandibular posterior fixtures rest on the superior cortical plate of the inferior alveolar canal establishing excellent osseointegration while avoiding the consequences of nerve damage.

The long-axis angulation of fixtures must take advantage of all available bone, even if the angulation is less than desirable for the prosthodontist. If fixtures are placed straight vertically there is a possibility of the apex perforating the labial plate of the maxilla or leaving only a very thin labial wall of bone on the facial aspect.

The mechanical principle of tripod stabilization should be used when selecting fixture placement sites in both jaws.[31] A straight line of fixtures provides little potential for reciprocating forces between fixtures[29] and may lead to *osseodeintegration*.

Deintegration occurs when excessive loading forces are applied to the titanium–bone interface. This condition is compounded by the degree of facial cantilevering required for appropriate facial tissue support. Although fixtures may be osseointegrated at the time of the abutment connection and subsequently support a TIP, it is only after months of excessive loading pressures that deintegration is observed (Fig. 21).

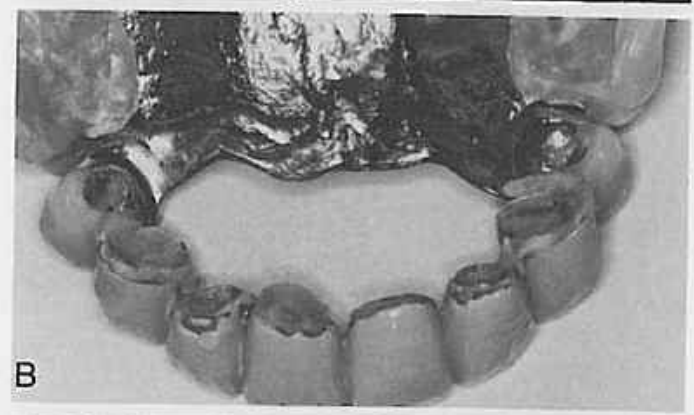
Other factors that also play an important role include the quality of bone and healing potential for patients who may have borderline systematic conditions such as blood dyscrasia, advanced osteoporosis, or who suffer from chronic alcoholism or drug abuse.

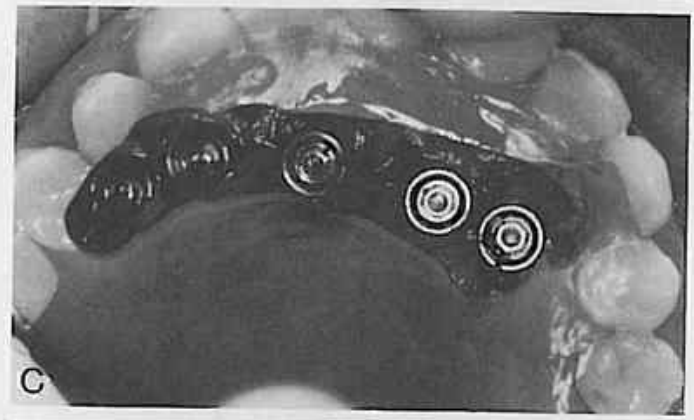
Postradiation

Patients previously treated for malignancies associated with the facial skeleton, especially in the area of anticipated fixture installation, should be obsered for 12 months following the last radiation treatment prior to fixture placement. Use of hyperbaric oxygen may also be considered following radiation therapy in conjunction with fixture placement.

Periodontally Compromised Teeth

When osseointegration is intended to supplement or totally replace periodontally compromised teeth while maintaining abutment support during the osseointegration process, several factors should be considered. Those reconstructions designed to maintain periodontally compromised teeth within the confines of the tissue integrated prosthesis (class II modification of the Branemark method)[5] must include in the design, complete irretrievability of the prosthesis and potential for modification should the natural dentition be lost. The use of interlocking attachments,





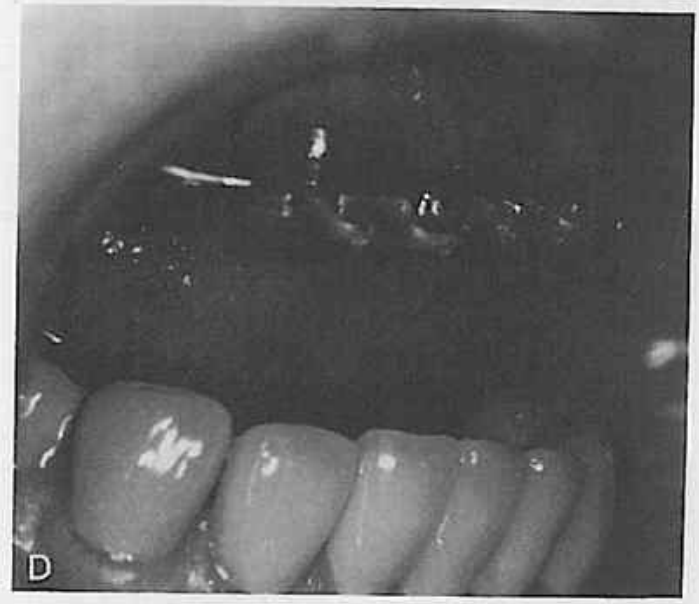


Figure 21. *A*, Four remaining maxillary anterior abutment teeth are periodontally hopeless. *B*, Pretreatment failing prosthesis consists of a maxillary anterior fixed bridge that has inadequate retention to withstand the torquing forces of the removable partial denture. *C*, A 6-month healing period followed the installation of five fixtures in the maxillary anterior residual ridge. *D*, Casting try-in shows the extended anterior cantilever required to provide lip support.

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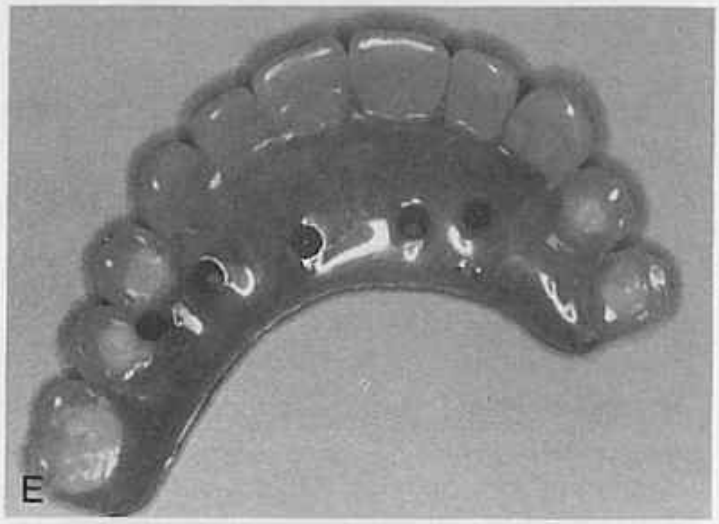

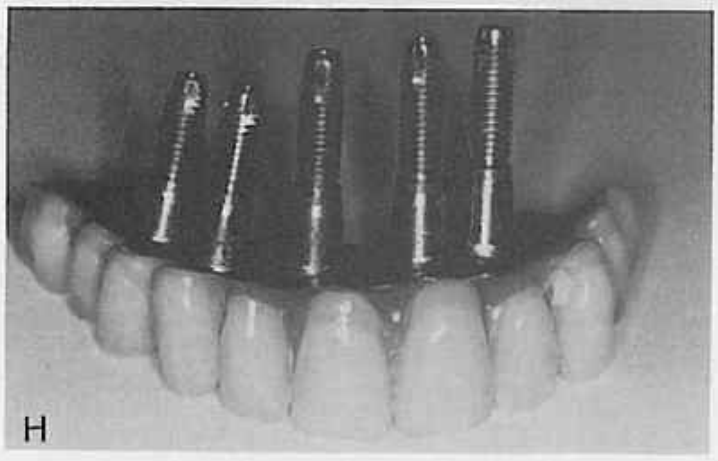

Figure 21 *Continued E*, Final tissue integrated prosthesis has minimal posterior cantilevering. Note the straight line of the fixture position from right to left. *F*, Fourteen months following fixture installation. All five fixtures deintegrated. *G* and *H*, Relative parallelism, the straight line and the horizontal angulation may have played a role in the biomechanical failure of this TIP.

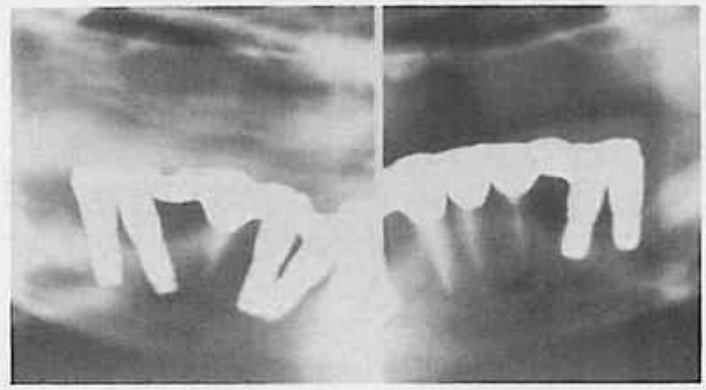

Figure 22. Complete arch TIP retaining four periodontally mobile teeth. Telescopic copings on the natural dentition permit complete retrievability of the TIP.

as well as telescopic copings, play an important role in this prosthetic design (Figs. 22 and 23).

