CASE II–MAXILLA BILATERAL SINUS ELEVATION: ENDOSTEAL ROOT FORM IMPLANTS 15, 16, 24, AND 26 AND MANDIBLE ENDOSTEAL ROOT FORM IMPLANTS 37, 36, AND 46

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KEY WORDS

Bilateral Sinus elevation
Endosteal root form implants
Subantral augmentation

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PATIENT EXAMINATION

History

Chief Complaint

On March 7, 1997, an adult male patient was seen regarding the possibility of receiving dental implants and the procedures of implant placement. A friend who had already undergone the implant placement procedure had recommended this office. The patient, who had lost teeth in all four quadrants, felt very much compromised as to his masticatory function and esthetics. He had experienced temporomandibular joint (TMJ) problems several times and was afraid of losing more teeth.

Secondary Complaint

The particular reason for this appointment was pain in the upper right area, which was getting worse. He had been taking analgesics for 3 days, which gave him only short periods of relief.

Physical Evaluation

Besides the analgesics, he was not taking any medication. His laboratory values (blood, urine, and posthistory) were within normal limits.

Clinical examination

Existing Dentition

Missing teeth were 18, 16, 15, 24, 26, 36, 37, 46, and 48. The residual dentition presented with carious lesions and inadequate restorations of teeth 12, 11, 21, 25, 28, 37, and 45. Of teeth 14, 13, and 22, only the roots existed, all of which had been endodontically treated (Fig 1). Due to missing adjacent teeth or antagonists, tooth migration had occurred vertically and horizontally. Tooth 25 was inclined to the lingual and elongated. Teeth 38 and 47 were inclined to the mesial, and tooth 45 was elongated. Overall, a loss in vertical dimension had occurred, with a resulting deep bite.

1. The adjacent soft tissues on the remaining teeth in the arch were pink

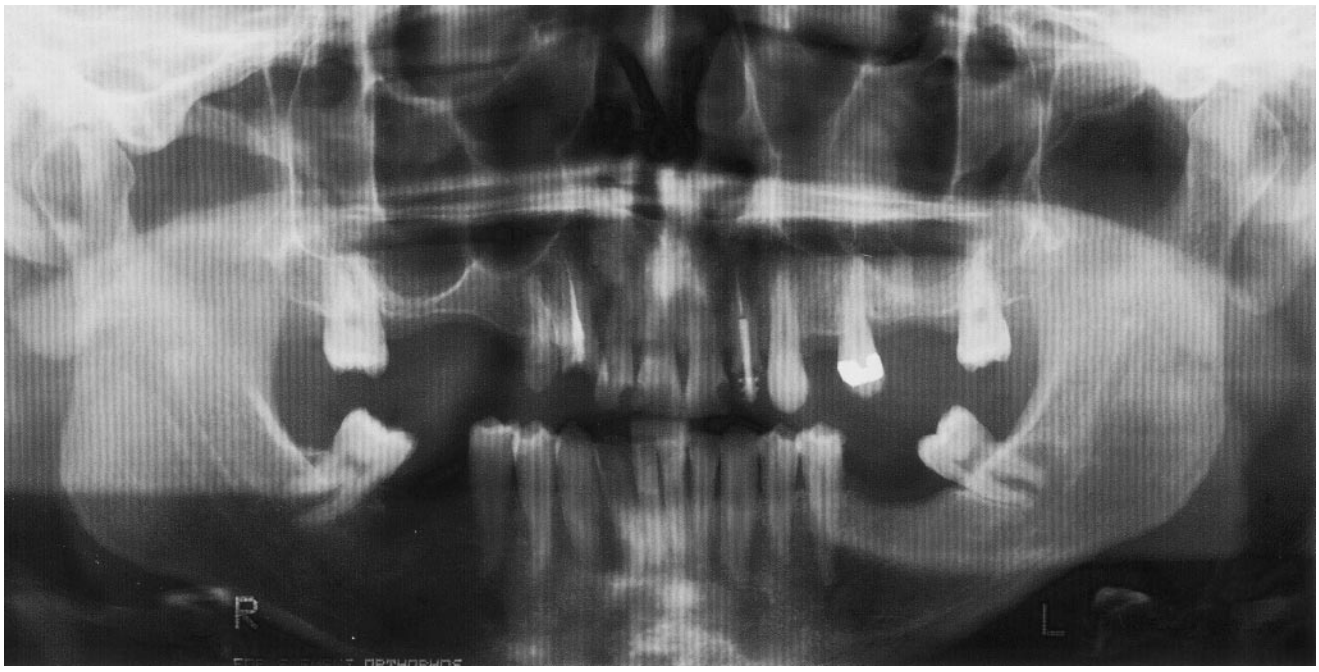

FIGURE 1. Initial panoramic X-ray.

and firm and demonstrated no bleeding on periodontal probing. The soft tissue adjacent to the remaining roots was hyperplastic and inflamed and demonstrated bleeding at the slightest manipulation.

