

# Management of the posterior maxilla in the compromised patient: historical, current, and future perspectives

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The posterior maxilla has been described as the most difficult and problematic intraoral area confronting the implant practitioner, requiring a maximum of ingenuity for the achievement of successful results(39, 59). Both anatomical features and mastication dynamics contribute to the challenge of placing titanium implants in this region.

Anatomic factors include decreased bone quantity, especially in older edentulous or partially edentulous patients who have experienced alveolar resorption in the wake of tooth loss. The antrum also tends to enlarge with age, as well as with edentulism, and this further decreases the amount of available bone. In addition to the diminished quantity, bone in the posterior maxilla often is softer and of poorer quality. Radiographs typically reveal a dearth of trabeculations, and the tactile experience of drilling here often more closely resembles the penetration of styrofoam rather than anthracite. Limited access to the pterygomaxillary region constitutes yet another problem.

Mastication dynamics also affect the long-term stability of implants placed in the posterior maxilla. Whereas masticatory forces of 155N have been reported in the incisor region, the premolar and molar regions have exhibited forces of 288N and 565N, respectively(3). Parafunction can increase these forces as much as three-fold(4-6), applying significant stress to the bone-implant interface and the component hardware.

Despite the biomechanical impediments to creating prostheses in the posterior maxilla, patients who have lost teeth in this area have sought some means of restoring both their chewing ability and their

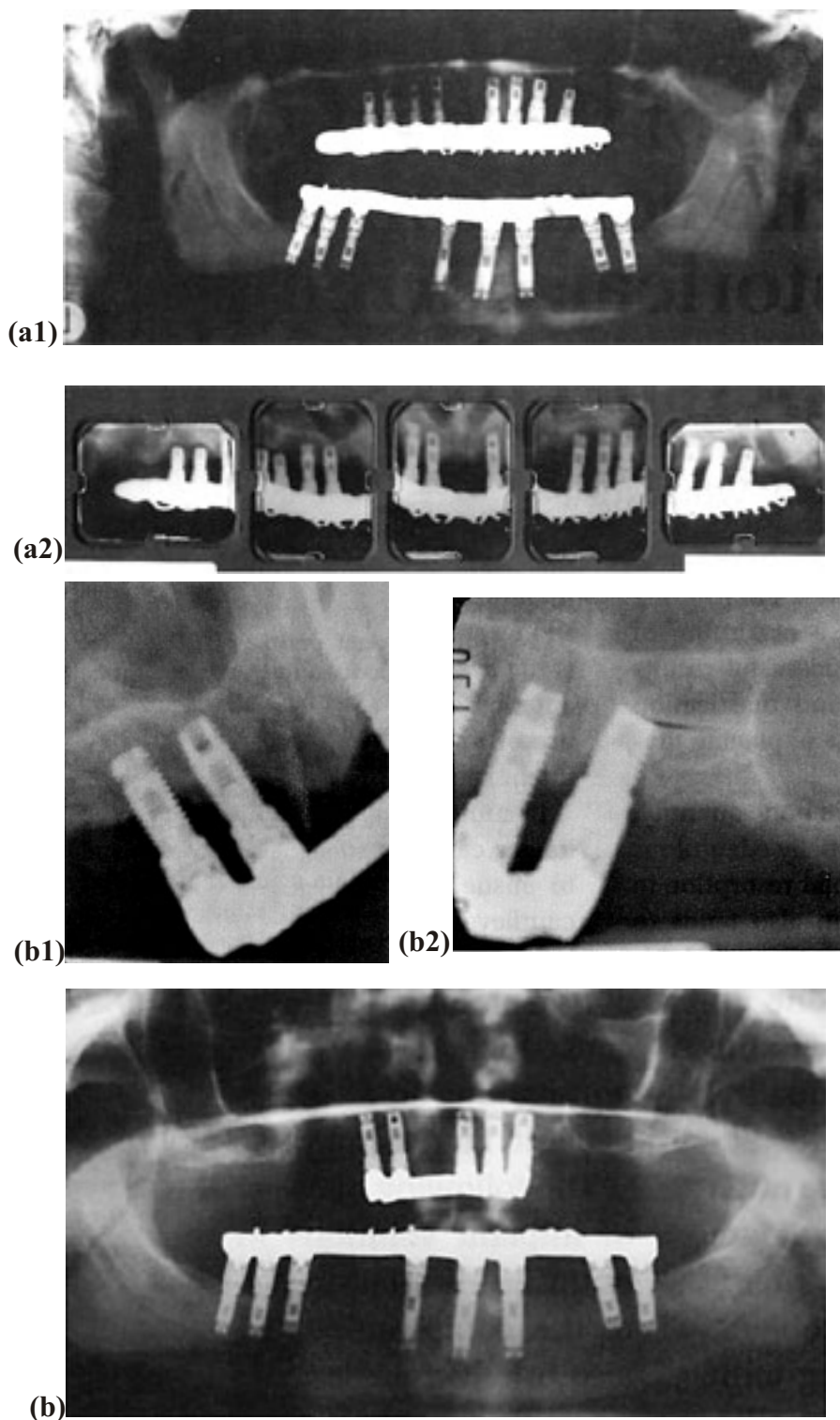
appearance. One solution has been the use of posterior cantilevers on implant prostheses. When designed to minimize the occlusal forces applied to the pontic, short cantilevers can function successfully. One key is the availability of several long and strong implants anterior to the cantilever. The author also suggests the use of implants of 4mm diameter or greater, if the intent is to create a cantilevered prosthesis.

If sufficiently strong anchors are unavailable or longer cantilevers are required, problems are likely to ensue. Complications associated with posterior cantilevers include screw loosening and fracture, bone loss around the most distal fixtures, and loss of osseointegration(7) (Figure 1). As awareness of such consequences has grown, the alternative of creating non-cantilevered bone-anchored restorations has become increasingly desirable.

The following discussion reviews the development of implant solutions in the posterior maxilla and examines the feasibility of applying these solutions to the compromised patient. Future prospects are also briefly assessed.

## Standard Implant Placement

Studies of the long-term success of osseointegrated implants placed in the posterior maxilla have painted a mixed picture. Jaffin and Berman, reporting specifically on implants used in this region(8), noted a higher failure rate related to Type IV bone. Schnitman(9) showed that only 72 percent of implants placed in the posterior maxilla achieved osseointegration. When Widmark et al studied the results of implants placed in the severely resorbed maxillae



**Figure 1 (a) Panoramic and periapical radiographs of maxillary fixed detachable prosthesis with cantilever illustrating advanced bone loss on posterior fixture. (b) Transition from fixed detachable prosthesis to maxillary implant overdenture one five implants after removal of three posterior implants with advanced bone loss. Note the bone loss on the remaining implants as well. (1c) Additional fixtures placed in the pterygoid region for extension of the overdenture bar for better stability.**

of 36 patients (16 of whom received bone grafting and 20 of whom did not), they found that after three to five years, the success rates in the two groups were 74% and 87%, respectively<sup>10</sup>.