For patients undergoing the class III modification of the Branemark method,[5] as described previously, the maintenance of previously diagnosed periodontally hopeless teeth to support a provisional fixed prosthesis can lead to treatment complications. While the patient undergoes the first stage surgery and the subsequent healing, frequent periodontal maintenance is required. Presurgical planning must carefully outline the position and long access angulation of the fixtures to be installed. Fixtures should be installed no closer than 2 mm to the closest periodontally compromised root. Following second-stage surgery and fabrication of the conversion prosthesis,[10] the remaining periodontally hopeless teeth are removed, permitting the completion of the final reconstruction to be totally supported by the osseointegrated titanium fixtures (Fig. 24). Complications in this treatment method are both biologic and mechanical. The biologic problems include potential periodontal infection, swelling, and pain associated with the hopeless teeth. Antibiotic therapy and even surgical drainage may be required to maintain a hopeless tooth in function as an abutment until osseointegration of the fixtures occurs.

A mechanical complication associated with periodontally mobile teeth is the fracture of the provisional fixed prosthesis caused by torquing forces of the moving abutment teeth. Wire reinforcement and repair generally solve this problem and permit the patient to continue using a fixed provisional prosthesis during the healing period.

Chronic Pain Following Tissue Integrated Prosthesis: A Difficult Diagnostic Complication.

Recently, several patients have been referred to our center with chronic pain following the placement of a prosthetic rehabilitation supported by osseointegrated Branemark fixtures. On review of their recent dental histories, the patients described the initiation of pain or moderate discomfort immediately following delivery of the final prosthesis. Initial clinical and radiographic examination was negative. In each instance, however, additional clinical evaluation consisted of removal of the TIP and the discovery of either one of the two following conditions: slight looseness of an abutment connector (Fig. 25) or microscopic discrepancy in the accuracy of the fit of

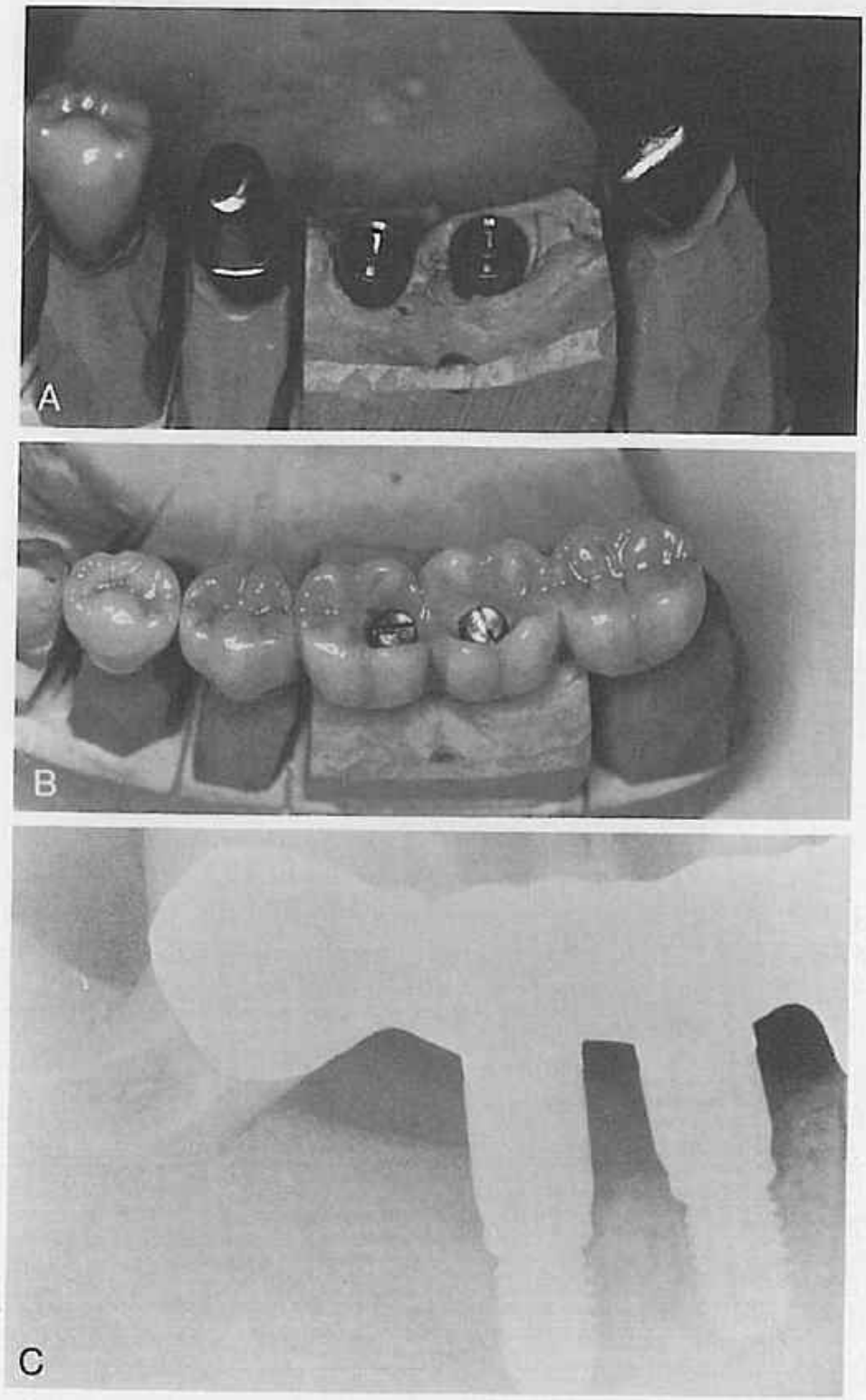

Figure 23. *A*, Partially edentulous TIP periodontally compromised and mobile molar and second bicuspid restore the natural dentition with telescopic copings. *B*, Four unit porcelain fused to gold TIP is securely fastened with prosthetic gold screws maintaining its retrievability. *C*, Postoperative radiograph illustrates the type II modification of the Branemark method for stabilizing periodontally compromised teeth in a partially edentulous patient.

the cast substructure framework determined by extraoral analysis of a new master cast (Fig. 26). The immediate solution to both complications include removal of all tissue between the fixture and loose abutment, tightening of all abutment connectors, followed by a new master impression and fabrication of a totally new TIP framework.

As Benjamin Franklin once observed, "An ounce of prevention is worth a pound of cure." Preventive treatment for this condition would include an assessment of the abutment connector–fixture relationship prior to the master impression. In addition, exceptionally accurate impression methods followed by exact duplication of the clinical relationships on the master cast are essential to framework fabrication. Meticulous inspection and analysis of the casting fit is imperative before delivery of the final TIP.

MECHANICAL COMPLICATIONS

Prosthetic Screw Fractures

Mechanical complications primarily relate to failure of prosthodontic materials to resist forces and stresses of oral function. Most often these failures appear as fractures of the screw joint system or the castings. When fractures are related to the prosthetic materials, such as the casting, the

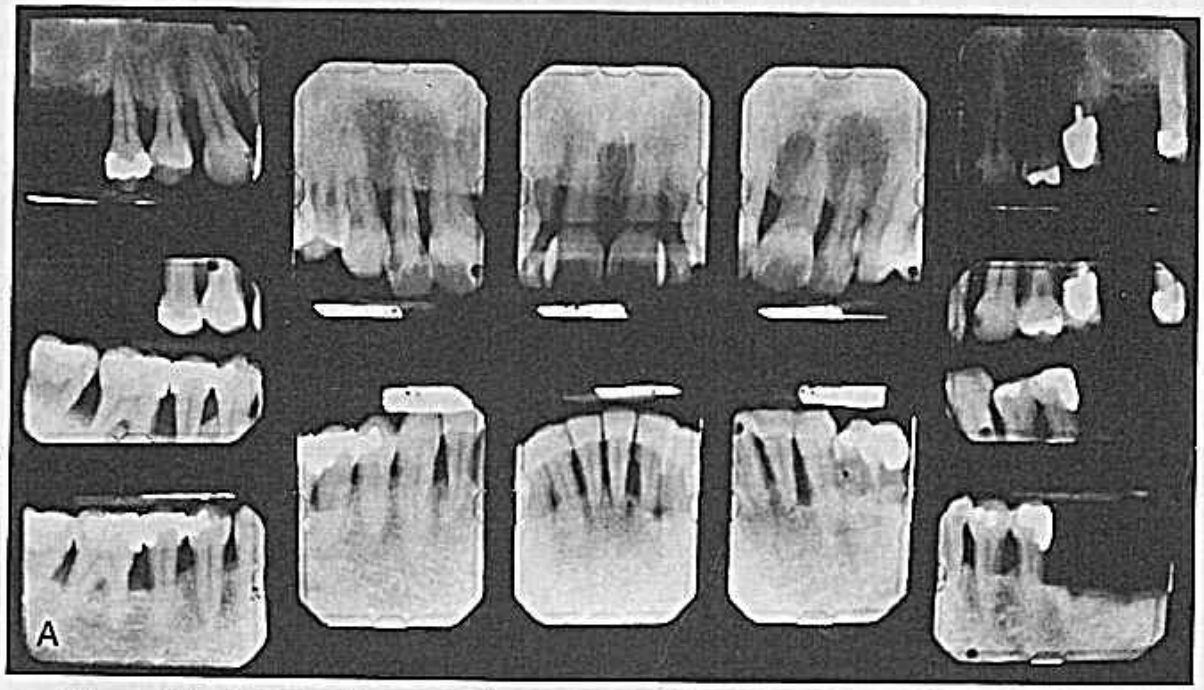

Figure 24. Radiographs. A, Advanced periodontal disease in both the maxilla and mandible.