2. Periodontal probing revealed no pathologic sulcus depths, which ranged between 2 and 3 mm.
3. The patient presented with a very low resting lip line as well as a very low smile line. Even with a broad smile, it was hardly possible to see teeth at all.
4. A tenderness was apparent in the bilateral ear and condyle area, most likely the result of an insufficient occlusal plane and subsequent abuse of the articulations.
5. Parafunctional habits were not unearthed.
6. The soft tissues of the edentulous areas were of the same color and consistency as the tissues adjacent to the remaining teeth. The bone in the area of sites 36, 37, 46, and 24 was slightly atrophic in width and height. The alveolar ridge of future sites 15, 16, and 26 presented an advanced degree of resorption in height but not in width.

Radiographic examination

Radiographic Findings

The periapical X-ray of tooth 14 taken at the first appointment demonstrated incomplete root canal treatment and a resulting apical granuloma. Tooth 13 presented with complete endodontic treatment and without apparent pathology.

The panoramic X-ray dated March 3, 1997, confirmed the dental status as diagnosed in the clinical examination, except for the presence of a residual part of the palatal root of tooth 26. Root 22 already presented a restoration with a titanium root post and an acrylic temporary crown, which was done prior to the X-ray. The well-dimensioned sinuses were clear and without pathology. A buttress divided the right sinus into two sections.

Limitations

Maxilla. The situation was unfavorable for dental implant placement due to insufficient bone height because of pneumatization of the maxillary sinuses. Residual bone heights in the areas of sites were $15 > 5$ mm, $16 < 3$ mm, $24 > 12$ mm, and $26 > 5$ mm. It was unfavorable for a fixed prosthesis because of the long distance between putative abutment teeth 17 and 14.

Mandible. There were no limitations for implant placement. The edentulous areas in the mandible proved to be of sufficient bone height and width (division A) and of good density. A limiting factor for tooth-supported bridges from 35 to 38 and from 45 to 47 was the advanced mesial inclinations of the molars.

Preoperative diagnosis

The unfavorable situation in the posterior maxilla for implant placement required prior sinus membrane elevation and augmentation due to bone atrophy in combination with a low position of the sinuses. Due to the number and position of the remaining dentition, there was an unfavorable prognosis for tooth-supported fixed prostheses. Favorable conditions existed, however, in the posterior mandible for implant placement.

DEVELOPMENT OF THE TREATMENT PLAN

Treatment goals

Patient Desires

The patient wished to have fixed prostheses with implant- or tooth-borne porcelain fused to metal crowns and bridges.

1. A correct intercuspation was to be reestablished to permit satisfactory mastication and to inhibit further tooth migration.
2. The patient was very much concerned about the esthetic result, although the low smile line and low lip line virtually would not permit visualization of the restorations.
3. The final prosthesis design had to be designed to facilitate oral hygiene.

Limitations

Other than anatomical limitations in the posterior maxilla, no limitations for dental implants were designed. The patient was in good general health and was physically as well as psychologically well prepared for the planned procedures.

Evaluation of existing natural dentition

1. The patient had a favorable crown to root ratio of <1 of all remaining teeth.
2. Acceptable periodontal conditions existed in maxilla and mandible, except for an incipient pocket on the mesial aspect of tooth 38, which was planned for extraction due to its advanced inclination.
3. Abutment suitability for all teeth was established, with the exception of teeth 14, 13, and 22, which had to be restored with titanium root posts and composite. Teeth 38, 47, and 25 were unsuitable for abutments due to their severe inclination. Since the patient declined orthodontic treatment prior to implant placement and prosthetic treatment, the extraction of 38 and endodontic treatment of 25 were mandated.
4. All other teeth were of acceptable alignment.
5. Teeth 12, 11, 21, 25, 28, 37, and 45 had been previously treated; however, due to carious involvement and also for esthetic reasons, new restorations were necessary.

