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Management of Implant-related Problems and Infections

Abstract

Problem-solving and treating various types of infections that can cause alveolar bone loss or inferior alveolar nerve dehiscences by failed implants or teeth are discussed. The reasons why implants fail from either surgical or prosthetic errors are reviewed. Treatment remedies which have solved numerous implant-related problems are offered. The eclectic, multi-modal implant surgical and prosthetic abilities of the clinician necessary today for successfully treating patients presenting with troubled or infected implants are reviewed.

Introduction

All surgical procedures involve risks. Dental implant procedures also present risks, with a possible result of implant failure and removal (Linkow, 1979; Linkow and Kohen, 1980). This often means that the patient's prosthesis or part of it must be removed as well.

The authors believe that implant dentistry involves much more than the knowledge of how to insert a screw, root-form, blade, or plate-form implant or how to design and place a subperiosteal implant. It involves an in-depth knowledge of the methods of replacing or repairing a failing implant of any type or design that may have lost its state of integration, as well as how to replace failed teeth with implants, as demonstrated by Linkow (1986a). In his early work on osseointegration, Brånemark *et al.* (1977) wrote in detail about his system's heavy reliance upon re-entry for the replacement of failing fixtures. His initial success rate was only 59% for the maxillary arch and 74% for the mandibular arch. In order to bring his success rate into the 90% range, he had to replace his failing implants with re-entries in 41% of his maxillary cases and 26% of his mandibular cases.

The disappointment, disability, inconvenience, as well as loss of confidence by patients having to go through implant removal procedures vary in degree according to individual reactions. The ability to re-enter directly upon the removal of an implant offers a practitioner the opportunity to provide a patient with the resurrection of his/her prosthetic superstructure. This is of particular importance if the patient is to be spared the burden of having to become acclimated to a removable prosthesis, as well as the additional psychological and physical burden of undergoing an additional operative procedure.

Physiology of alveolar bone breakdown around endosseous dental implants

Much has been said and written with regard to whether bone resorbs initially because of primary bacterial invasion from the oral cavity, causing the epithelial cuff to invaginate and the underlying connective tissue to lose its integrity. The results of these phenomena may cause a loss of the tenacious physical attachment to the implant surface, resulting in implant mobility, bone loss, and pain (James and Swope, 1981; Linkow, 1989b). It is the authors' opinion that most implant failures begin within the bone rather than from microbes within the oral cavity. Therefore, it is proposed that the etiology of the infectious process becomes secondary rather than primary in nature.

Failure of an endosseous implant can occur for a number of reasons which involve both the surgical and prosthetic phases.

From a surgical point of view, implant failure can occur from trauma to the osseous tissue beyond its physiologic limits. This can be affected by:

(1) overheating the bone with rotary instruments during implant insertion, causing excessive tissue necrosis;
(2) spreading the bone beyond its viscoelastic limit by attempting to insert a blade or root-form implant into a horizontal or vertical osteotomy of insufficient depth or width;
(3) failing to seat and bury the shoulder of a blade implant below the crest of the alveolar ridge;

(4) failing to bend a blade implant to fit passively into a curved osteotomy;
(5) perforating the facial/lingual or facial/palatal cortical plate with an oversized root-form or blade implant;
(6) perforating the submaxillary or sublingual cortices while inserting a blade, plate-form, or root-form implant;
(7) inserting an implant into medullary bone of insufficient density without engaging the facial/lingual or facial/palatal cortical plates;
(8) failure to follow surgical protocols to prevent contamination of the implant;
(9) placing a titanium implant in contact with a dissimilar metallic endosseous material—such as ligature wire, amalgam scraps, stainless steel screws, fixation plates, stainless steel or vitallium implants—which could create a galvanic reaction and corrosion of the implant, resulting in tissue necrosis; and
(10) inserting a root-form, blade, or plate-form implant that does not fit tightly in its osteotomy and exhibits digital mobility.

The violation of any of these surgical protocols may cause implant failure (Linkow, 1979, 1986).

In the prosthetic phase, implant failure can be caused by:

(1) creating excessive hydrostatic pressure, forcing impression material into the implant's osteotomy or below the gingival sulcus at the implant post;
(2) dislodging the implant by forcing a provisional or permanent restoration on or off non-parallel implant abutments during the early stages of healing;
(3) creating hyper-occlusion on the temporary or permanent prosthesis, or overloading an implant beyond its physiologic limits;
(4) patients' incorrectly cementing their own provisional or permanent implant-supported restorations;
(5) fractured castings, attachments, or screws on permanent prostheses, which, by overloading supporting teeth or implants, may cause loss of integration;
(6) improper pontic design, which can impinge, or cause food impaction, upon soft tissues;
(7) utilization of superstructures or castings of insufficient rigidity to resist vertical flexure;
(8) overloading individual root-form implants from unequal torquing of the fixation screws of a fixed-detachable prosthesis;
(9) use of some non-precious crown and bridge alloys, which may cause corrosion resulting from galvanic reaction with the implant's post; and
(10) utilization of occlusal schemes that introduce excessive lateral and occlusal loading.

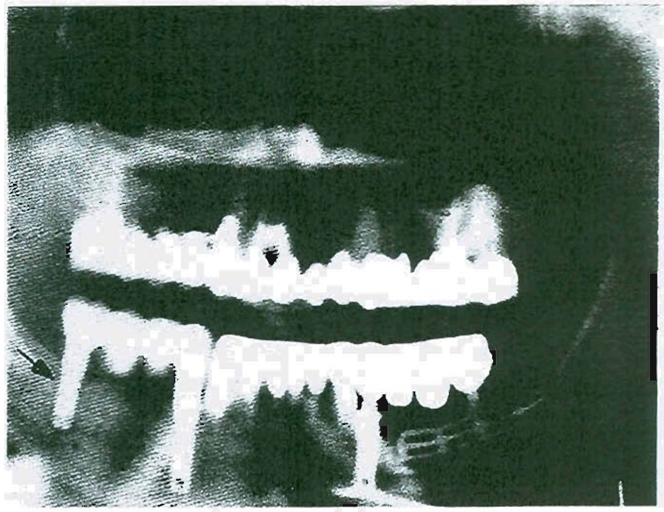

Figure 1. A panoramic radiograph shows a right mandibular posterior bridge with free-standing fixtures as abutments. When the mesial fixture's locking screw fractured, overloading and disintegration of the previously osseointegrated distal fixture occurred. The blade implant contralaterally replaced a fixture that also failed due to fracture of the mesial fixture's locking screw.

These prosthetic errors are more subtle but nevertheless play a significant role in determining implant prognoses (Misch, 1990; Awadalla *et al.*, 1992; Wagner, 1992).

The authors believe that implant failures caused by surgical or prosthetic errors begin from within the bone. These errors should not be confused with other causes of failure, such as poor patient hygiene, systemic disease, or osteoradionecrosis. Such conditions can cause failure in implants that have been healthy and functioning well for years.

When surgical or restorative errors have been made, the course of events is predictable. The bone is traumatized by thermal or physical trauma, resulting in necrosis. Bone resorption starts to occur around the buccal and lingual interfaces of the implant. A venous, arterial, and capillary stasis occurs, resulting in engorgement of the blood vessels in the area. This circulatory breakdown causes continued bone resorption. As the process continues, a fibrous tissue membrane develops at the implant/bone interface, which thickens progressively and becomes granulomatous. The bone continues to resorb due to a lack of functional stimulation between the implant and the bone. Mobility becomes apparent, and the implant exhibits tenderness on vertical pressure. At this stage, when the implant is in function, a pumping action begins, which draws oral fluids and debris into the host site. Microbial invasion can now begin (McKinney and Lemons, 1986). Bacterial invasion appears to be of a secondary rather than a primary nature in such

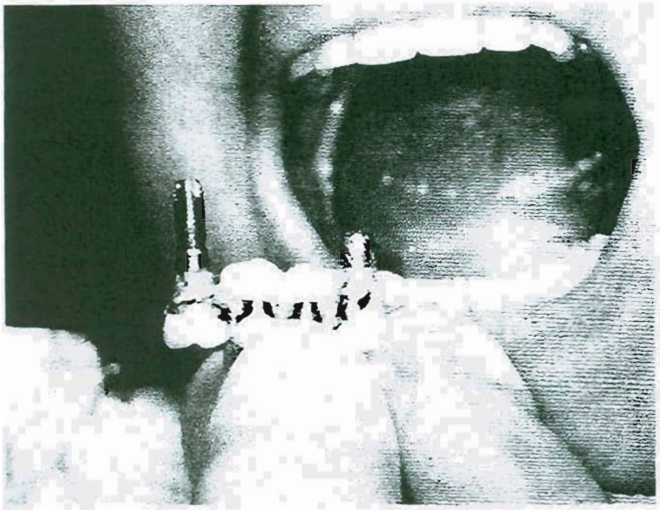

Figure 2. The mandibular right posterior bridge with its failed distal abutment fixture intact was digitally removed.