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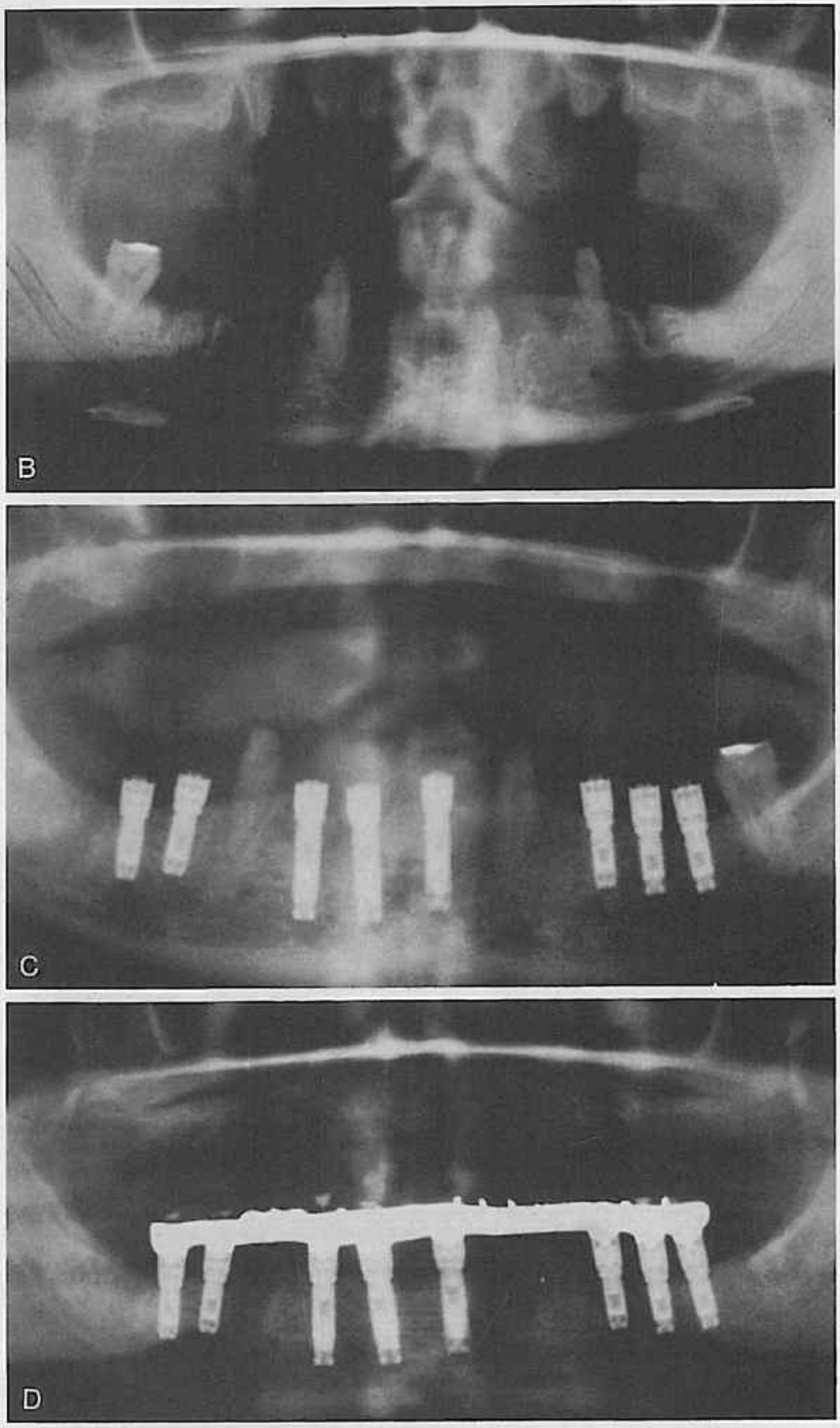


Figure 24 *Continued B,* Removal of the majority of periodontally hopeless teeth followed by a fixed provisional restoration in the mandible arch. *C,* Following appropriate socket healing of fixtures, Branemark fixtures are installed between the periodontally hopeless teeth. *D,* After osseointegration and fabrication of the final prosthesis, the remaining periodontally hopeless teeth are removed. The entire treatment process permits the patient to maintain dentate function in the mandibular arch without the use of a removable prosthesis.

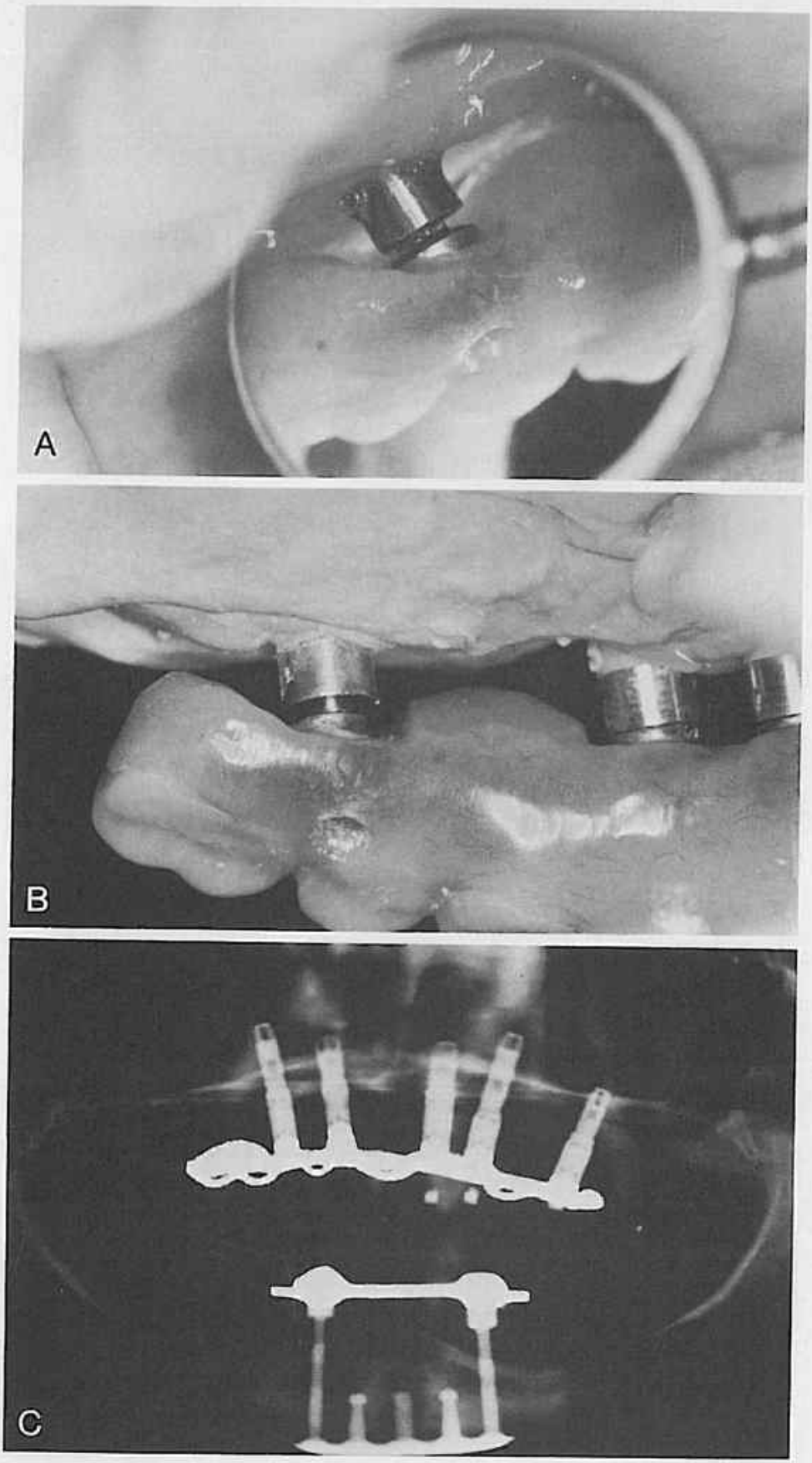


Figure 25. *A*, Following the repositioning and tightening of the titanium abutment connector, the pain disappeared; however, the prosthesis no longer fit. *B*, A new master cast also illustrated the space discrepancy between the prosthesis and the distal abutment connector. *C*, Panradiograph following the fabrication of a new maxillary TIP casting.