Interarch relationships

Occlusion

Sagittal. There was a left-angle class I canine relationship and a right-angle class II canine relationship.

Vertical. The patient had a deep bite.

Transverse. There was a midline mandibular shift of 3 mm to the right.

Neutral Jaw Relation

The TMJ function was essentially normal.

Evaluation of the edentulous ridge

Classification

Sites 15 and 16 were classified as division C-h (Misch). Site 24 was diagnosed as division B and site 26 as division C-h. The mandible demonstrated abundant bone width and height and was classified as division A.

Soft and Hard Tissue Anatomy

1. There was a reduced width of the alveolar ridge with a pronounced concavity of the buccal wall at site 24 and an inclination of teeth 38 and 47 to the mesial-reducing space for future implant-borne restorations. A residual root in the area of site 26 required extraction prior to implant surgery. No soft tissue deficiencies were detected.
2. Limiting factors for implant placement in the maxilla were bilaterally enlarged maxillary sinuses, which left little more than 5 mm of residual bone at the crest.

Suitability for Implants

Excellent suitability for dental implants was observed in the posterior mandible and was favorable for site 24.

Prosthetic restoration plan

In accordance with the patient's desire, fixed restorations were chosen.

Advantages

1. Improved esthetics.
2. Greater comfort.
3. Positive bone conservation by functional loading the bone using implants.

Disadvantages of Treatment With Dental Implants

1. Necessity for several surgeries.
2. Necessity for bilateral sinus membrane elevation and antral augmentation with incumbent risks.
3. Higher costs.
4. More difficult access for oral hygiene.

Alternatives

1. Removable prostheses in the maxilla and mandible with clasps as attachments, or
2. Removable prosthesis in the maxilla with precision attachments in porcelain fused to metal crowns for teeth 17, 14, 13, 25, and 27. Tooth-supported fixed bridges in the mandible from 35 to 38 and from 45 to 47.

Rationale

Maxilla. For convenient and esthetic reasons, the patient favored an implant-bone fixed solution. A removable prosthesis based on telescopic crowns would seem unreasonable because of the relatively high cost for a removable prosthesis, while a simpler construction with clasps would not guarantee the positive fixation, in addition to unsatisfactory esthetics.

Mandible. Incipient periodontal problems of teeth 38 and 47 contraindicated the restoration with tooth-borne bridges. To achieve parallelism, endodontic treatments and subsequent titanium root post reinforcements were necessary. To maintain alveolar ridge mor-

phology and for long-term success, the choice for dental implants was made.

Hard and soft tissue modifications

To make implant placement possible in the posterior maxillae, sinus membrane elevations and antral augmentations were mandatory. For the left site, simultaneous implant placement was planned, as the residual bone height was >5 mm (Misch classification SA3). In the right maxilla, residual bone height was <5 mm, which would require an additional procedure for implant placement 3 months after consolidation of the sinus graft. The patient declined orthodontic treatment prior to implant surgery in order to improve the existing occlusal plane and to enlarge the interdental space by correcting the inclinations of teeth 38 and 47. Plans for the extraction of 38 were made. No other hard or soft tissue modifications were necessary.

Implant selection rationale

For the maxilla, four endosteal root-form implants in positions 16, 15, 24, and 26 were planned. For sites 24 and 26, a titanium plasma spray (TPS) coating was selected, as TPS-coated implants provide greater surface areas than machined titanium implants, thus enhancing the possibilities for osseointegration. The alveolar ridge of site 16 had sufficient width for the insertion of a wide-diameter (WD) implant, which would provide a significant increase of bone to implant interface. For sites 15 and 16, Biohorizons implants were chosen. According to their philosophy, implant design and nature of coating should vary depending on bone density; D4 implants were chosen. This implant, which was designed for D4-type bone, has a very large surface because of its deep finlike threads and HA coating.

In the mandible, the placement of three endosteal root form WD implants was planned in positions 36, 37, and 46. TPS surface coatings were chosen.