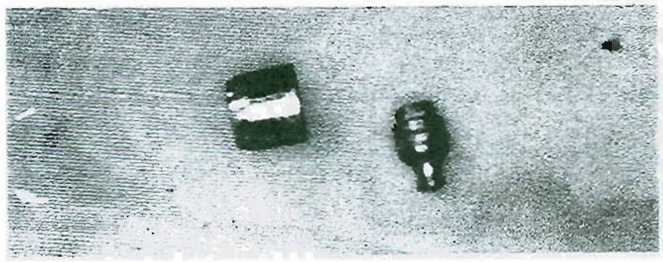

Figure 3. The fractured locking screw recovered from the mesial fixture of the failed bridge shown in Fig. 2.

cases. Consequently, if this breakdown was caused by a surgical or prosthetic problem, and the implant cannot be periodontally treated, grafted, and immobilized, it must be removed and <u>all of the granulomatous tissue excised</u> in order to assist in the regeneration of new bone (Linkow, 1979).

The failure of osseointegrated systems often occurs in cases that were performed correctly and resulted in clinical and radiographic osseointegration. This may be followed by a loss of integration, or "disosseointegration". The authors have observed this most often when Brånemark implants were used solely for posterior free-standing implant-supported bridges. At that time, when an implant becomes disintegrated and displays mobility, an irreversible process of resorption at the interface has occurred. The stabilizing influences that afford maintenance of that interface within a state of equilibrium are exceeded (Linkow *et al.*, 1990; Falk *et al.*, 1989). These forces, now destructive, initiate increased osteoclastic activity, which results in an accelerated catabolic process of destruction of the supporting bone. An example of this phenomenon may be seen in a case in which two free-standing fixtures supporting two pontics became dramatically mobile as a result of shearing off one of the internal coronal screws. The remaining fixture without the broken screw could be readily lifted from the bone (Figs. 1, 2). Shortly before this traumatic event, the case was considered to be osseointegrated. In the four-unit, free-standing, fixture-supported bridge described, the anterior and posterior abutments were expected to distribute the normal masticatory forces. The fracture of the coronal screw at the anterior abutment allowed the posterior abutment to become subjected to excessive occlusal loads by transferring a disproportionate force to the posterior fixture, which creates a class I lever arm, leading to its rapid failure. The question then remained, why did the coronal screw in the anterior fixture break in this case? (Fig. 3)

Just as alveolar bone is in a constant state of flux, it can be hypothesized that, in situations where fixtures were used as free-standing support for posterior bridges, they too are in flux. Some investigators suggest that the loosening and breakage of retentive screws could also be due to intergonial and torsional flexure of the mandible (Misch and Bidez, 1992). These hypotheses could help explain the frequency of snapped off coronal screws in fixtures and should be investigated further.

If the coronal screws were indeed designed to shear in order to save the fixture from being overloaded (Linden and Lekholm, 1992), important factors that remain are the consequences which affect the remaining free-standing fixture with an intact screw. In such instances, it appears that one fixture might be saved by the screw breaking, but the other fixture could be lost before the problem is diagnosed.

Management of operative sites after implant removal

After the removal of any failed root-form implants, the sites should be enucleated of all granulomatous tissue. Replacing these implants on an immediate basis by using horizontally designed conventional, blade, or plate-form implants and returning the patient to function is an acceptable form of therapy. These patients should be inconvenienced as little as possible. They should not automatically be obliged to wear a conventional denture while the bone regenerates or the grafts used to repair defects mature. By making a thin osteotomy between enlarged sockets after removing teeth or root-form implants and continuing the channel through the cribriform plates, the retention of blade implants placed in these sites can be effected (Figs. 4-6). These areas contain bone of density comparable with or superior to that of the surrounding cortical plate of the mandible and maxillae (Linkow, 1989a).

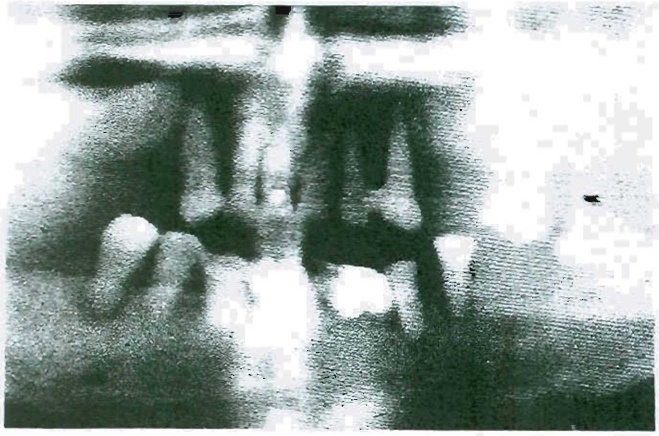

Figure 4. A pre-operative panoramic radiograph reveals an adequate quantity of mandibular alveolar bone of good density for immediate placement of blade implants after removal of the remaining periodontally compromised teeth.

In fact, it is the authors' belief that placing implants across open sockets and through the cribriform plates has been responsible for a higher rate of success than placing them into virgin medullary bone. Unlike the medullary bone, the dense bone of the cribriform plate does not occupy a state of continual flux.

These interseptal areas are pierced by Sharpey's fibers and receive nutrients and enzymes *via* an active transport system involving incoming vessels, the periosteum, nutrient canals, canaliculi, and Volkman's canals.

Case Histories that Help Demonstrate These Findings

Case 1: Bridging mandibular vertical tooth extraction sites using horizontal blade implants.

A patient presented with upper and lower partial dentures that were poorly retained by periodontally failing teeth. In the maxilla, the right premolar and the left canine, both left premolars, and the second molar remained. In the mandible, the right 2nd molar, 1st and 2nd premolars, both canines, the left 2nd premolar, and 3rd molar were present. It was determined that the mandibular blade implants could be inserted at the time of the extractions, bridging the extraction sites to utilize the dense interseptal bone of the cribriform plates.

All of the failed lower teeth were removed, the right 2nd molar and left 3rd molar being retained. All granulomatous tissue was removed and the extraction sites decorticated (Fig. 7). An osteoplasty was done using rongeur forceps and bone files to form a smooth, level alveolar crest. A continuous, 12-mm-deep osteotomy was made through the cribriform plates using circular internally irrigated bone saws and a 700 XXL surgical bur. Three titanium

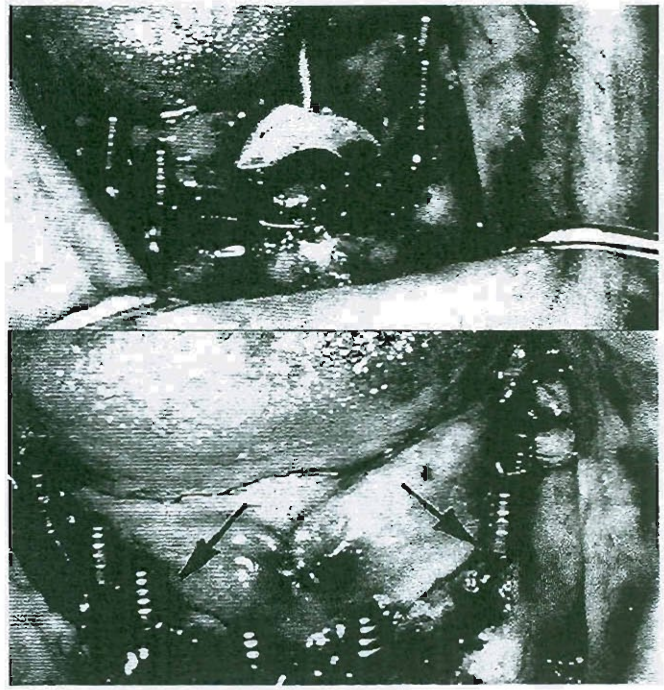

Figure 5. After tooth extraction and alveoplasty, a continuous osteotomy is prepared from right to left, with four blade implants spanning the residual sockets, with dense interseptal bone affording additional buccal and lingual support to the blade implants. Abutments are seated crestally on interseptal areas (arrows).