Other investigators, however, have found significantly higher success rates. Bahat<sup>(11)</sup>, analyzing the experience with 660 Brånemark System implants placed in the posterior maxilla and followed in 202 patients for up to 12 years after loading, found a cumulative success rate of

94.4 percent at five to six years and a 93.4 percent rate after 10 years. Lazzara and coworkers found a success rate of 93.8 percent among 529 implants placed in the posterior maxilla<sup>12</sup>. The Kaplan-Meier success rate for 167 IMZ posterior maxillary implants after 80 months was 96.9 percent, according to Haas and colleagues<sup>(13)</sup>. And when Buchs and associates studied Steri-Oss HA-coated threaded implants, including 416 placed in the posterior maxilla, their life-table analysis indicated a 96.6 percent five-year success rate<sup>(14)</sup>.

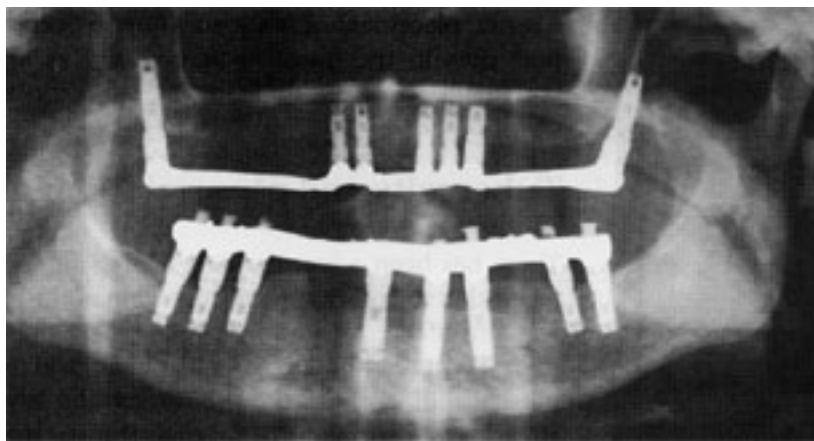


Figure 1. continued

A number of recommendations for achieving predictable implant osseointegration in the posterior maxilla have been made. To obtain a greater surface area for bone contact, Langer et al suggested the use of wider diameter implants(15). More recently, Bahat recommended placement of a sufficient number of implants to support the occlusal load in a way that avoids nonaxial loading(11).

In the author's experience, standard implant placement in the posterior maxilla is indicated if at least 8mm of bone is available below the sinus. In such cases, a 10mm implant can be utilized. The apical threads of the implant will engage the layer of cortical bone that forms the antral floor, thereby creating bi-cortical stabilization of the fixture and a slight apical tenting of the sinus membrane. This tenting, or mini sinus lift, is similar in effect to the osteotome technique for fixture placement(16).

Another alternative is to utilize longer implants, tilting them anteriorly between the floor of the sinus and the apex of the canine or other anterior teeth. Such off-axis loading of maxillary anterior implants has been shown(17,18) to achieve osseointegration and create a stable support system for the prosthesis.

Immediate extraction sites also offer opportunities for standard implant placement in the posterior maxilla because residual bone usually exists around the extraction site.

When standard implants are placed in the posterior maxilla of partially edentulous patients, the final prosthesis will not enjoy the benefit of cross-arch stabilization. Therefore, more implants are recommended to prevent the overload bending moment forces that can cause bone loss around the implants (Figure 2).

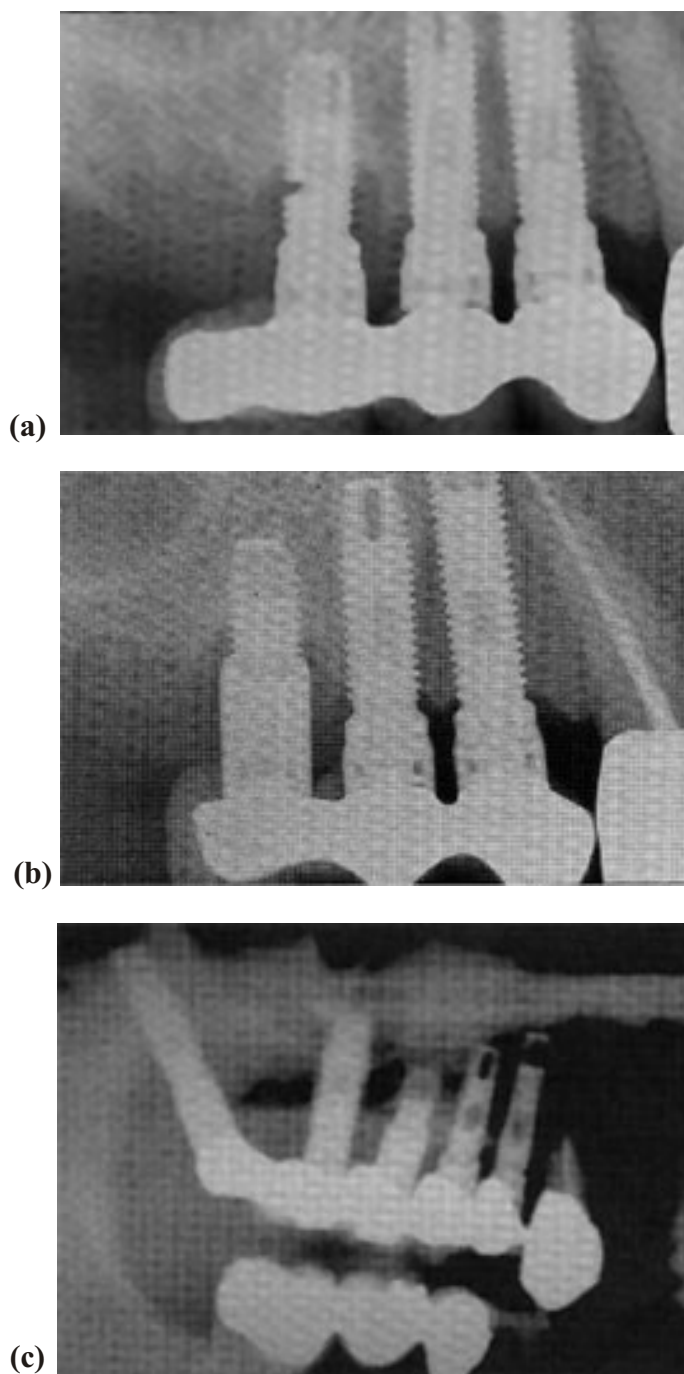
### Hard-Tissue Grafting in Conjunction with Standard Implants

When standard implant placement is contraindicated because of inadequate bony volume, one approach historically has been to augment the ridge. Breine and Brånemark first described the use of onlay composite bone grafts for reconstruction of compromised severely atrophic ridges in 1980(19). Although the original technique has evolved considerably since then, unpredictable resorption of the graft material has been a continuing problem(20). Verhoeven et al, assessing various studies of onlay grafts, sandwich osteotomies, and onlay grafts plus hydroxyapatite augmentation, found that in the first year after bone grafting, resorption is significant and may continue for up to three years(21).