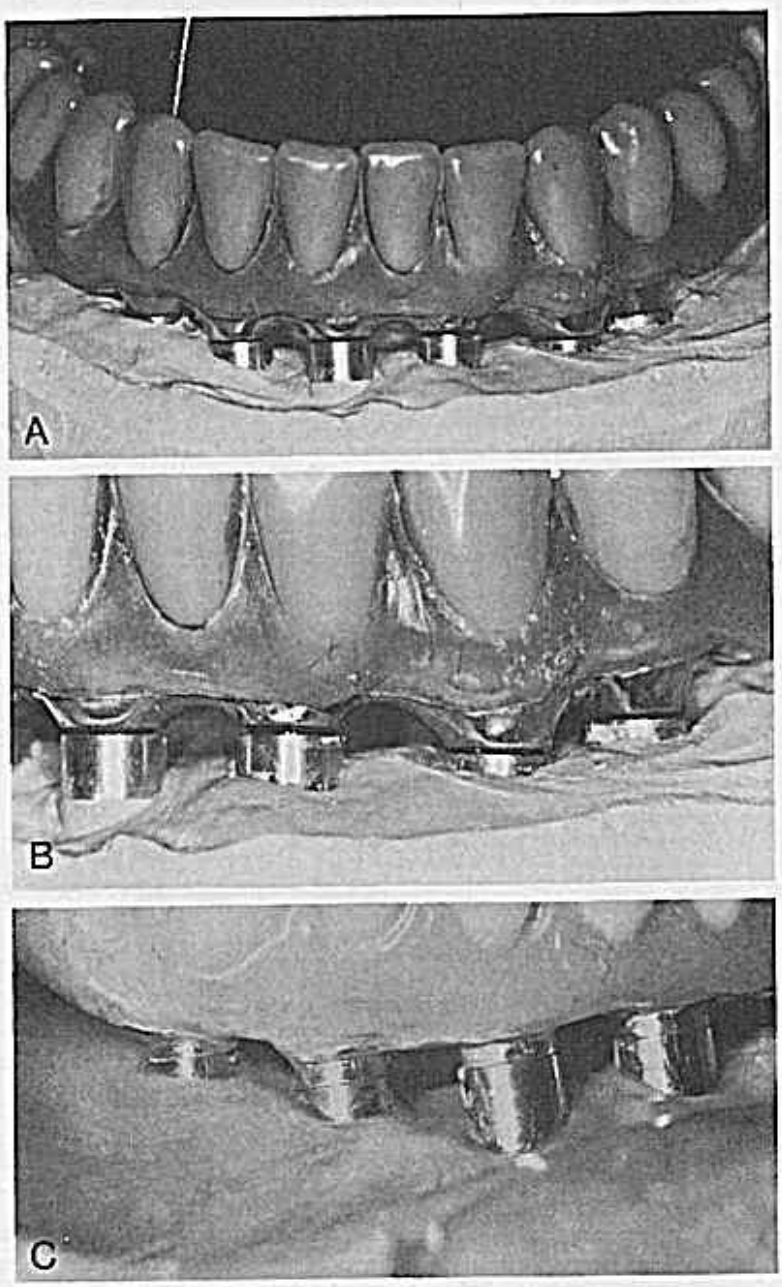


Figure 26. *A*, Following 6 months of chronic discomfort, this 70-year-old patient presented for evaluation. A new master cast was fabricated and the existing tissue integrated prosthesis closely inspected by tightening only one screw (right posterior) into position. *B*, On tightening a single screw, open discrepancies are readily identified between the prosthesis casting and the abutment replicas. *C*, Following the fabrication of a new tissue integrated prosthesis, the chronic pain was eliminated.

solution to this problem is the use of an additional thickness of the metal casting or the change of the prosthesis design. When fractures occur in the screw joint component system, there is a strong indication of either a discrepancy in the occlusion scheme or, more likely, a discrepancy in the accuracy of fit of the framework (see Figs. 25 and 26).

The prosthetic gold screws of the Branemark system have been designed as the fail-safe mechanism, fracturing when excessive loading forces are applied rather than permitting undue stresses to be transmitted to the osseointegrated fixtures and surrounding bone. Fractures can be anticipated when exceptional buccal cantilevering is required for a unilateral partially edentulous tissue integrated prosthesis (Fig. 27). The solution to this complication may require additional fixtures and a new prosthesis.

Bent or Fractured Abutment Screws

The bending or complete fracture of abutment screws has been noted in patients who have been successfully using a TIP with posterior cantilevers. The example illustrated in Figure 28 shows clearly the severe bending and fracture of the abutment screws after the patient had successfully worn the prosthesis for 3½ years. A significant change in the occlusal scheme of the opposing denture was identified as the etiologic factor in this mandibular TIP complication. Resolution of this problem occurred when the occlusal scheme correctly loaded the TIP. Another examination 1 week after the delivery of a TIP, revealed that all four abutment screws were loose and severely bent. Abutment set replacement allowed further diagnosis of significant occlusal disharmonies. The solution to this complication required construction of a new prosthesis (Fig. 29).

Fixture Fracture

Fixture fracture should be the least frequently occurring component failure. An example of this complication is observed in a patient with two osseointegrated maxillary anterior fixtures supporting a removable overdenture for a 2-year period. Change in the patient's level of stress induced a nocturnal bruxing pattern without the overdenture in place. Direct loading of the two-unit fixture-supported splint eventually loosened one of the prosthetic gold screws. Fracture of the adjacent fixture was easily identified when the patient presented with discomfort and inflammation in the area immediately adjacent to the fixture fracture.

The resolution of this problem required precise repreparation of the remaining portion of the titanium fixture to stimulate the smooth surface of the original fixture face. Retapping the internal abutment screw thread and reinstallation of an appropriate length abutment connector returned the remaining portion of this osseointegrated fixture to useful service (Fig. 30).

SEVERE PARAFUNCTIONAL FORCES

A pretreatment diagnosis of severe bruxing or clenching may require the placement of additional fixtures. The mechanical design of a TIP for

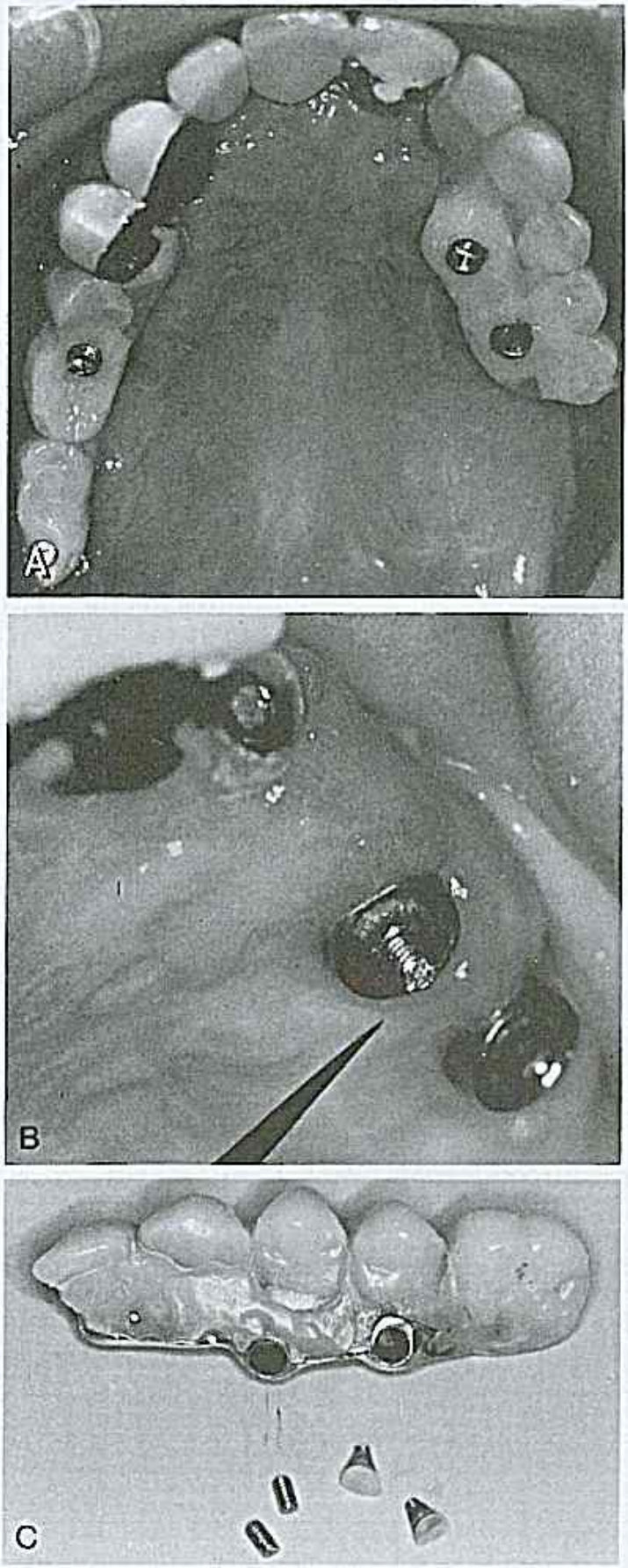
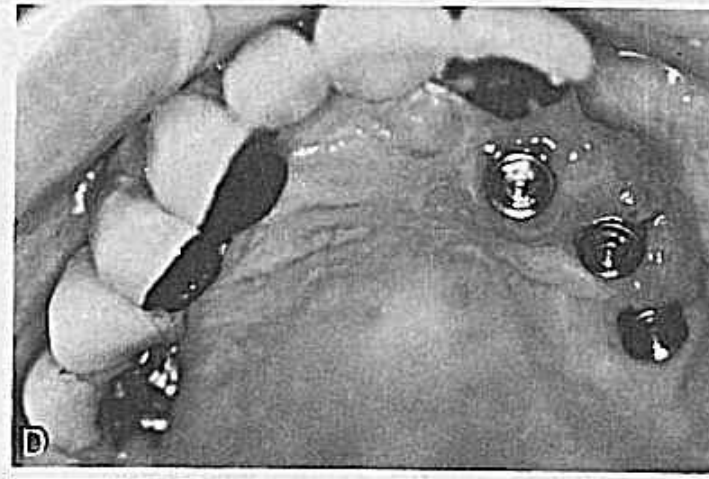
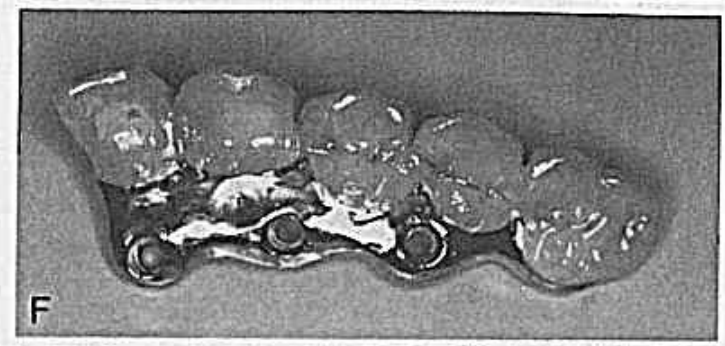


Figure 27. *A*, Maxillary left tissue integrated prosthesis with extensive buccal cantilever also provides a canine guided occlusion. *B*, Chronic fractures of the gold prosthetic screws were frequent enough to become annoying for both patient and prosthodontist. *C*, Fractured tapered gold screws and the traditional acrylic veneered TIP.