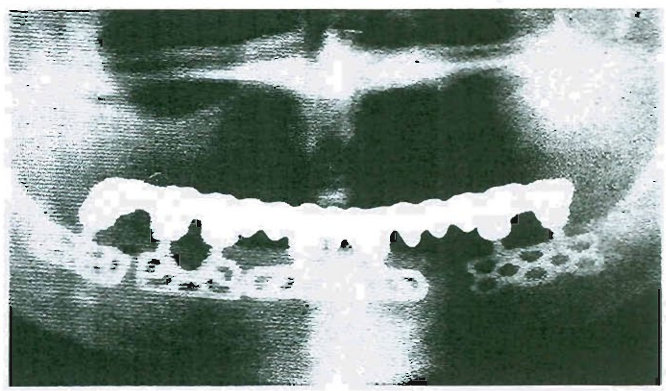

Figure 6. A panoramic radiograph of the completed case shown in Figs. 4 and 5.

blade implants were inserted into the channel, with the implant shoulders buried 2 mm below the crest of the ridge. The abutment placements were predetermined to be located in areas of interseptal bone (Figs. 8, 9). The extraction sites and osteotomy were grafted with a resorbable hydroxylapatite, autogenous bone shavings, venous blood, and a microfibrillar collagen matrix for complete coverage of the shoulders of the implants and filling of the sockets. The patient was provided with a full-arch

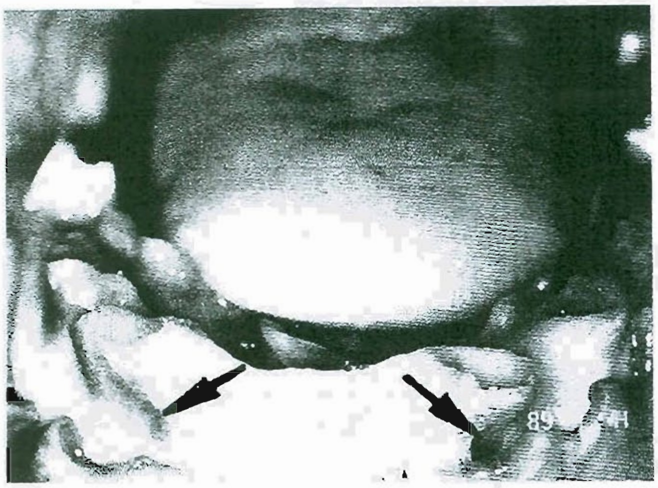

Figure 7. Case 1: A view of the alveolar ridge with mucoperiosteal flaps reflected and failed teeth extracted prior to alveoplasty. Note the fenestrations of the labial cortical plate at each canine (arrows). Sound right second and left third molars are retained as posteror abutments.

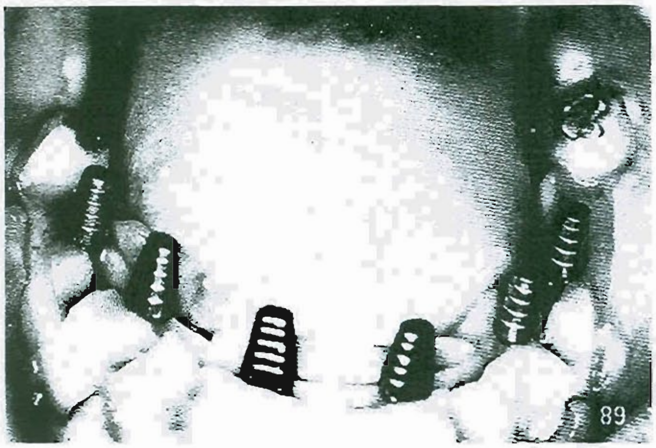

Figure 9. Case 1: Blade implants were seated 2 mm below the alveolar crest, with all six abutments resting on the crest, avoiding the open sockets. The dense bone of the interseptal cribriform plates buttress the seated blade implants on the facial and lingual aspects.

acrylic splint placed in light function on the day of surgery. Impressions for a 15-unit porcelain veneer bridge were taken one month following surgery (Fig. 10).

The upper arch was restored a few months later. After extractions, two HA-coated root-form implants were inserted in the right canine and left central incisor positions. Bilateral sub-antral augmentations were performed in which plate-form implants were placed at the same time and allowed to heal for four months prior to being loaded. The right 1st premolar, left canine, and 1st premolar were retained and incorporated with the implants to support a 15-unit porcelain veneer bridge. (Fig. 11).

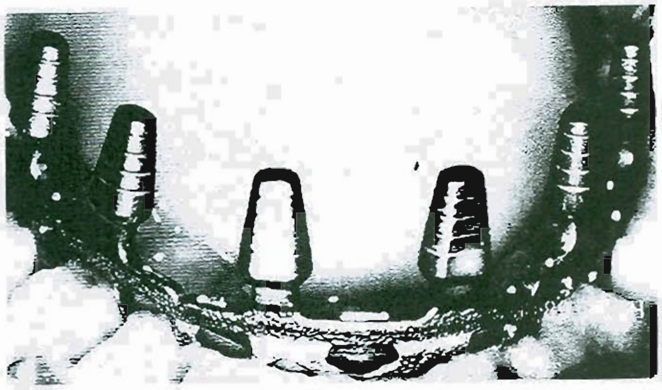

Figure 8. Case 1: A continuous osteotomy is prepared from right to left and the three blade implants partially seated to confirm alignment and relationship to interseptal bone of the abutments.

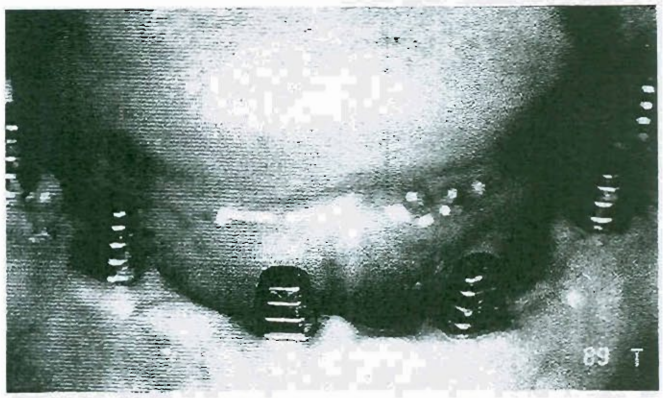

Figure 10. Case 1: A five-week post-operative view of the healed implant abutments, showing firm, healthy, attached gingiva.

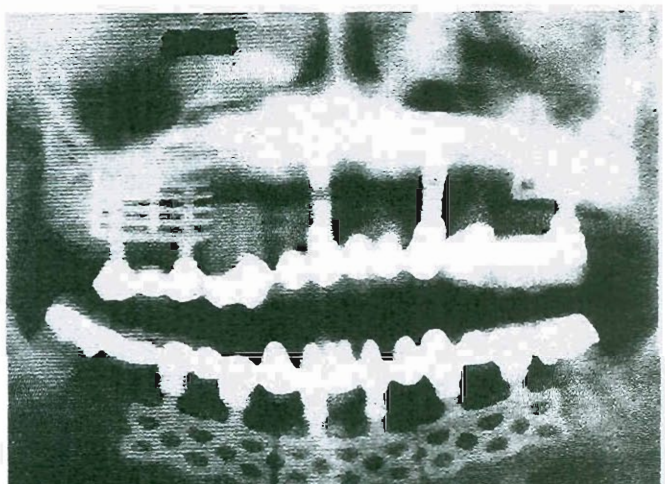

Figure 11. Case 1: A panoramic view of the completed case, restored with porcelain-veneer fixed prostheses. The maxillary arch utilized bilateral sinus elevations with blade implants, two root-form implants, and three natural teeth serving as abutments.

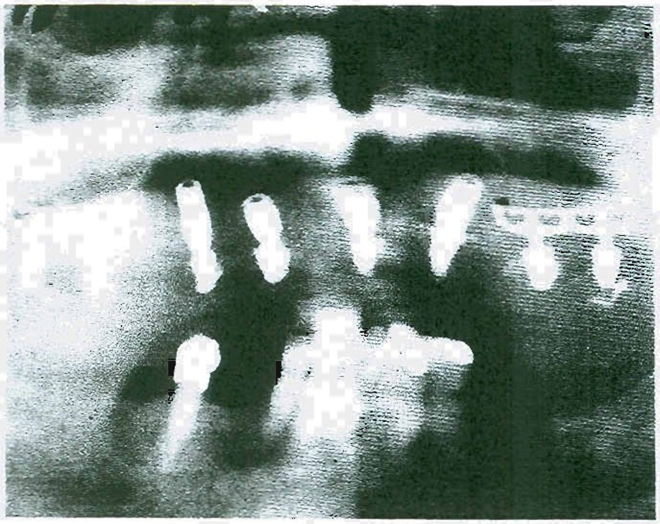

Figure 12. Case 2: A pre-operative panoramic view showing failure of four maxillary root-form and two blade implants supporting an unstable provisional prosthesis.