Even when successful, grafting of the ridge may reduce the posterior interocclusal space so significantly as to cause prosthetic restorative problems(22). Another approach, therefore, has been to augment the floor of the sinus. Introduced by Dr. Hilt Tatum in 1975(23), the sinus lift graft has gradually gained proponents over the years, and a 1996 consensus conference on sinus grafts organized by the Academy of Osseointegration found that sinus grafting should be considered a highly predictable and effective therapeutic modality(24).

Today two basic sinus grafting strategies exist. In the first, elevation of the sinus and placement of the implants occur simultaneously. This approach offers the advantage of requiring fewer surgeries, while at the same time allowing for a shorter treatment time and reduced expense. However, at least 5mm of bone must be present in order to ensure rigid fixation of the implant at the time of placement(25) (Figure 3).





**Figure 2a** Unilateral maxillary posterior implant reconstruction showing advanced bone loss around distal fixture and subsequent implant fracture. **(2b)** Replacement of fixed prosthesis without cantilever after distal implant was resurfaced. **(2c)** Additional implants placed for better stability of unilateral maxillary posterior prosthesis.

When atrophy of the antral floor is more advanced, the alternative is to stage the surgeries, placing the implants six to ten months after the initial bone graft. Allowing additional time for the implants to heal in the grafted bone, the overall procedure may require a time

commitment of close to two years, a prospect that is unattractive to many patients.

Furthermore, all grafting may result in complications, including infection and loss of grafted bone. As a result, placement of implants in more distant support sites in the maxilla has emerged as another potentially attractive alternative.

### Tuberosity and Pterygoid Implants

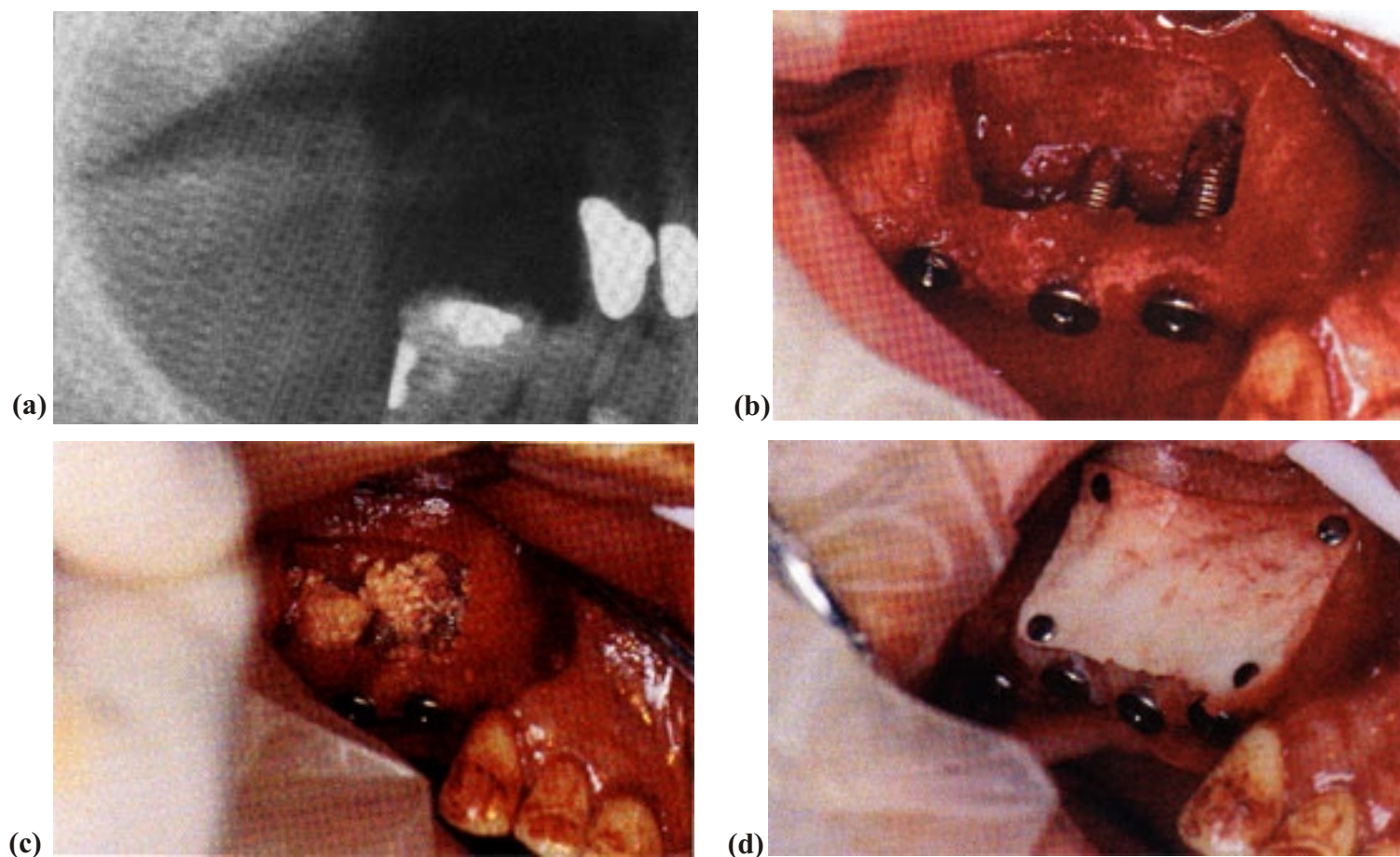
There has been a longstanding feeling among clinicians that the pterygomaxillary region of the maxilla was unsuitable for implants because of large fatty marrow spaces, limited trabecular bone, and the rare presence of cortical bone covering the alveolus. However, subsequent clinical trials showed that titanium fixtures could successfully osseointegrate in this area(26-27). Indeed, the density of some of the pterygomaxillary structures may provide stability that exceeds that offered by the anchorage in any other part of the maxilla(28).

Reiser's anatomic investigations using cadaver dissection have shown that the specific structures that may support implants are the tuberosity of the maxillary bone, the pyramidal process of the palatine, and the pterygoid process of the sphenoid bone(29). At times it is possible to place an implant completely within the first of these (and avoid angling the implant apex more distally), depending on the tuberosity's dimensions and quality. If the height, length, and/or width of the tuberosity are not adequate, however, the implant can be angled and the apex made to engage either the pterygoid process, the pyramidal plate of the palatine bone, or both. Recent observations and measurement of the height, anteroposterior distance, and mediolateral distance of the pyramidal process indicate that placement of implants in the lower half of the pyramidal process is advantageous(30).

Such fixtures have provided successful support for a variety of tissue-integrated prosthesis forms, including multi-fixture complete-arch fixed prostheses (Figure 4), complete removable overdentures with fixed retention bars (Figure 1c), multiple fixture-supported restorations independent of the natural dentition (Figure 2 c), and terminal abutments for partial fixed prostheses connected to the natural dentition (Figure 5).