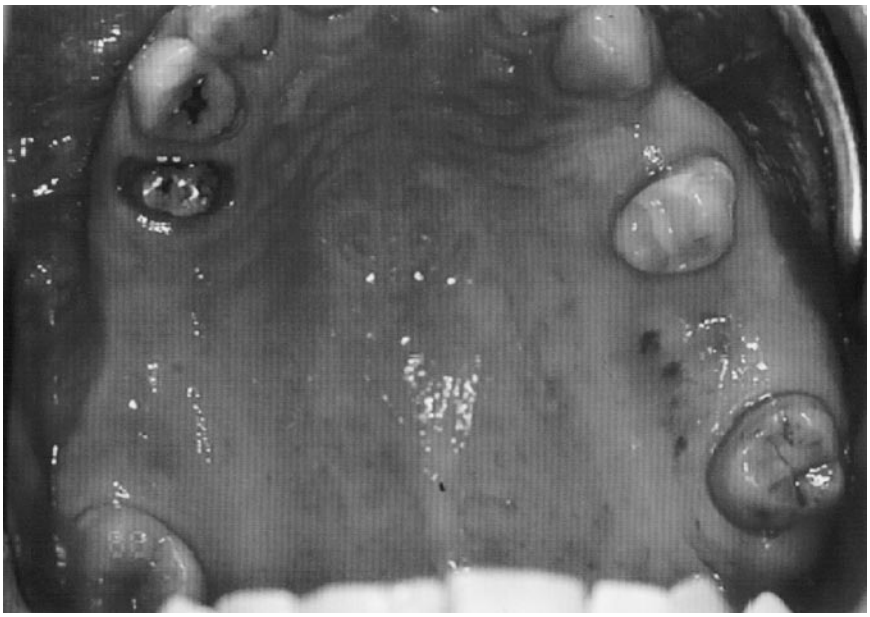

FIGURE 2. Maxilla presurgical site 24 and 26.

SURGICAL PROCEDURES

Subantral augmentation of the left sinus (SA3) and implant placement sites 36 and 37

Prescriptions and patient instructions were identical to those given to patient I.

On January 16, 1998, the patient was scheduled for surgery of the left maxilla and the left mandible. The patient had been previously instructed to prepare himself for a 2-week minimum period of nonsmoking postoperatively, to maintain a soft diet, and to avoid alcoholic beverages, coffee, and tea. On the morning of surgery, the patient was orally sedated with 10 mg of diazepam (Fig 2).

A division II block and local infiltration in the mucoperiosteum of the vestibulum were given as well as an inferior alveolar nerve block.

An incision was made on the palatal aspect of the edentulous ridge from the mesial surface of tooth 27 around the mesial aspect of tooth 24 to the canine area. A vertical relieving incision was made at the buccal aspect of tooth 27. A mucoperiosteal flap was developed and elevated, exposing the complete lateral wall of the maxilla. A previously fabricated vacuform sterile surgical template was placed in the patient's mouth. A 6 round bur was used to mark future implant sites 24 and 26. The implant at site 24 was enlarged first, increasing drill diameters step by step from 1.5 to 3.2 mm under copious irrigation with refrigerated sterile saline and to a depth of 13 mm. During the drilling process, suction was performed, using a bone chip filter, to capture as many bone particles as possible. For later use, this autogenous bone was deposited in a small sterile glass container. The next step was the extraction of tooth 38 and the preparation of implant sites at 36 and 37. A midcrestal incision was made with a 15 blade from the distal aspect of tooth 35 to the left ramus area. Full-thickness mucoperiosteal flaps were developed and reflected from the underlying bone buccally and lingually. Tooth 38 was delivered using elevators and an extraction forceps. With a double-action rongeur, a considerable amount of autogenous bone was harvested from the extraction site and added to the bone from the bone filter. The vacuform guide was then replaced, and future implant sites 36 and 37 were marked with a 6 round bur. The sites were en-