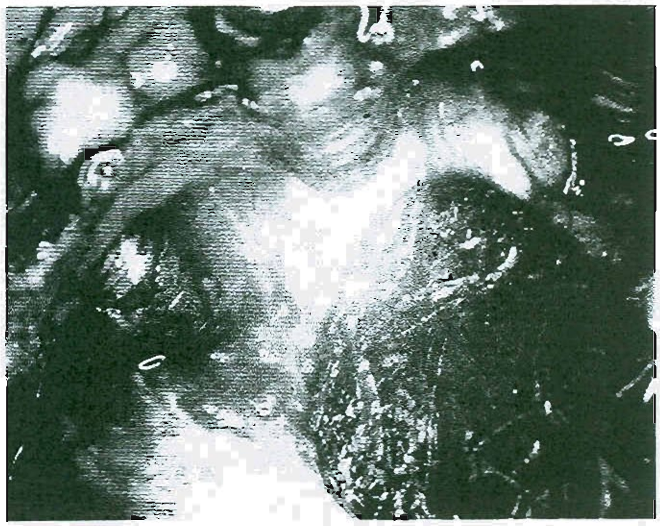

Figure 13. Case 2: A palatal view reveals perforation of the palatal cortical plate by the root-form implants.

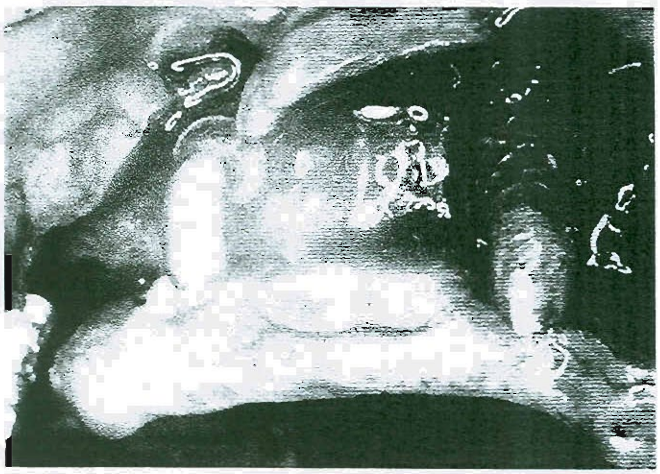

Figure 14. Case 2: The failed root-form implants are encapsulated in granulomatous tissue and removed digitally.

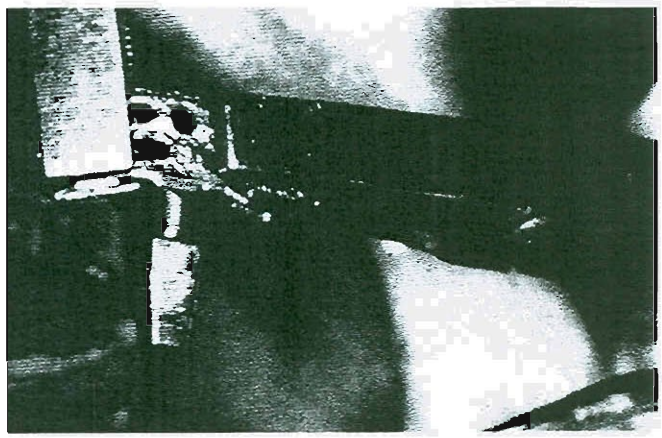

Figure 15. Case 2: Adjusting the blade implant to conform to curvature of the alveolar ridge.

Case 2: Bridging maxillary vertical root-form extraction sites using horizontal blade implants and replacing posterior blade implants with unilateral subperiosteal implants.

A patient presented with four maxillary anterior Core-Vent implants and two posterior blade implants supporting a temporary prosthesis. The Core-Vent implants had been assumed to have been osseointegrated, because they had been submerged for eight months prior to being loaded. The two posterior blade implants had not been submerged, and the upper denture had been supported by fixed abutments during the entire period. After an oral examination and radiographic survey, it was evident that the six implants had failed (Fig. 12).

The mucoperiosteal tissues were reflected, exposing the implants. It was obvious that all of the Core-Vent implants had perforated the cortical plates of what appeared to be a very dense and wide maxilla (Fig. 13). A mass of granulation tissue surrounded each of the implants, all of which were removed digitally (Fig. 14). The granulation tissue was removed and the sites decorticated. An alveoplasty was performed using rongeur forceps prior to creation of an osteotomy for the insertion of two anterior submergible blade implants (Figs. 15, 16). Tricalcium phosphate was used to cover the shoulders of the seated implants and to repair the bony defects left by the root-form implants (Fig. 17). Closure of the premaxilla, with 3/0 black silk sutures, was then accomplished. Direct bone impressions were taken bilaterally for two unilateral subperiosteal implants.

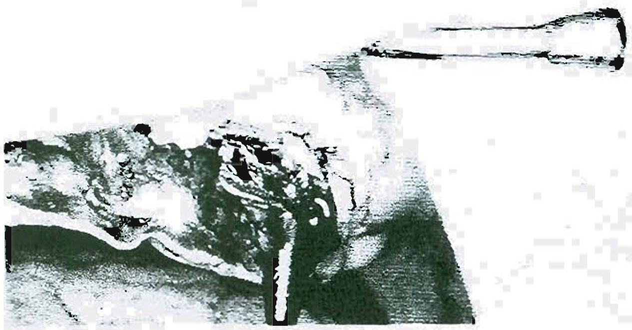

Figure 16. Case 2: With the abutment adjusted for parallelism, the blade implant is placed in the anterior osteotomy.

Figure 17. Case 2: The implant osteotomies and bony defects of the alveolar ridge are grafted with resorbable hydroxylapatite to restore ridge architecture.

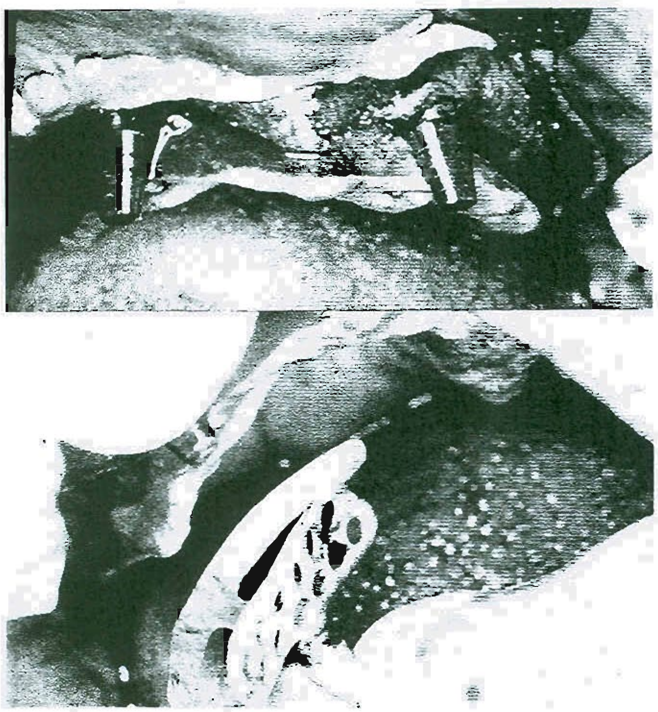

Figure 18. Case 2: The prosthetic abutments are affixed to the anterior blade implants at second-stage surgery, and a unilateral subperiosteal implant with a broad fenestrated palatal strut is inserted posteriorly.

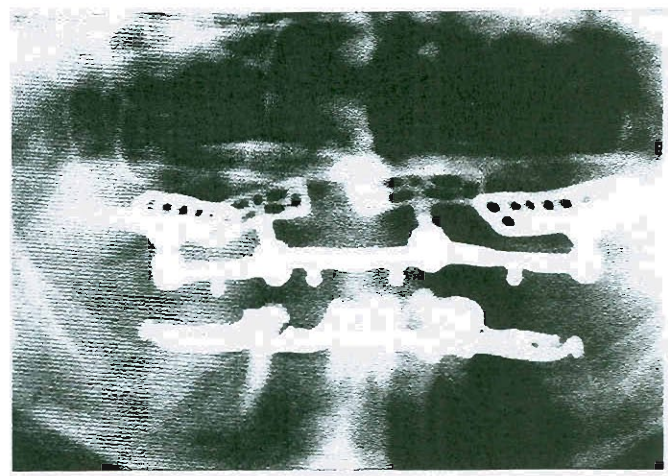

Figure 19. Case 2: Panorex of the completed case, showing the replacement of the failed anterior root-form and posterior blade implants with two-stage osseointegrated anterior blade implants and posterior unilateral subperiosteal implants. The four abutments are splinted with a rigid cast superstructure to affix a removable O-ring attached prosthesis.