### Treatment planning

Several factors should be weighed by the treatment team when considering the use of implants in the tuberosity or pterygomaxillary region. Access to the oral cavity is often limited. Prior to surgery, therefore,



**Figure 3a** Preoperative panoramic view of advanced bone loss in maxillary posterior region. **(3b)** Caldwell-luc procedure in fracturing buccal plate of bone and placement of three fixtures to support and elevate the bone plate and sinus membrane. **(3c)** Placement of 50/50 mixture of autogenous bone and Bio-Oss bovine bone material for sinus grafting. **Figure 3d** Placement of a Bio-Gide resorbable membrane with the use of four titanium

tacks. **(3e)** Postoperative panoramic radiograph showing the placement of three implants in the grafted area and a pterygoid fixture for posterior support. **(3f)** Clinical view five months postop showing complete bone fill. **(3g)** Panoramic view of final prosthesis in place. **(3h)** Periapical views showing final prosthesis in place and bone graft one year after surgery.

it is critical to measure the vertical opening available for fixture placement and restoration. The amount of space required for the drilling instrumentation and the fixture mount, as well as the length of the implant to be placed, must be considered.

Accurate radiographic analysis of the available bone using computerized tomography and panoramic radiographs also is important in planning implant placement in this complex region.

Finally, because of the limited access in the pterygomaxillary area, placement of implants here requires considerable surgical skill. Extensive experience in fixture placement in other areas of the maxilla is recommended.

### Clinical results

Given adequate surgical expertise, the success rate for implants in the pterygomaxillary regions compares favorably with the results of previous studies of implants

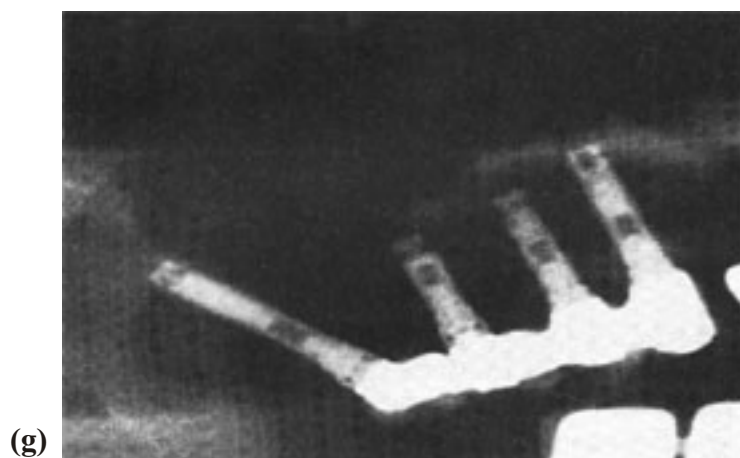
placed in the maxillary arch. In 1999, the author reported on the results of placing 356 pterygomaxillary implants in edentulous arches and found a cumulative survival rate of 88.2 percent after an average functional period of 4.68 years(31). Five other studies of pterygomaxillary implants(32-36) also have revealed cumulative survival rates that were consistently above 86.0 percent.

### Zygoma fixtures

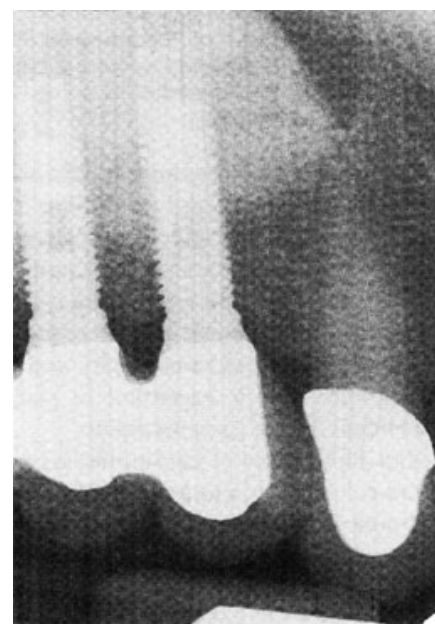
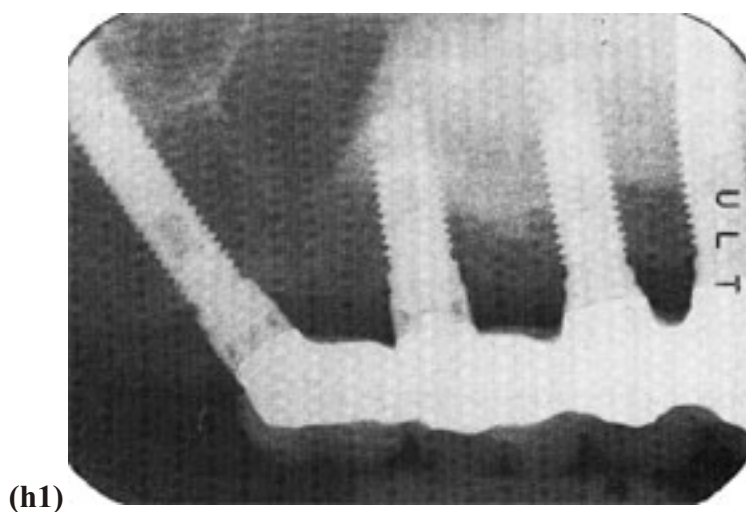
The volume of bone in the pterygomaxillary area is not always sufficient to support placement of implants. In such cases, when patients have severely atrophic maxillas and are unwilling or unable to undergo extensive bone grafting, Zygoma fixtures (Nobel Biocare, Göteborg, Sweden) may provide an alternative.

Ranging in length from 30mm to 52.5mm, Zygoma fixtures are anchored in two different types of bone. The head of the fixture normally emerges in a slightly palatal position in the second premolar or first molar