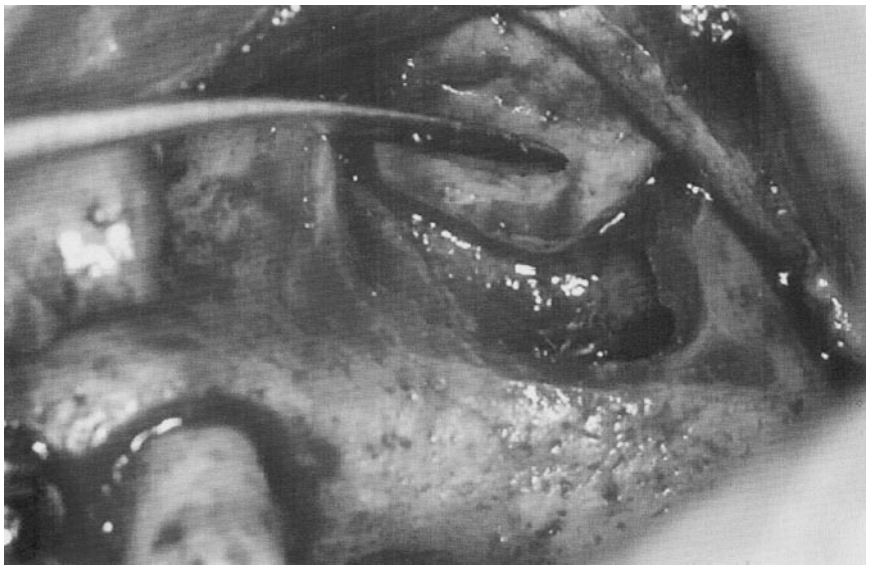

FIGURE 3. Site 26 with window tapped inside.

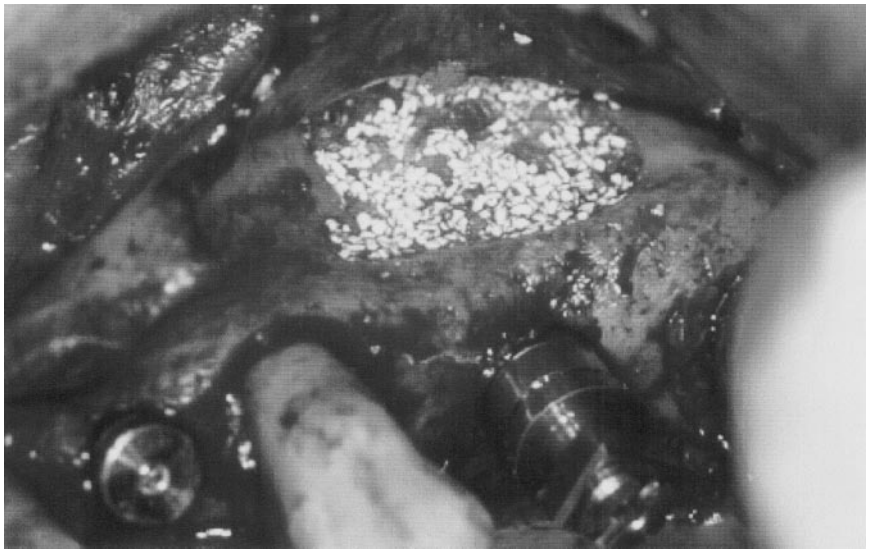

FIGURE 4A. Left sinus grafted.

larged with an increasing drill sequence, beginning with a 1.5-mm bur and terminating with a 4.7-mm-diameter drill. Drilling depth for site 36 was 13 mm and for site 37, 10 mm. Threadformers were used to facilitate the implant insertion in the dense D2-type bone. Here, too, a suction filter was used to harvest bone particles floating out of the drilling site for later use as graft material. The implants were inserted with a 100:1 gear reduction handpiece at 35 rpm under saline irrigation. Titanium cover screws were placed. The site was closed with interrupted sutures using 3-0 Vicryl. Next, the lateral wall access for the antral augmentation was prepared. With a normal handpiece speed and a diamond round bur at 20,000 rpm under irrigation, the outline of the lateral access window was scored. A large soft tissue retractor was placed on to secure the flap superior to the window. With brushing movements of the bur, the cortical bone was carefully reduced until the bluish hue of the underlying membrane and a slight hemorrhage could be observed. With the flat end of a mirror handle tapped by a mallet, the window was carefully tapped inward by causing a greenstick fracture of the residual links between the lateral window and the surrounding bone (Fig 3). A soft tissue curette was introduced along the margin of the window, and the underlying membrane was carefully released from the sharp bony margins. The Schneiderian membrane was reflected from all surrounding cavity walls and pushed upward, together with the lateral window. This cortical plate, rotated into a horizontal position, became the new sinus floor. The implant site was then prepared with the same drilling sequence used for sites 36 and 37. Venous blood was drawn from the patient's arm and centrifuged, which divided the blood into three layers. There was a serum above, red blood cells on the bottom, and a middle buffy coat layer of white blood cells, fibrin, and platelets. Among other factors, the buffy coat contains platelet-derived growth factor, which is involved in the cascade of bone mineralization, as it aids in blood clotting, increases the growth of healing cells, develops new capillaries, promotes bone cell function, and leads to bone regeneration. To take advantage of the osteogenetic capacity of these platelet-derived bone morphogenetic proteins, only this gelatinous part of the sample is added to the graft material, while the rest is discarded. The graft material was prepared from the harvested autogenous bone and consisted of demineralized freeze-dried bone, resorbable HA particles, the buffy coat, and water-soluble ampicillin.