After soft tissue healing had been completed, the mucoperiosteal tissues were reflected bilaterally from the canine area to the pterygoid notch, and the unilateral subperiosteal implants were seated (Fig. 18). After healing, the subperiosteal implant abutments were attached to the abutments of the blade implants and splinted by means of a cast mesostructure bar designed for a palateless maxillary denture retained by O-ring fixation (Fig. 19).

Case 3: Treating a subperiosteal implant that is failing in the posterior.

A patient presented with an 11-year-old complete mandibular subperiosteal implant with four separate abutments. The patient wanted the implant removed because he was experiencing pain in the posterior regions bilaterally.

Clinical observation, palpation, and radiographic

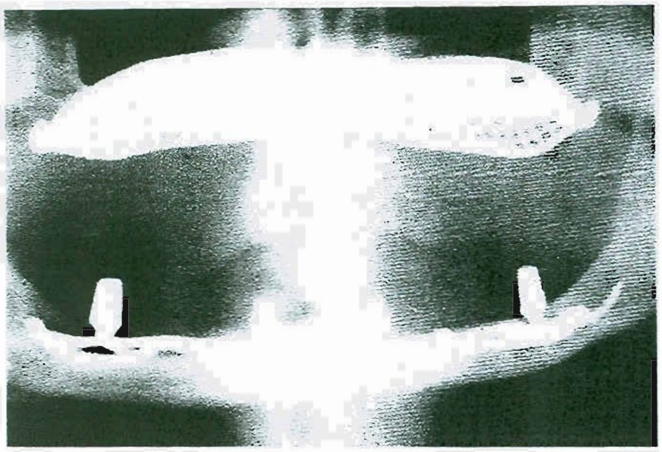

Figure 20. Case 3: Pre-operative radiograph reveals settling of the lower right posterior third and bone resorption beneath the left posterior abutment of an 11-year-old mandibular subperiosteal implant. The anterior segment of the implant remains normal and free of any problem.

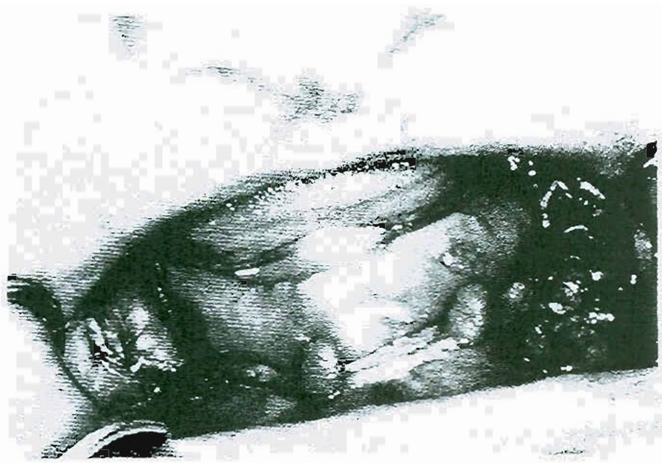

Figure 21. Case 3: Duralay patterns for copings are placed on posts of the anterior segment of the existing implant and are picked up with posterior subperiosteal impressions in a final pick-up full-arch impression.

Figure 22. Case 3: New posterior subperiosteal implant segments with ramus and horizontal anterior extensions bearing O-ring attachments are fabricated. These units are designed to telescope over the distal extensions of the cast anterior copings.

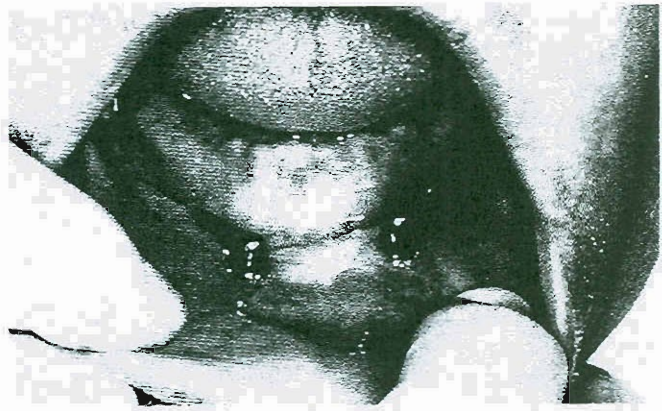

Figure 23. Case 3: Two copings with distal extensions seated on the posts of the existing implant.

aids dictated that the entire implant did not require removal. The right posterior quadrant had settled into the bone, which eventually covered the strut. The left side revealed bone resorption beneath the posterior molar abutment and part of the underlying primary struts, with a great amount of associated granulomatous tissue (Fig. 20). The left posterior quadrant was sectioned from the body of the implant and removed, while, in the right quadrant, the molar abutment post was sectioned at its base. The lateral and anterior surfaces of both rami were exposed. Direct bone impressions were made of the rami. Included in the final impression were two previously fabricated polymeric copings that had been placed over the anterior abutments of the implant that had been permitted to remain (Fig. 21). Two unilateral subperiosteal implants were designed that covered the rami and had anterior horizontal bars with O-ring mesostructures. The most anterior portions of both castings were hollow. This allowed them to house the distally extended horizontal extensions which protruded directly from the anterior copings (Figs. 22-24). These were later cemented over the anterior subperiosteal implant abutments and locked into the posterior horizontal extensions (Fig. 25). In this manner, the posterior occlusal forces were dissipated *via* the mesostructure to the unilateral subperiosteal implants (Figs. 26, 27).

Case 4: Correction of a design error in a subperiosteal implant.

A patient presented with a well-fitting, bipodal subperiosteal implant having good ramus exten-

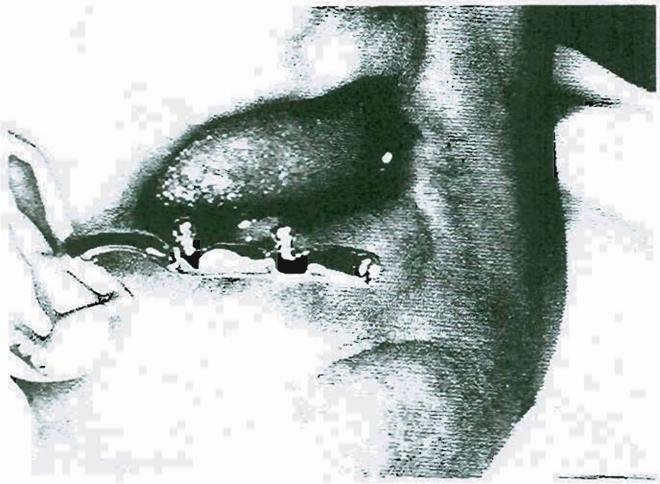

Figure 24. Case 3: The right posterior subperiosteal implant with an anterior hollow tube in the horizontal extension. This tube is designed to telescope over the distal extension noted in Fig. 23.

Figure 25. Case 3: The left implant is seated on the ramus with its tubular section engaging the anterior coping. The tubular sections are cemented in place.

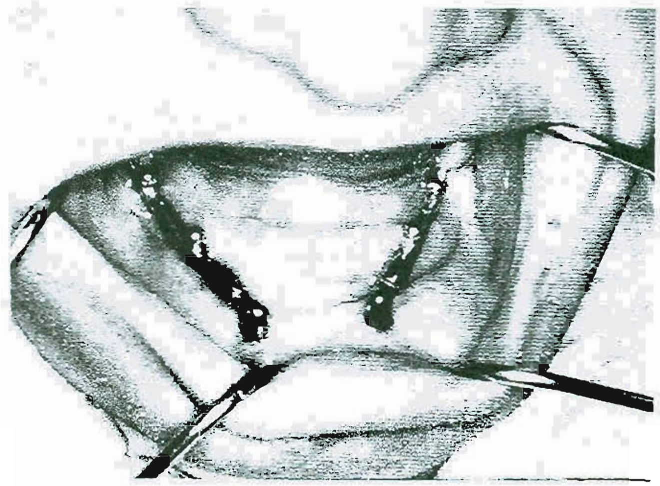

Figure 26. Case 3: Clinical view showing four O-ring attachments which are adapted to the patient's existing denture.