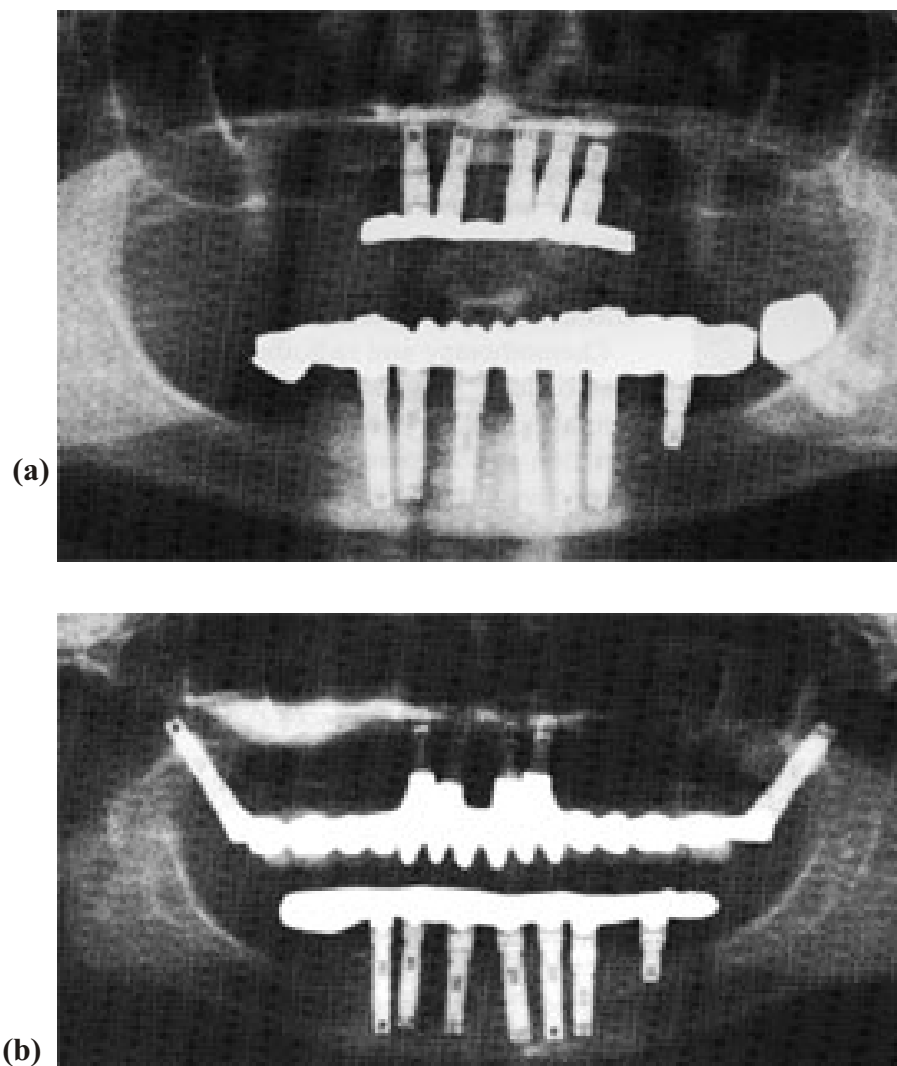


(f)



area of the maxilla, while the other end of the fixture engages the very dense midfacial zygomatic bone. The body of the fixture thus traverses the posterior portion of the maxillary sinus, ideally avoiding penetration of the sinus mucosa. Initial sinoscopic studies of patients treated

with Zygoma fixtures indicate that the presence of a titanium foreign material inside the sinus cavity does not appear to increase the risk of inflammatory reactions in the nasal and maxillary sinus mucosa.



**Figure 4a** Five implants to support a mandibular implant overdenture in the anterior region. **(4b)** After loss of one of the anterior implants, implants were placed in the pterygoid maxillary region to support a full arch maxillary fixed detachable porcelain fused to gold prosthesis.

Preparation of the fixture sites is accomplished with the patient under deep sedation or general anesthesia. After determining the exact point on the alveolar crest to start the drilling sequence and the direction of the long axis of the fixture, a series of long twist drills of increasing diameter is used to prepare the receptor sites. A Zygoma fixture is then placed and allowed to heal for five to six months before being loaded.

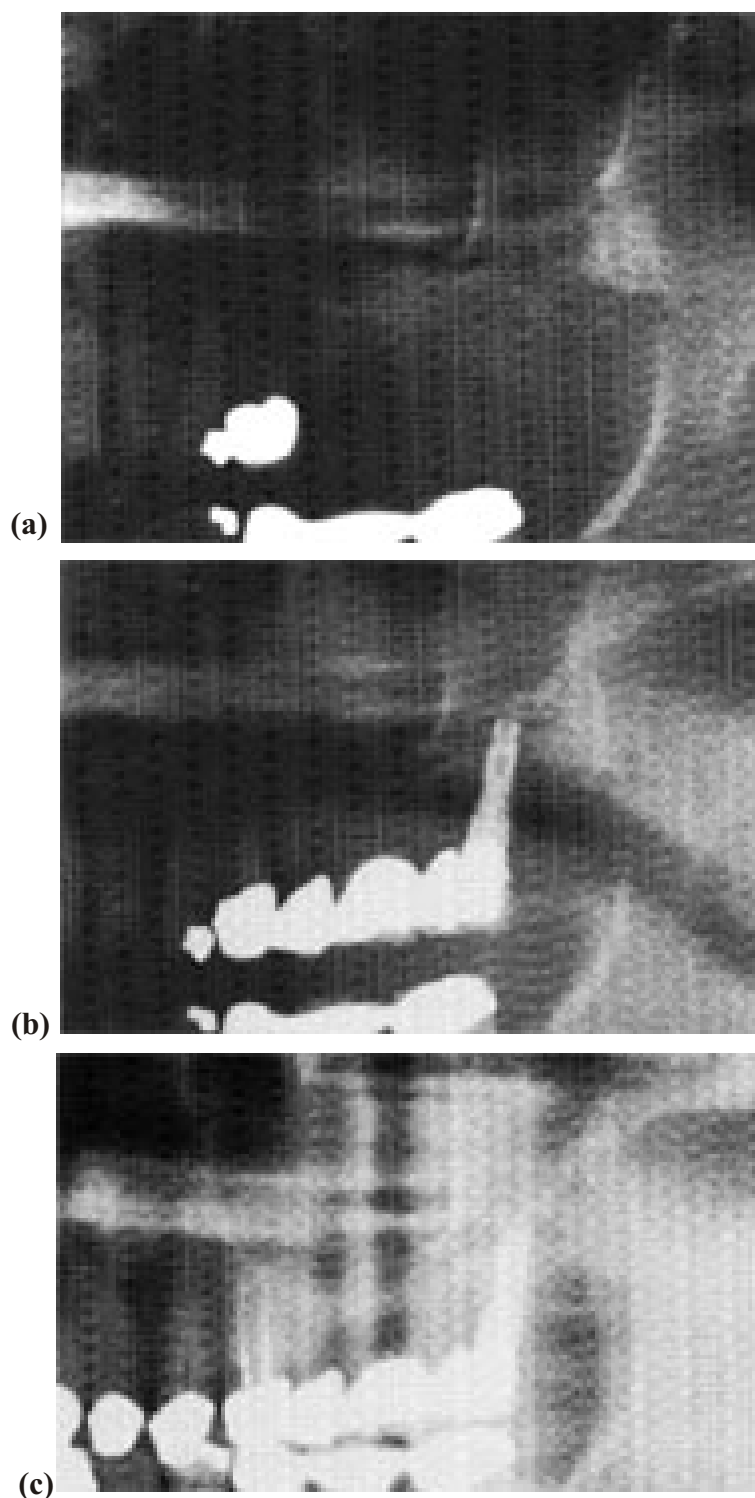
Because of the greatly increased length of the fixtures and the limited bone support commonly found in the alveolar crest, Zygoma fixtures have an increased tendency to bend under horizontal loads. Since bending forces can jeopardize the long-term stability of implant-supported restorations, Zygoma fixtures must be placed in combination with at least two, and preferably more, standard implants in the anterior maxilla, in order to distribute the functional load and prevent rotation. The restoration should ideally include cross-arch stabilization (Figures 6,7), decreased buccal lever arms, decreased cantilevers, balanced occlusion, and decreased cuspal inclination.