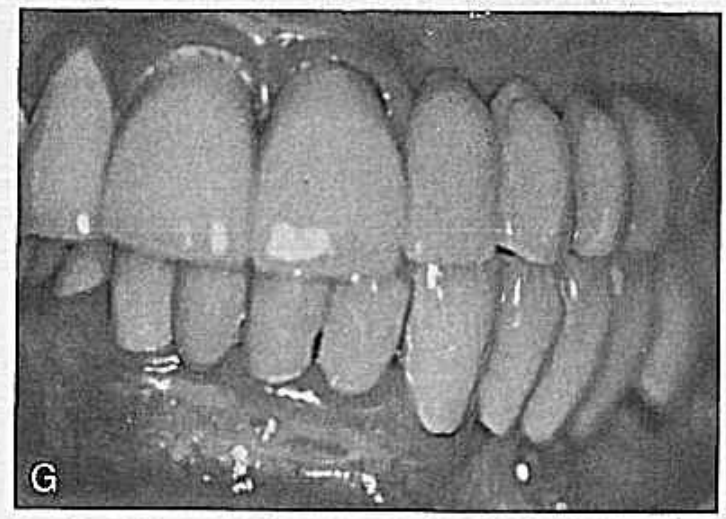
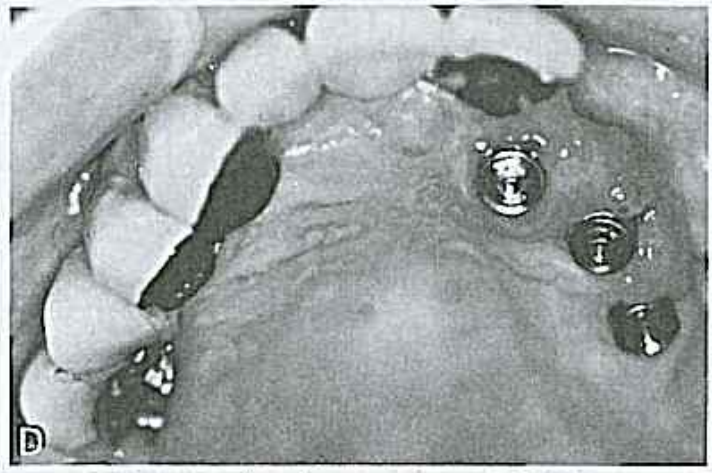
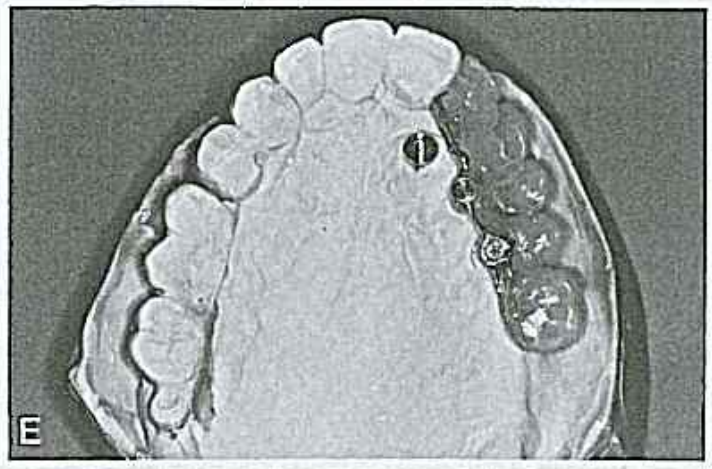
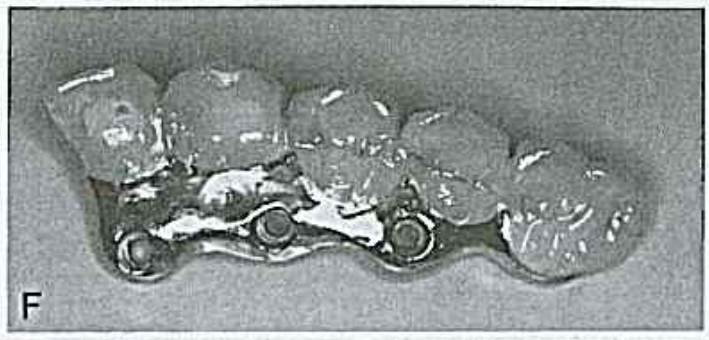


Figure 27 *Continued D*, Solution: removal of the lateral incisor root and installation of a third fixture. *E*, The third fixture lingual to the left lateral incisor changes the load distribution to the maxillary bone. *F*, The final TIP replacement now consists of porcelain fused to gold supported by three osseointegrated fixtures. *G*, Esthetic facial appearance of the maxillary left posterior has remained in function for 2 years without additional gold screw fractures.







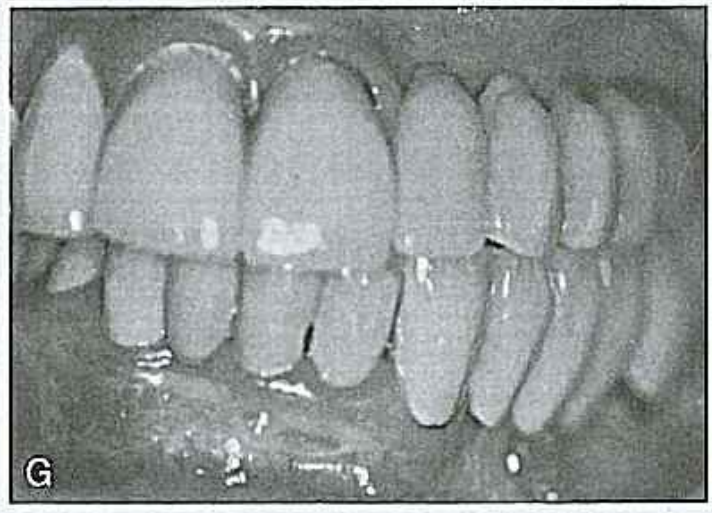


Figure 27 *Continued D*, Solution: removal of the lateral incisor root and installation of a third fixture. *E*, The third fixture lingual to the left lateral incisor changes the load distribution to the maxillary bone. *F*, The final TIP replacement now consists of porcelain fused to gold supported by three osseointegrated fixtures. *G*, Esthetic facial appearance of the maxillary left posterior has remained in function for 2 years without additional gold screw fractures.