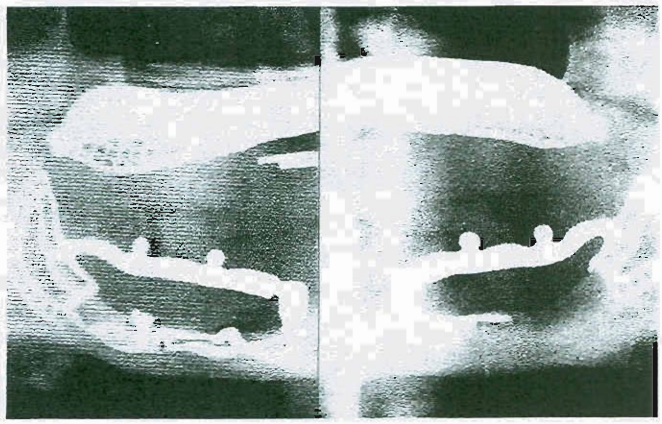

Figure 27. Panorex of completed Case 3. The occlusal forces are dissipated in part to the dense bone of the ramus.

sions. It had been inserted four years earlier. On a routine re-call examination, the patient complained of pain and occasional swelling on the left side. It was determined that bone resorption had occurred under the distal, load-bearing post on the left side (Fig. 28). The anterior and right posterior segments of the implant were healthy and normal. In an effort to keep the fulcrum low, the mesostructure had been reduced in height, which decreased the implant's load-bearing burden at the posterior abutment. Consequently, the occlusal loads were not directed through the dense bone of the retromolar triangle to dissipate throughout the ramus and condyle, but instead were routed in a downward direction into weaker bone. Bone resorption and a dehiscence of the left inferior alveolar canal resulted in this area.

Two pilot holes were drilled in the left posterior mesostructure. One hole was made 5 mm distal to the anterior abutment of the implant, and the second hole was drilled 1 cm distal to the first hole in the mesostructure. The mesostructure was sectioned from the implant 18 mm distal to the anterior post, by use of a sintered diamond disk (Fig. 29).

The mucoperiosteal tissues in the left quadrant were incised and reflected, revealing the left ramus section of the implant. This subperiosteal implant, which did not have a left peripheral strut, was removed from the remaining periosteal attachment and lifted from the bone by use of rongeur forceps to grasp the sectioned distal portion of the mesostructure, dissecting the implant free. The area of bone resorption was debrided of all granulomatous tissue, and a 1-cm dehiscence of the inferior alveolar canal was noted. The tissues were

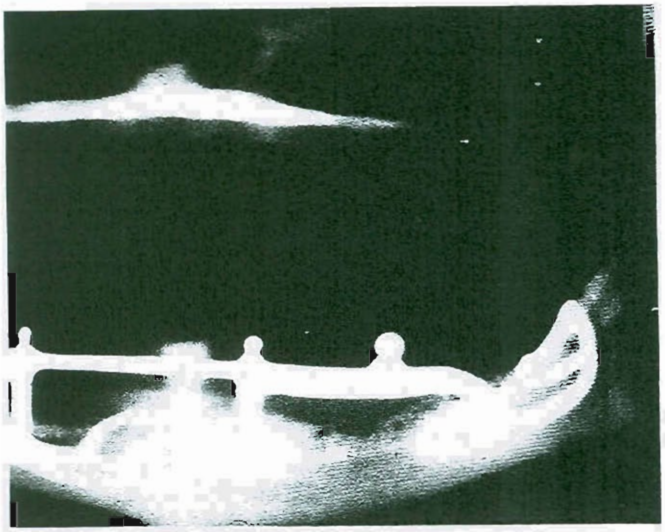

Figure 28. Case 4: Pre-operative panorex showing bone resorption of left posterior section of a four-year-old bipodal subperiosteal implant. The anterior and right posterior segments are not affected.

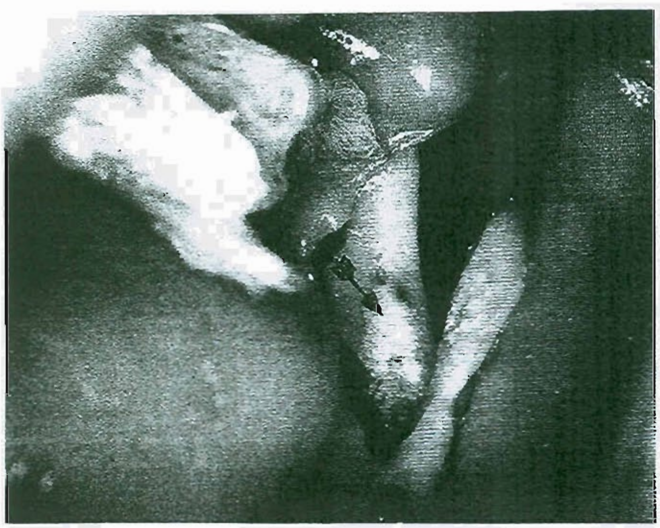

Figure 30. Case 4: The subperiosteal posterior section was removed, and the area of bone resorption was debrided of all granulomatous tissue, revealing a dehiscence of the inferior alveolar canal 1 cm in length at the area of the distal post. The dehiscence was covered with resorbable HA, venous blood, and a collagen hemostatic matrix (arrow).

irrigated with saline and the site cleaned of all debris. A direct bone impression of the left ramus was made with polyvinylsiloxane. It included the anterior mesostructure as well as the exposed site. The bony defect caused by the resorption under the abutment was decorticated and lightly filled with a mixture of resorbable hydroxylapatite, a microfibrillar collagen matrix, and venous blood to cover the dehiscent canal and restore bony architecture. The

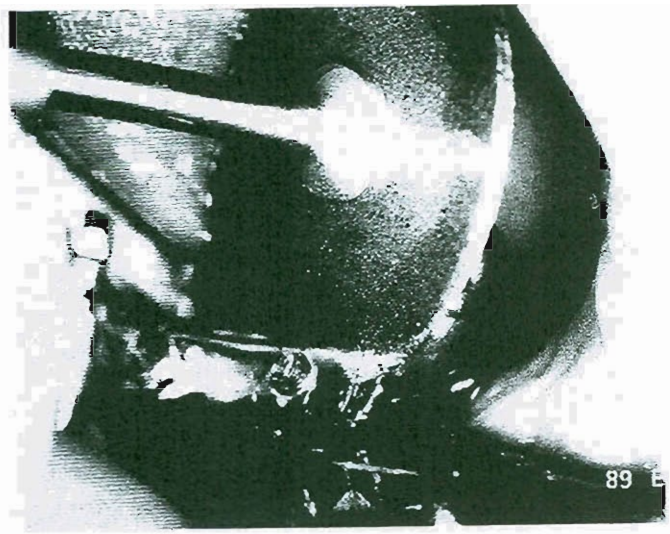

Figure 29. Case 4: The left posterior horizontal extension is sectioned from the implant 18 mm distal to the anterior post with a sintered diamond disk. Two pilot holes are drilled in the remaining portion of the horizontal extension (arrows).

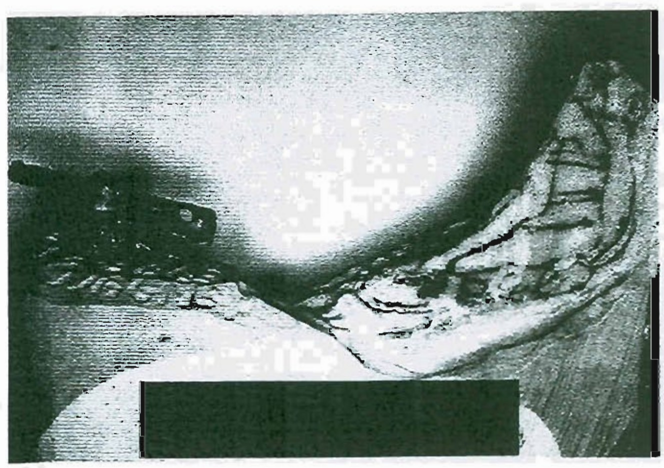

Figure 31. Case 4: A Duralay model of the remaining anterior mesostructure, to which the new posterior implant section's horizontal extension is connected.

tissues were co-apted and sutured with 3/0 black silk. The patient was still able to wear her lower prosthesis, supported by the remaining mesostructure and three remaining implant abutments.

One month later, the site was re-opened, and the graft was found to be firm but not ossified (Fig. 30). A new posterior subperiosteal implant section had been designed to by-pass the healed defect, with the new load-bearing ramus abutment placed at the retro-molar triangle (Figs. 31, 32). After the new implant section was seated passively, the new mesostructure was connected to the existing im-

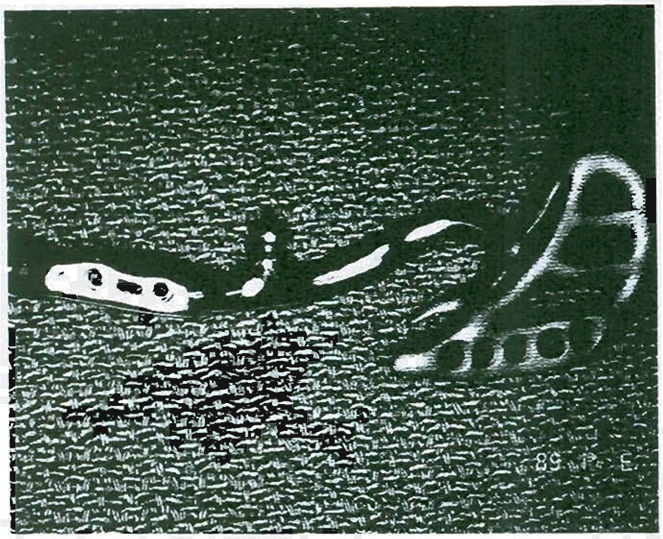

Figure 32. Case 4: The horizontal extension of the new unilateral subperiosteal implant is designed to connect to the existing implant by utilizing a saddle-like section straddling the existing 18-mm-long section still attached to the left anterior post. Corresponding pilot holes in the saddle section are precisely aligned with the holes placed in the distal extension of the existing anterior implant segment during the first surgery.