Placement of the Zygoma fixtures is demanding and difficult, requiring considerable surgical expertise. On the other hand, this approach offers patients and implant practitioners a number of advantages, including shorter treatment and hospitalization times than that required by most grafting procedures, as well as reduced pain and risk of morbidity. The ability to use fewer implants may also result in lower treatment cost.

One study of the Zygoma fixture by Brånemark has indicated an overall success rate of 97 percent(38), but this evaluation is only preliminary.

#### **Treatment of the Maxillary Sinus in the Compromised Patient**

A variety of medically compromising conditions may be encountered in patients who lack dentition in the



**Figure 5a** Panoramic view showing advanced bone loss in maxillary posterior region. **(5b)** Placement of one fixture in the pterygomaxillary region and restoration in connection to the natural tooth. **(5c)** Panoramic view thirteen years later showing the response of the restoration of an implant in the pterygomaxillary region connected to a natural tooth.

posterior maxilla and seek implant therapy as a means of restoring form and function in that area. Unfortunately, the body of clinical studies evaluating the success of various implant modalities in various categories of

compromised patients is limited. Until more definitive evidence emerges, the following set of guidelines may prove useful.

### Contraindications

Three conditions are considered by the author to be absolute contraindications for the placement of any type of implant in the posterior maxilla: a recent or imminent course of chemotherapy and radiation, drug or alcoholism addiction, and blood dyscrasias that directly effect bone metabolism.

Chemotherapy and radiotherapy disturb the bone metabolism, suppresses the immune system, and diminishes healing potential. All three elements must function well for osseointegration to succeed. A retrospective study by Wolfaardt et al(39) found that the implant loss rate for patients who had had chemotherapy was 21.88 percent. That study also found one reported case in which all eight mandibular implants placed in a patient who had received chemotherapy one day prior to surgery were lost. Although more investigation of the affect of chemotherapy upon osseointegration is needed, the author currently recommends delaying implant therapy for several months after completion of the chemotherapy.

The metabolic and psychological problems exhibited by patients who are addicted to drugs or alcohol, coupled with their tendency to be non-compliant, make them poor candidates for any sort of implants, let alone those in the challenging and compromised posterior maxilla. As for patients with blood dyscrasias such as hemophilia or leukemia, the author believes that the risk of an adverse outcome due to uncontrolled bleeding or compromised healing warrants recommending against any posterior maxillary implant placement.

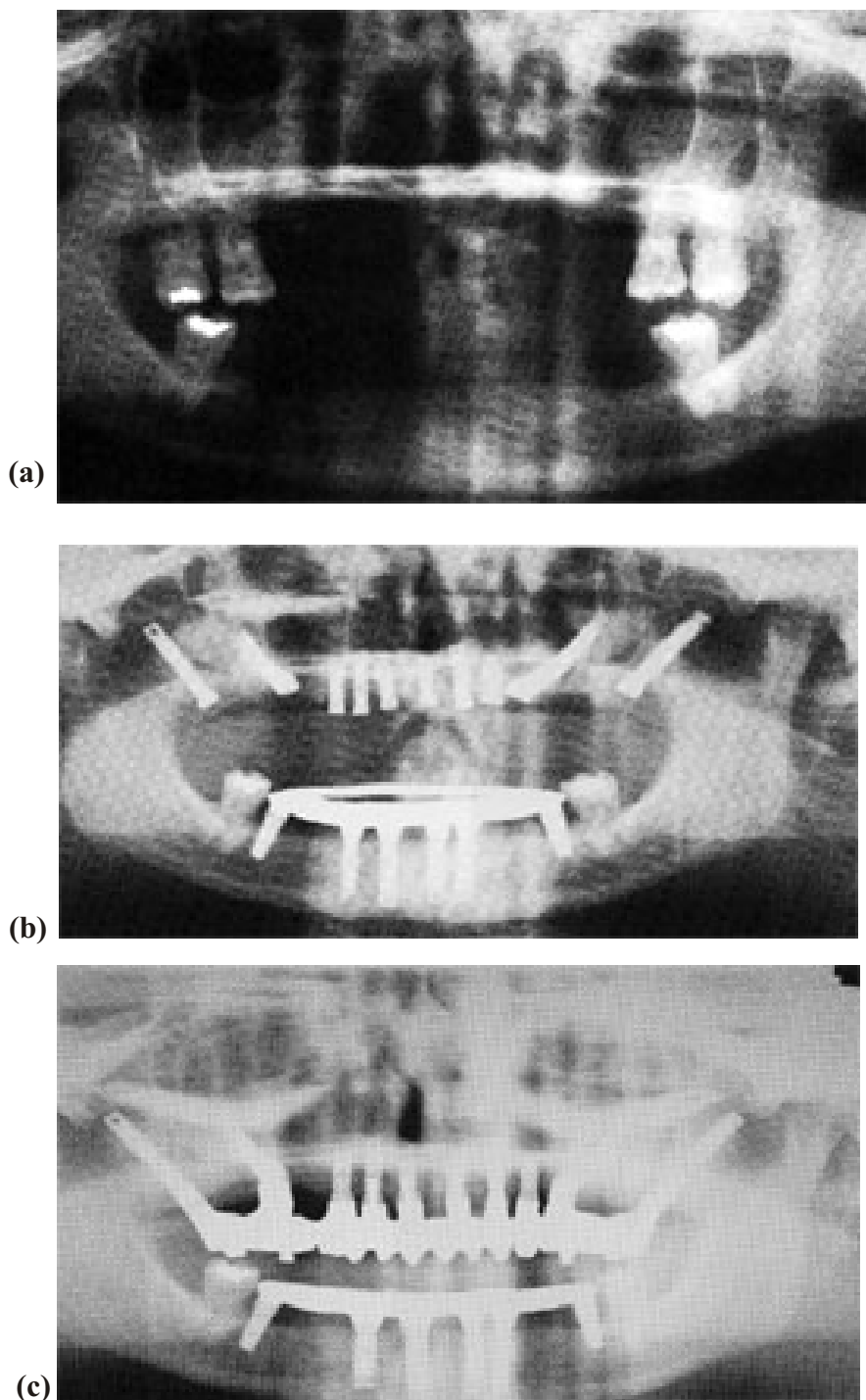
### Indications in compromised conditions

A number of medical conditions may significantly increase the risk of posterior maxillary implant failure when unaddressed. Coupled with appropriate corrective action, however, implant placement in patients with such conditions can enjoy a reasonable likelihood of success. These conditions include diabetes, smoking, severe parafunctional habits, osteoporosis, and Crohn's disease.