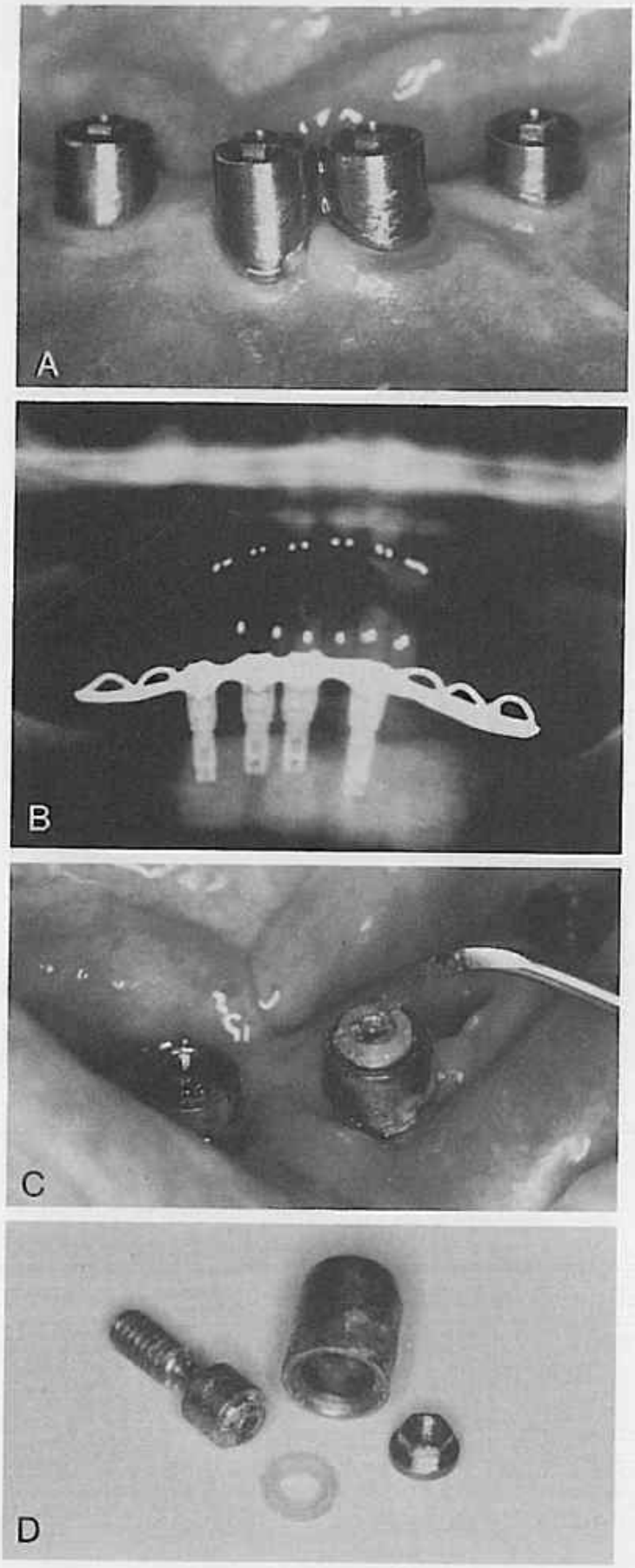


Figure 28. *A*, Four osseointegrated fixtures after 3½ years of function with fixed tissue integrated prosthesis. *B*, Panradiograph 3½ years following delivery of the TIP successful function. *C*, Change in the opposing occlusion (via new denture) created stress, fracturing the hexnut portion of the titanium abutment screw. *D*, The abutment connector set with the fractured hexnut portion and dislodgement of the o-ring gasket.

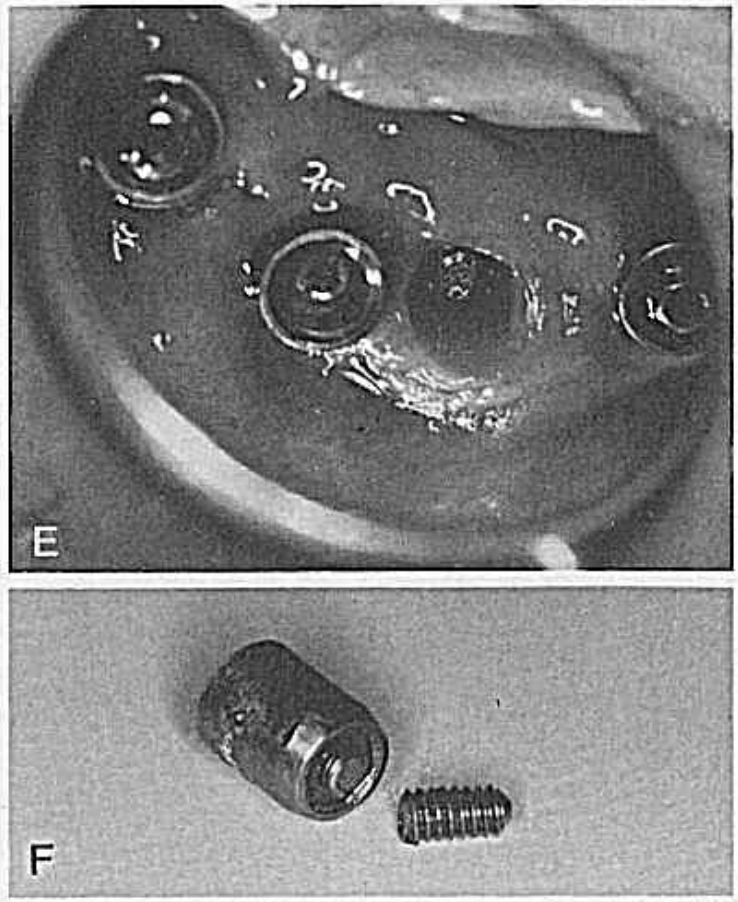


Figure 28 *Continued E*, Clinical view of the fractured abutment screw deep inside the titanium fixture. *F*, After retrieval of the screw thread portion the abutment set was simply replaced.

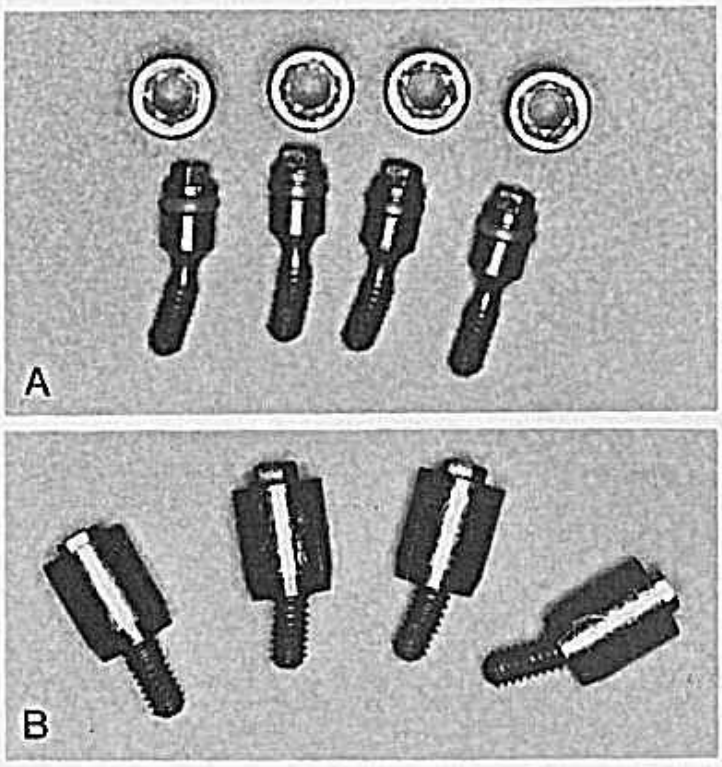


Figure 29. *A*, Bent abutment screws removed from the abutment connectors from patient referred for "complication management." *B*, Abutment screws inside the abutment connectors showed the severity of bending one week after TIP delivery. When new abutments were installed and the TIP replaced, one could observe significant occlusal harmonies requiring refabrication of the entire prosthesis.

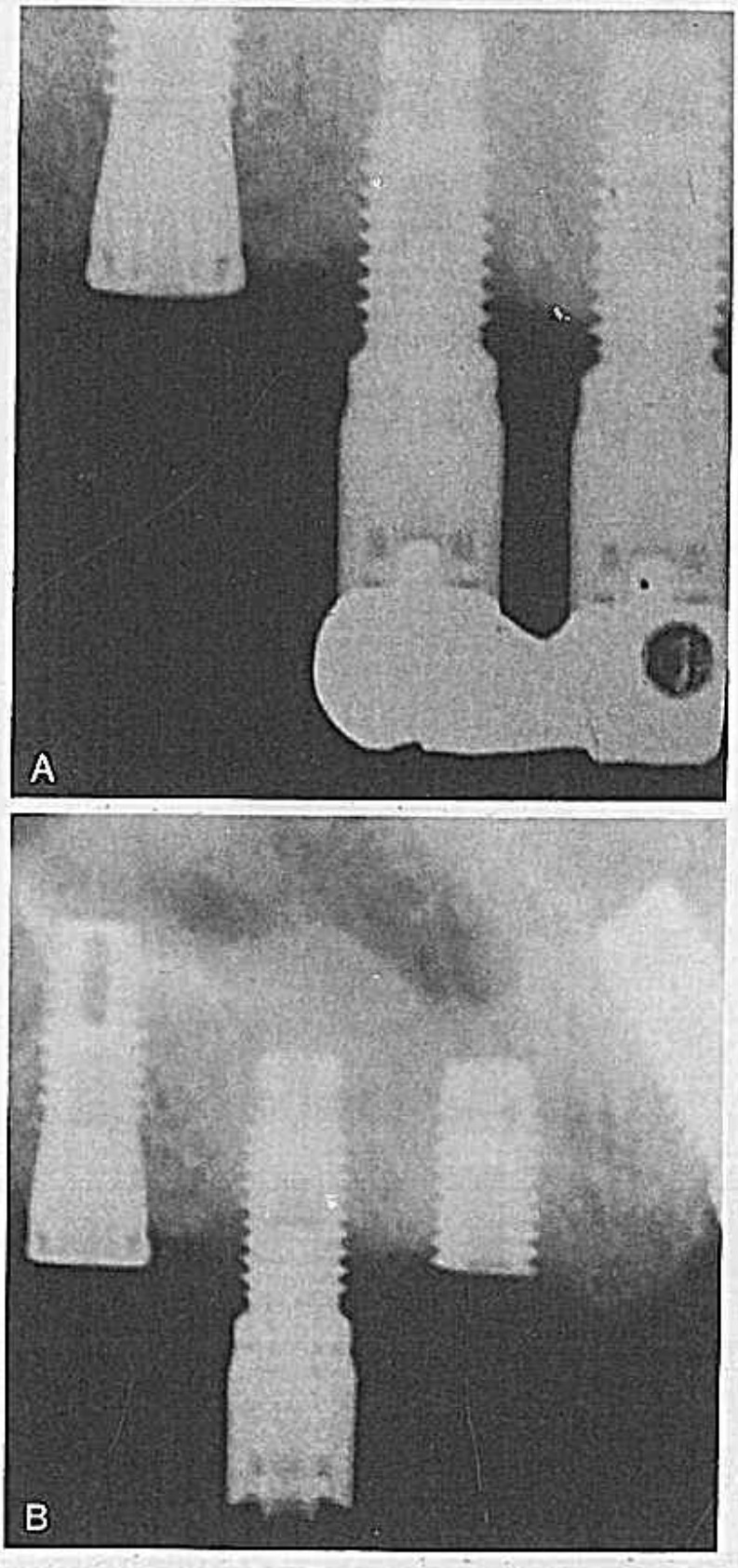


Figure 30. *A*, Two osseointegrated fixtures supporting a cast gold overdenture splint functioned adequately for 2 years until the patient's stress level changed. *B*, Severe bruxing patterns fractured the fixture at the level of the osseous crest.