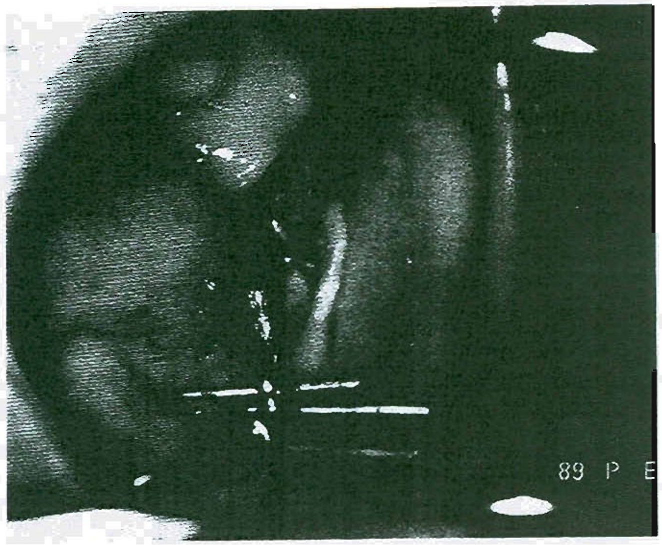

Figure 33. Case 4: After the implant is seated and the new mesostructure cemented over the existing bar, corresponding cast vitallium tapered pins mechanically lock the two segments securely into position.

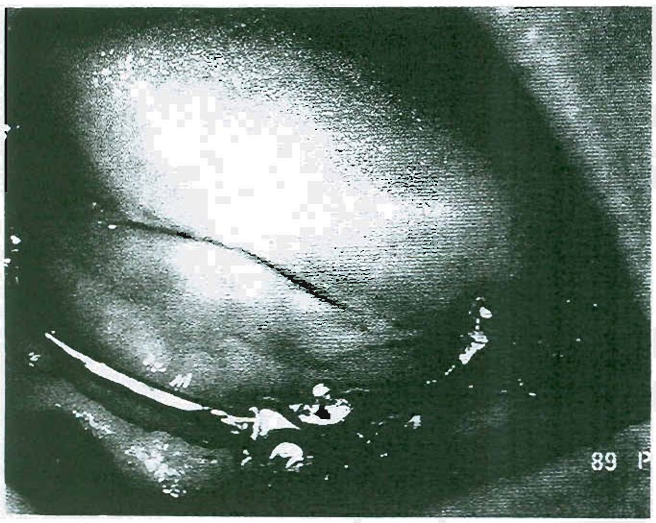

Figure 34. Case 4: The cemented tapered pins are cut flush buccally and lingually. Closure is made with chromic gut sutures.

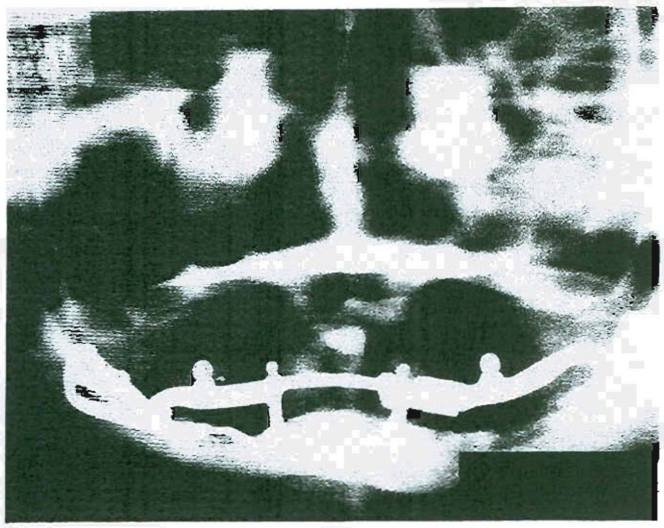

Figure 35. Case 4: Four-and-a-half-year post-operative Panorex of replacement section of the subperiosteal implant.

plant by a saddle-like casting, straddling the existing 18-mm-long section still attached to the left anterior abutment. Corresponding pilot holes had been created in the new subperiosteal implant's mesostructure which aligned with the holes that had been made in the existing bar during the first surgery. The aligned pilot holes were precisely mated by being reamed with a tapered high-speed diamond. Corresponding cast vitallium tapered pins were used to lock the two segments into position after the new mesostructure had been cemented (Fig. 33). The surgical site was sutured with 3/0 chromic gut sutures. The cemented tapered pins still extending through the conjoined mesostructure were cut flush with the casting (Figs. 34, 35). The existing mandibular prosthesis was relieved internally, new O-ring keepers were inserted, and it was re-lined. No parasthesia occurred at the dehiscent site, although prior to treatment the patient was experiencing transient symptoms.

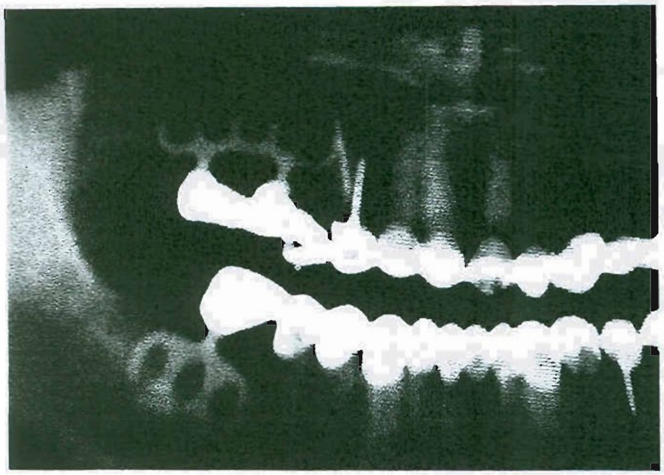

Figure 36. Case 5: Pre-operative Panorex showing failure of maxillary right blade implant after 11 years in function. A full-arch splint was sectioned at the distal of the right canine for endodontic therapy and endodontic post on the canine. The endodontic post perforated the canine root, and the posterior bridge section was not rigidly reconnected. A large bony defect resulted from failure of the canine and the overloaded posterior implant.

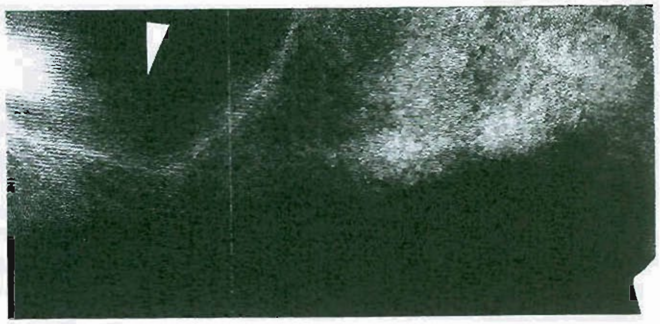

Figure 37. Case 5: Six-month radiograph of resorbable HA graft at canine site and sinus elevation (arrow).

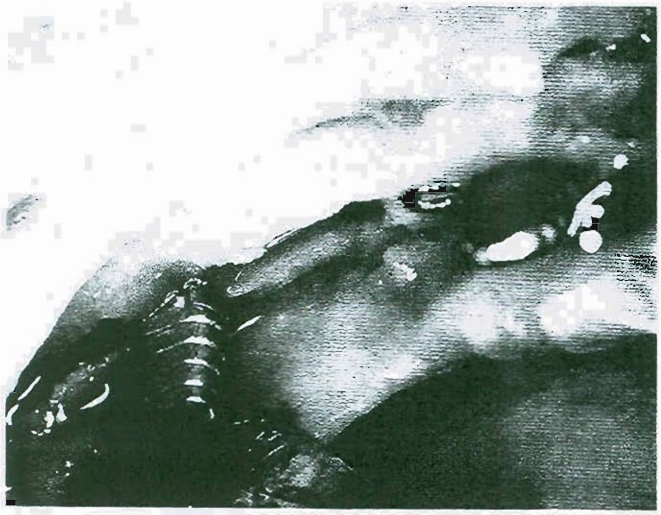

Figure 38. Case 5: Blade implants are seated in regenerated bone of the grafted area shown in Fig. 37.