### Diabetes

Diabetes has been associated with numerous complications, including an increased incidence of caries(40) and periodontitis(41), a higher susceptibility to





**Figure 6a** Preoperative panoramic view of patient with congenitally missing teeth. **(6b)** Maxillary anterior implants. A total of 10 implants: 2 zygomatic and 2 in the pterygomaxillary area. **(6c)** Restoration of the maxillary arch utilizing implants in both the zygoma and pterygoid regions. **(6d)** Anterior/posterior cephalometric radiograph showing projection of implants in the zygoma area. **(6e)** Lateral cephalometric radiograph showing projection of posterior implants in the pterygomaxillary and zygoma regions.

infection(42-44), and slower healing after surgery(45). However, evidence has accumulated that diabetic patients who effectively control their disease incur a lower risk of various health complications than their uncontrolled cohorts(40,43,46). When Kapur et al compared 37 diabetic patients who received conventional removable mandibular overdentures with 52 individuals who were fitted with implant-supported ones, the researchers concluded that implants could be successfully used in diabetic patients with even low to moderate levels of

metabolic control<sup>47</sup>. A 1994 study found a 92.7 percent implant success rate for Type II diabetic patients under acceptable glucose control(48). And when the author conducted a study of 227 implants in 34 diabetic patients, a survival rate of 94.3 percent was found<sup>49</sup>. This study included 73 implants placed in the posterior maxilla, where the success rate was 94.5 percent.

Implant practitioners should make clear to diabetic patients the importance of achieving adequate

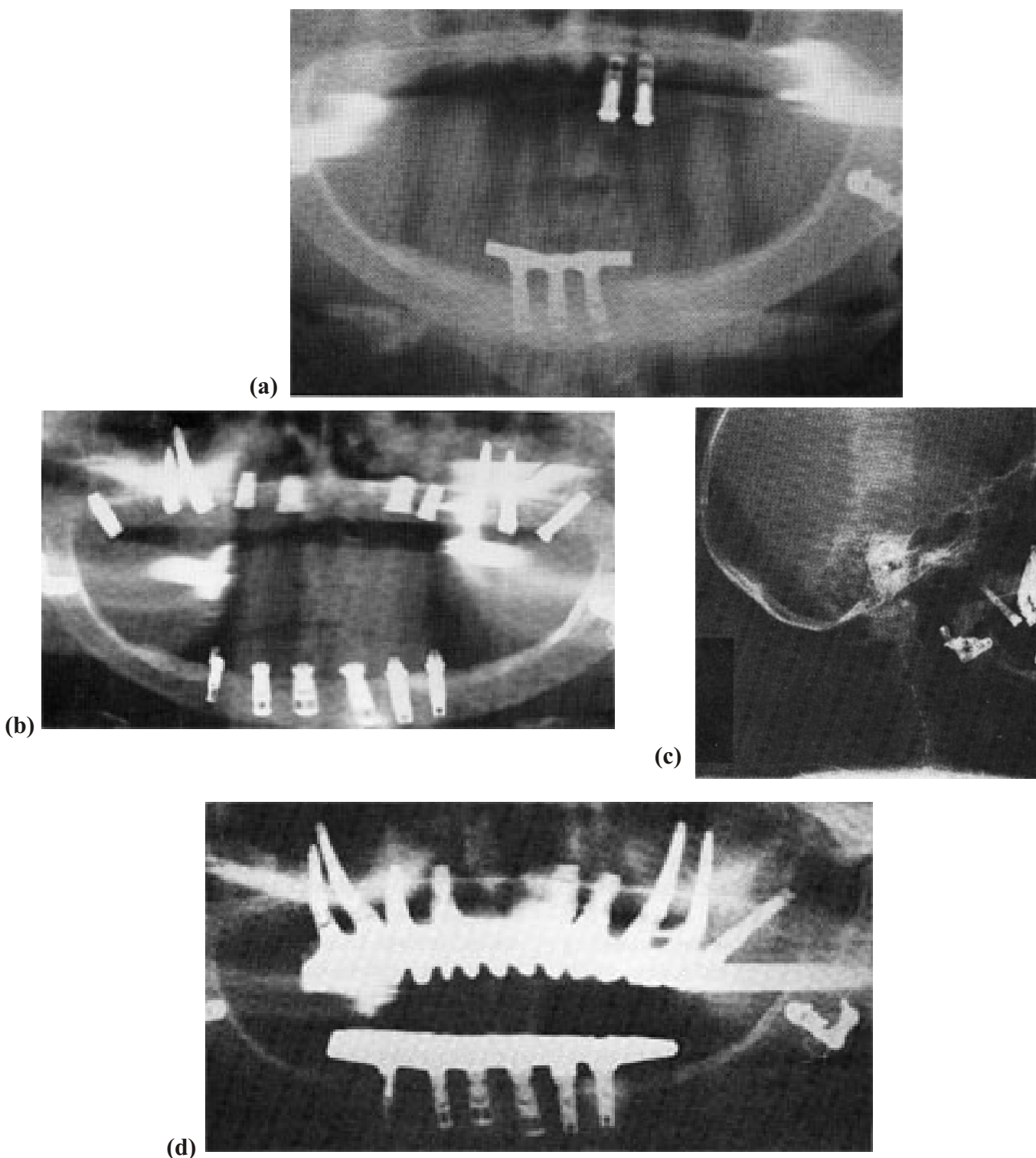


**Fig. 6 continued**

metabolic control, along with stressing the need to take all diabetic medications on the day of surgery and maintain them throughout the healing period. A ten-day regime of broad-spectrum antibiotics beginning on the day of surgery is also recommended.

### **Smoking and parafunctional habits**

The deleterious impact of smoking on osseointegration has been well documented(50,51). Furthermore, implants placed in the maxillary posterior of smokers appear to fare worse than those placed in maxillary



**Figure 7a** Preoperative panoramic radiograph with old implant restoration. **(7b)** Post-surgical radiograph showing implants in the severely resorbed maxilla; a total of two implants on each side were placed in the zygoma region. **(7c)** Lateral cephalometric radiograph illustrating the implants in the pterygomaxillary region and the four implants in the zygoma region.

**(7d)** Post-treatment panoramic radiograph showing reconstruction of severely resorbed maxillary utilizing the four implants in the zygoma region. **(7e)** Anterior/posterior cephalometric radiograph showing projection of the four implants in the zygoma region to support the full fixed maxillary reconstruction.

posterior sites in non-smokers(10,52). Patients should thus be urged to enroll in a smoking cessation program before and after undergoing implant placement.