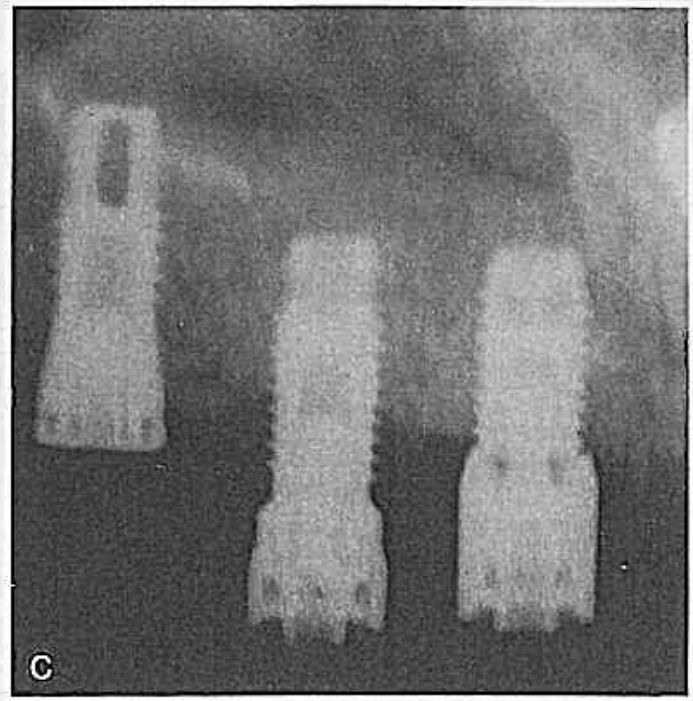


Figure 30 *Continued C,* Careful modification of the fixture face and retapping the fixture thread permitted a new abutment connector to be placed, returning this fixture to useful service.

patients with noted clenching habits should reduce the cantilevered extension or support those areas with added fixtures. In a clinical evaluation of 52 patients with 302 fixtures supporting 76 bridges during a 4-year period beginning in 1984, the highest group of osseointegration failure was seen in maxillary nonsplinted overdenture fixtures. However, the most important factor in recorded failures appeared to be patients' clenching and bruxism, which led to overloading. The patient illustrated in Figure 13 had a clenching diagnosis confirmed only after the standard mandibular posterior cantilevered TIP had been in function. The unsupported cantilever combined with the excessive loading forces resulted in fracture of the gold framework.

The solution to the problem for this patient was the addition of fixtures in the posterior mandibule followed by fabrication of a new TIP (see Fig. 13*H*).

ERGONOMICS

Swallowed and Aspirated Hardware

Ergonomic complictions focus primarily on the ability of the clinician to easily manipulate the surgical and prosthetic components. As with all dental procedures, the potential for accidental laceration or injury of the mucosal and other oral tissues is always present when rotating cutting instruments are used. The additional use of tiny screws, screwdrivers,, and other small components present potential hazards. For the most part, accidental ingestion of hardware generally passes safely through the alimentary canal (Fig. 31).

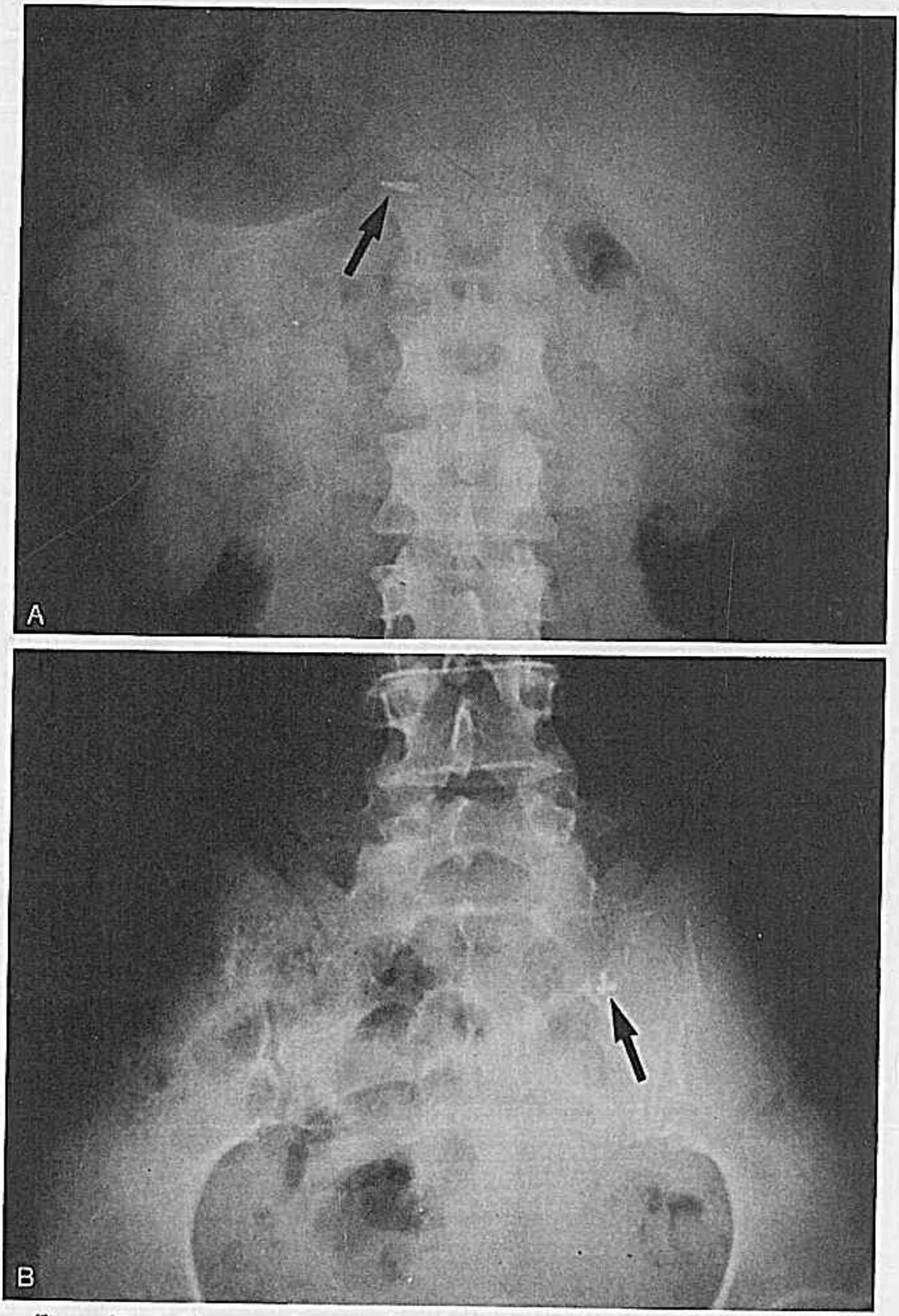


Figure 31. *A*, 10-mm guidepin swallowed during impression procedure. *B*, Titanium cover screw swallowed at the time of the abutment connection surgery. Both screws passed uneventfully through the digestive system.

Aspiration of tiny components into the lungs presents a more complex problem. One example was the undiscovered inhalation of a 10-mm guide pin impression screw at the time the maxillary impression was made. Its position, deep in the lung, was discovered by a routine chest x-ray film approximately 2 years after delivery of the final prosthesis. There are no clinical signs or symptoms that would indicate the need to remove this screw; however, continued observation is required.