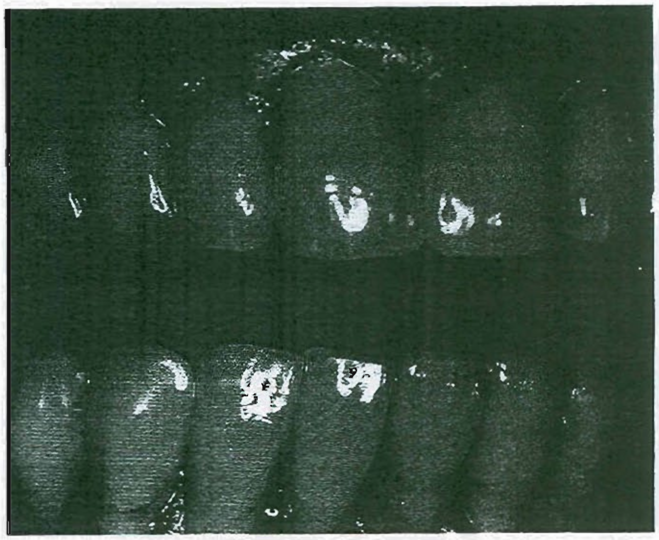

Figure 39. Case 5: Completed prosthesis which uses blade implants and natural teeth as abutments.

Case 5: Replacing a failed implant and tooth to save part of the existing prosthesis and restore the arch.

A patient was evaluated for whom the maxillary arch had been restored 12 years earlier with a 12-unit fixed porcelain bridge. It included a double-abutment, titanium blade implant in the maxillary right posterior area (Fig. 36).

The terminal natural tooth for the implant portion of the bridge was the right canine. Several years before, this tooth required endodontic therapy and a post and core. This treatment had been responsible for a root perforation mesially, the post extending over 7 mm into the interseptal bone. The canine crown had been sectioned from the implant-supported portion of the bridge and a new crown constructed with an extension to the 1st premolar pontic. This stabilized the implant-supported section, where resin composite was used on the components. The implant bridge, from the 1st premolar pontic to the 2nd premolar and 1st molar implant abutments, had separated from the new canine crown, however. This led to a "springing" action on the posterior right implant and portended failure. The perforation on the mesial surface of the canine had resulted in severe bone resorption and the formation of a large granuloma. The right canine tooth and the posterior implant were removed.

The large bony defects were debrided and decorticated. Large craters existed at the implant and the canine sites, with perforations of the facial cortical plate. An exposure of the maxillary sinus was noted.

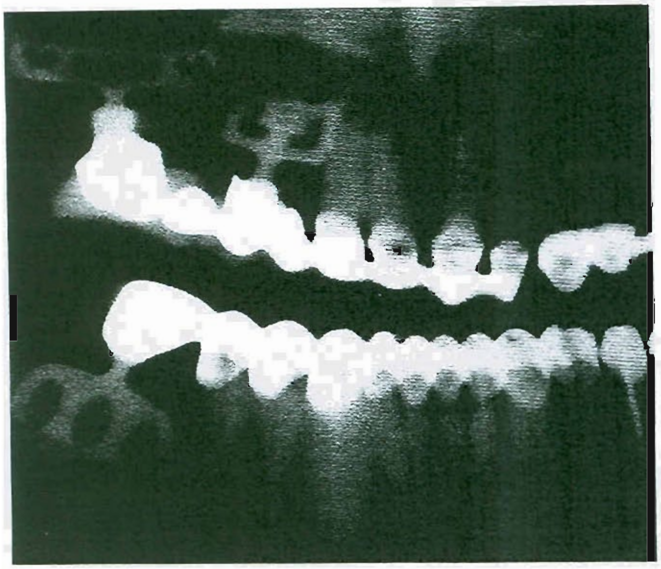

Figure 40. Case 5: Post-operative Panorex illustrating bridge shown in Fig. 39.

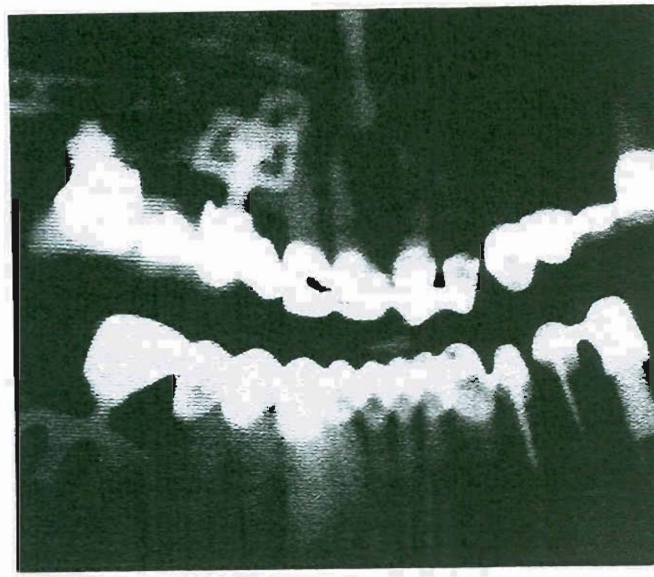

Figure 41. Case 5: Seven-year post-operative Panorex showing no radiographic changes of the blade implants in the grafted site. A root-form implant was used to replace the left mandibular 1st molar, which fractured at root bifurcation three years after the Panorex in Fig. 40 was taken.

There was inadequate bone available for immediate placement of implants. The intact Schneiderian membrane was elevated from a crestal approach for a distance of 8 mm.

Resorbable hydroxylapatite was mixed with venous blood and a microfibrillar collagen matrix into a thick putty consistency and placed into the bony defects and below the elevated Schneiderian membrane (Fig. 37). The soft tissues were co-apted and sutured with 3/0 black silk. The area was re-opened six months later, and two blade implants were inserted into the dense regenerated bone (Fig. 38). The existing bridge was sectioned from the left canine, and a new bridge was constructed from the left lateral incisor to the right canine and posterior implants (Figs. 39, 40). The bridge and two implants in the grafted sites have been in function for eight years and reveal no bony breakdown, and the lower blade implant has been in function for over 18 years (Fig. 41).

Discussion

During the past decade, it has been estimated that the number of dentists inserting implants in the United States has increased from fewer than 1,000 to over 25,000. The vast majority of these more recent entrants have been trained in root-form systems only. This has resulted in their inability to utilize the blade-vent, plate-form, and subperiosteal implants. These implants require additional training and experience. Their use appears to be confined, for the most part, to only a small number of practitioners. Although there have been problems with cases utilizing blade-vent and subperiosteal implants, thousands of early implant reconstructions utilizing these implants have been very successful for three decades or more (Bodine, 1978; Linkow, 1979; Cranin, 1987; James, 1983).

Blade, plate-form, and subperiosteal implants have a significant capability to serve as long-standing and viable abutments. Major refinements in design, materials, and surgical techniques have evolved for these implants (Linkow, 1983b, 1984, 1986b; Wagner, 1988, 1992). Blade and plate-form implants have as much capacity to osseointegrate as do root-form implants (Linkow *et al.*, 1992). Significant advances in allograft materials and techniques have enabled surgeons to place implants in sites previously unavailable (Tatum, 1986; Misch, 1987; Wagner, 1989, 1990, 1991a; Chanavaz, 1990).

These advancements have increased implant longevity and predictability (Linkow, 1986a,b; Cranin, 1987; Golec, 1980). Implant practitioners should be encouraged to enlarge their spectra of activities. The key to success in implant dentistry begins with a correct diagnosis and treatment plan. It is necessary to understand the prosthesis design which is most desirable and whether it is feasible to fabricate before the surgery. It is necessary as well to select the proper implant for the bone available on a case-by-case basis. Established surgical protocols for the implant's insertion must be followed scrupulously. Prosthetic designs and occlusal schemes must be utilized that do not overload the implants. Patient compliance and post-operative management of the implants and the prosthesis are essential to long-term success. If one or more implants fails, the entire case need not be lost. It is every implant practitioner's obligation to seek methods to repair, treat, or replace a problem implant, even with an implant of another design.

Use of osseointegrated root-form implants has been responsible for the acquisition of excellent surgical skills by their proponents, who have now amassed considerable experience. It is anticipated that this paper will encourage these practitioners to seek additional training in alternative implant techniques for the benefit of their patients. It is hoped that they will then be able to contribute their insights and expertise to the overall field. Teeth and implants can fail, and methods have been described which are designed to salvage many implant cases that have developed problems. An implantologist who gains these additional capabilities and who becomes eclectic has an enormous advantage in treating problem cases.

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