Patients who find it impossible to stop smoking should be counseled as to the additional risk of implant failure that they may be incurring. Furthermore, they should be advised that utilization



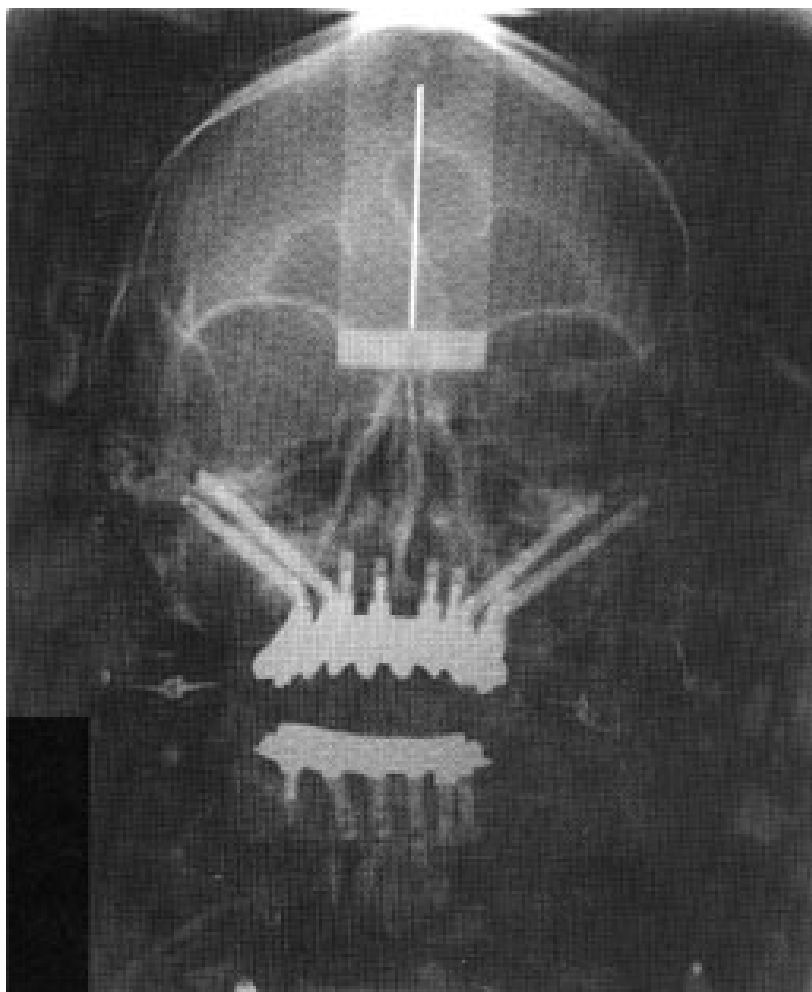


Fig. 7 continued

of additional implants might compensate for the failure of some fixtures to osseointegrate and thus increase their overall chances for prosthesis success. The author employs a similar strategy when counseling individuals with severe parafunctional habits. Additional biomechanical support has proven effective in counteracting the harmful effects of bruxism and clenching upon the prosthesis supported by osseointegrated implants.

### **Osteoporosis**

Osteoporosis currently threatens the health of 25 million Americans. Of those individuals (80 percent of whom are women), some seven to eight million are estimated to have the disease already, and an additional 17 million have low bone mass and consequently are at increased risk for osteoporosis and the fractures it causes.

Screening for osteoporosis is thus a prudent course when considering placement of implants in the posterior maxilla of post-menopausal females. This should include comprehensive reviews of medical history and family history, regarding bone fractures. Whenever osteoporosis

or osteopenia is identified, a program of supplementation should begin immediately. This should include 1200 to 1500 mg of calcium taken three times a day with meals to maximize absorption, as well as a multiple vitamin that includes C and E and between 600 and 800 mg of Vitamin D. Pharmaceutical preparations such as alendronate sodium or raloxifene HCl also should be prescribed.

Osteoporotic patients should be advised about the importance of continuing this therapeutic regime, not only throughout the healing period, but on a continuing basis. Counseling about lifestyle aspects of avoiding osteoporosis such as engaging in weight-bearing exercise and avoiding smoking, caffeine, excessive alcohol, carbonated sodas, and cortical steroids is also recommended.

### **Crohn's disease**

Crohn's disease is a serious inflammatory disorder that predominates in the ileum and colon but may

occur in any section of the gastrointestinal tract. Some 500,000 cases are estimated to exist in the U.S. alone(53).

Because of the potential for involvement of the oral mucosa, the author urges patients with Crohn's disease to achieve effective control of their condition before undertaking any form of implant therapy. Several categories of drugs constitute the mainstay of treatment for Crohn's disease today, including antibiotics, immune modifiers, oral and rectal aminosalicylates, and oral and rectal corticosteroids(54).

### Other Considerations

Although pregnancy in itself has no adverse impact on the osseointegrative process, the stress of surgery or the use of narcotics for pain relief may potentially compromise the unborn baby. Delay of implant therapy until after the baby is delivered is thus recommended.

One other compromising condition worth noting is that of the psychotic patient. When the psychosis relates to the teeth and/or mouth, as is not uncommon, implant therapy may create complications for both the implant practitioner and for the patient's psychiatrist.

### Future Considerations

Over the next decade, technological and scientific advances have the potential to transform the placement of posterior maxillary implants in all patients -- both healthy and compromised -- into a mundane and predictably successful operation. Likely developments include the implementation of genetic and tissue engineering in conjunction with bone surgery and implant placement, as well as systemic enhancement of bone metabolism.

These developments are already well underway. More than 35 years ago, Urist coined the term "bone morphogenetic protein" (BMP) to describe the bone-inducing substance that he hypothesized had caused the formation of new cartilage and bone after implantation of decalcified bone matrix in rabbits and rats(55). By the late 1980s, a group of proteins from bovine bone had been identified(56) and the first recombinant human BMP (rhBMP) had been cloned and characterized.(57) Today more than 20 BMPs have been described(58).

A number of preclinical studies have demonstrated that rhBMP-2 may be used successfully in animals to augment alveolar defects(59-61), and Hanisch and colleagues found significantly greater bone height in

augmented subantral space that had been implanted with rhBMP-2 in the *Cynomolgus* monkey(62). Recent human studies have also shown rhBMP delivered on an absorbable collagen sponge (ACS) to be safe, predictable, and effective(19).

Other delivery methods seem certain to develop with the introduction of new implant technologies. The TiUnite surface (Nobel Biocare, Göteborg, Sweden), for example, seems a precursor to the eventual ability to lace implant surfaces with genetically engineered proteins to stimulate bone growth.

Platelet Rich Plasma (PRP) in conjunction with autogenous grafting is already in use to biologically reconstruct and graft the sinus area. In the future, the growth factors made available through the use of PRP may very well be available through recombinant technology, thereby simplifying the entire treatment process.

### Conclusion

Although management of the posterior maxilla presents many challenges for the implant practitioner, progress on a number of fronts has made it increasingly possible to create successful bone-anchored restorations in this region predictably. When at least 8mm of bone exists below the sinus, standard implant therapy can be considered, particularly in immediate extraction sites or when wider-diameter implants can be employed. A variety of grafting procedures, including sinus lift grafts, may be considered when bone loss is more extensive. Alternatively, the use of implants that obtain support from more distant bony sites such as the pterygomaxillary region or the zygomatic bone has also proven successful. Future breakthroughs in the areas of tissue and genetic engineering are likely to enhance these developments still further. In the meantime, although a few compromising conditions contraindicate the placement of implants in the posterior maxilla, the use of such implants in patients who are diabetic, smokers, osteoporotic, or who have Crohn's disease or severe parafunctional habits can be a prudent option, given proper management of each condition.

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