To prevent accidental swallowing or aspiration of components and instruments, the surgeon and prosthodontist must be exceptionally careful in manipulation of the components as well as the position of the patient's head during these procedures. To avoid the accidental loss of impression screws upon the removal of the master impression, each screw should be

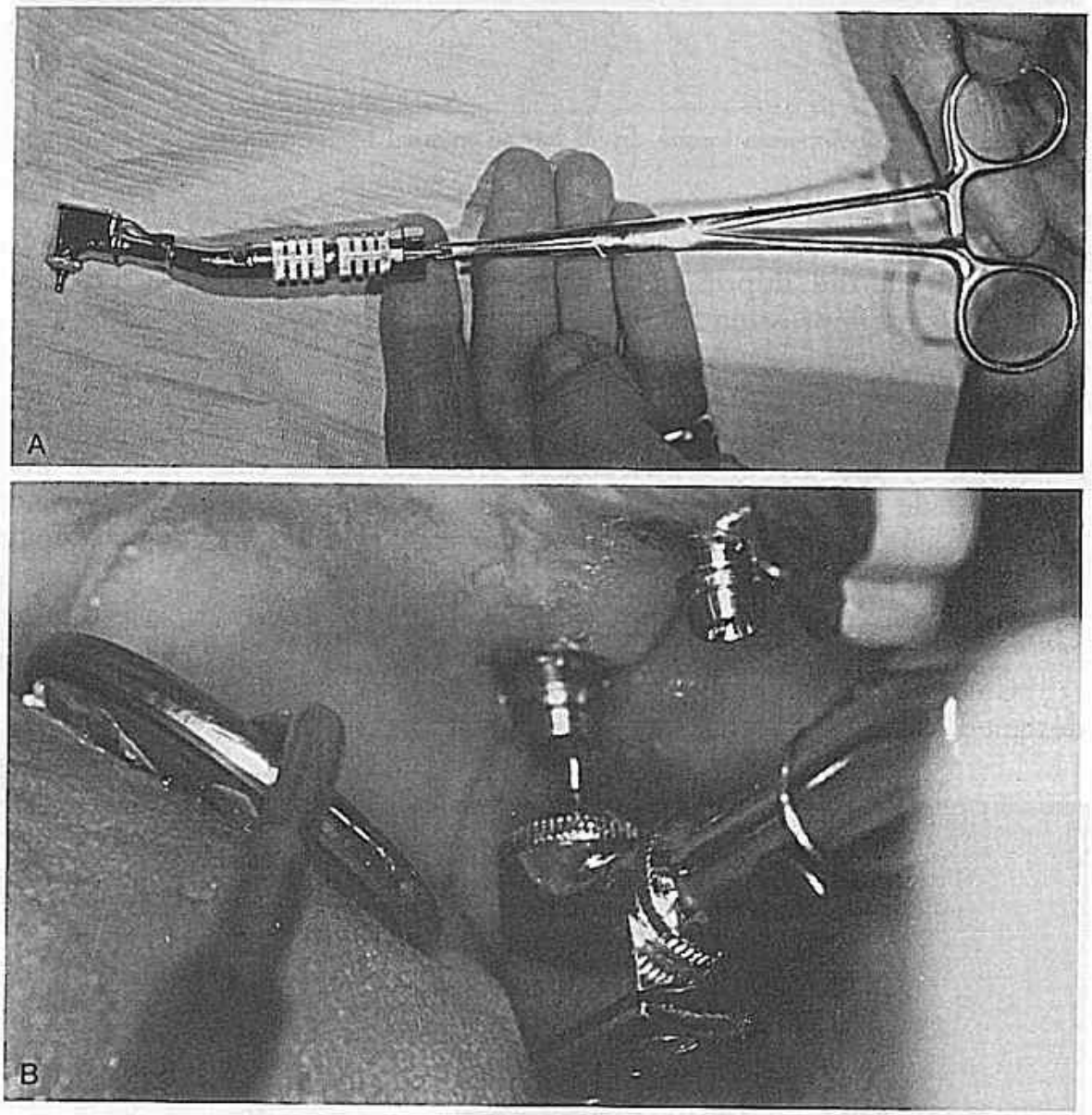


Figure 32. *A*, Contra-angled screwdriver with self limiting torque was devised using conventional latch type contra-angle and a hemostat fastened to the handpiece driveshaft. *B*, Modified latch type burr provided a screwdriver tip in the contra-angle hand piece for easy access in the tuberosity region.

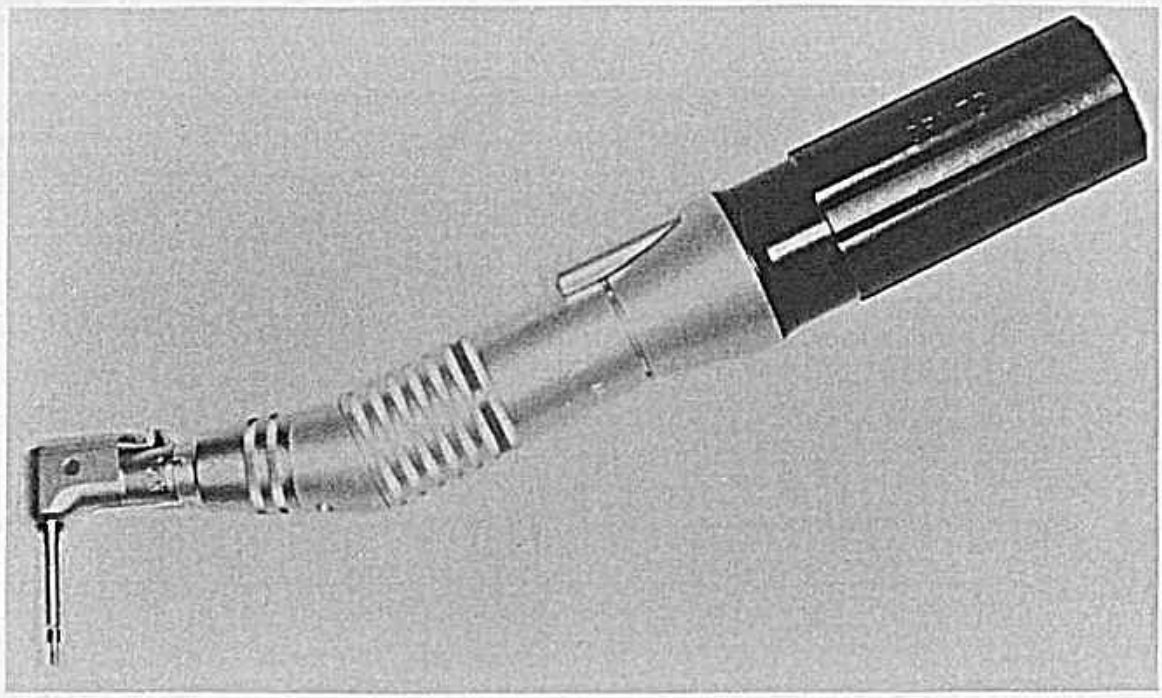


Figure 33. Nobelpharma torque driver has an internal torque regulator for tightening prosthetic gold screws.

removed from the impression cylinder and accounted for prior to the removal of the impression from the patient's mouth.

Instrument Access

The placement of prosthetic gold screws in the posterior is greatly enhanced by the use of contra-angled screwdrivers as illustrated by the custom made contra-angled/hemostat device originally designed to tighten screws in hard-to-reach areas (Fig. 32) and, more recently, its replacement by the Nobelpharma torque driver (Fig. 33).

Component Design

Gold prosthetic screws with an internal hexagonal slot have been designed to provide easier delivery of the screw in difficult-to-reach areas

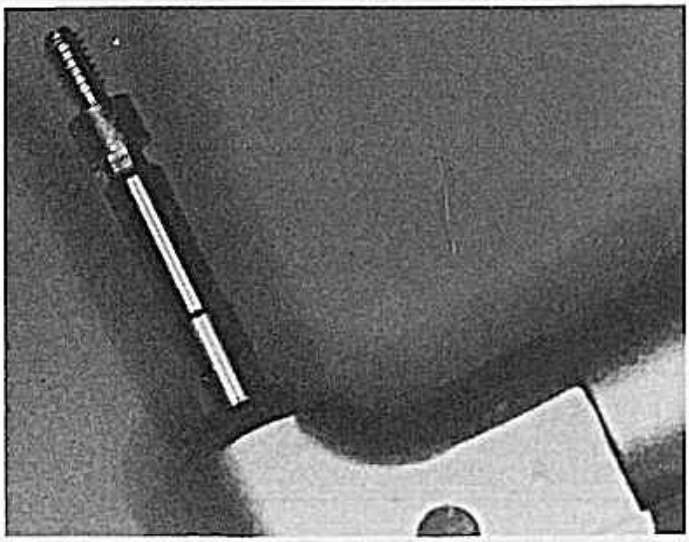


Figure 34. Internal hexagonal gold screw mounted with wax on the torque driver blade are easily delivered to posterior areas of the mouth.

of the mouth. A small dot of wax on the tip of the torque driver hexagonal blade stabilizes the screw during its delivery to the access hole (Fig. 34). When small hand screwdrivers are used, a safety ligature should be securely affixed to the top of the screwdriver that allows easy retrieval should this instrument slip from the fingers when the patient is in a reclined position.

SUMMARY

Zarb[36] has stated: "The technique of osseointegration is supported by compelling evidence of clinical longevity. It is an outgrowth of good science, painstakingly investigated, and meticulously executed. The success of edentulous patient treatment augers well for a diversified application of the technique." Along with scientific advancement and diversification of applied technologies are equally diverse challenges. A variety of potential complications, using osseointegrated implants, have been discussed. The objectives of this discussion is the development of concepts to prevent complications through careful treatment planning nad meticulous execution of surgical and prosthetic treatment techniques. The six major categories of potential complications include: (1) esthetic, (2) phonetic, (3) functional, (4) biologic, (5) mechanical, and (6) ergonomic. The most frequently observed difficulty with any implant prosthesis relates to esthetics in the maxillary anterior and is followed then equally by phonetic, functional, biologic, and mechanical. Ergonomic complications should be minimal with continued improvement in instrumentation and clinical techniques. Complications are but a challenge to our professional knowledge and ingenuity. Ultimately they benefit both patient and profession alike.

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