The sinus was packed with the graft material, beginning with the anterior portion of the cavity. Next, the mesial aspect of the antrum was filled, and the implant was inserted (Fig 4A, B). To achieve a maximum implant to graft interface, a TPS-coated WD implant of 5-mm diameter and 13-mm length was chosen. After the implant was inserted, the cover screw was placed, and the residual cavity was packed to the surface

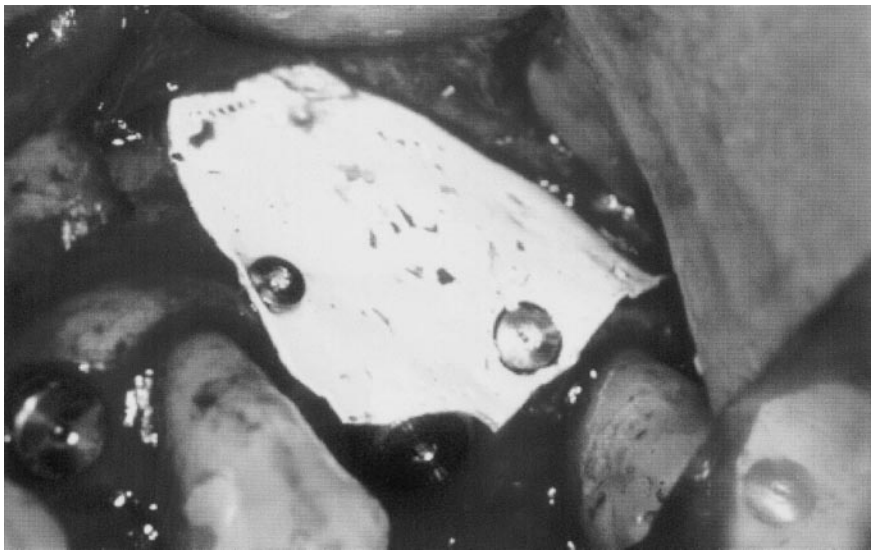

FIGURE 4B. Tef-gen membrane fixated with bone tacks.

of the lateral access window with the graft material; the implant mount was retrieved, and the cover screw was inserted. A nonresorbable barrier membrane was used to cover the graft material in order to inhibit epithelial cell ingrowth. The membrane was affixed with two titanium bone tacks (Fig 4B), and the site was sutured with interrupted sutures using 3-0 Vicryl. The patient felt well and was given ice packs and discharged with postoperative instructions, which included the classic antral regimen.

Postoperative complications

On January 23, 1998, the patient was appointed for postsurgery evaluation. His face was moderately swollen on the left side, and a hematoma had developed under his left eye. He was not suffering from pain. Intraoral examination showed a dehiscence of the suture line in the posterior region of the maxilla. Exposure of the cover screw of implant 26 and of the barrier membrane in the region of the vertical release incision was diagnosed.

The patient admitted that he had smoked after surgery and that he had not reduced his smoking habit at all. As the membrane did not appear infected, the patient was instructed to wash the exterior aspect of the membrane three to five times daily with chlorhexidin and to keep it in place as long as possible.

Also, the suture site of the mandible had suffered from dehiscence, and the implant cover screws were visible. Because of the potential risk of infection due to anaerobic bacteria, which are specifically destructive, on February 27, 1998, a decision was made for placement of healing abutments on implants 36 and 37 and for the removal of the barrier membrane. The advantage of the Tef-gen membrane was its easy removal through a small access opening. Anesthesia was not required for this procedure or for the placement of the healing abutments.

Antral augmentation (SA4) of the right sinus and site 46

On March 6, 1998, the antral augmentation of the right sinus and implant placement at site 46 were performed. Observation of the left maxillary and mandibular quadrants showed a remarkable improvement in their healing status. The site in the posterior maxilla was completely closed by secondary epithelialization, and the soft tissues around the perimucosal abutments of sites 36 and 37 were of healthy color and firmness.

To harvest bone from the drilling site with the suction filter, the surgery of site 46 was performed first. The implant site was enlarged with increasing diameters of drills to a final diameter of 4.7 mm. A threadformer was inserted under external irrigation with cold saline, and the implant was placed with a 100:1 reduction gear handpiece at 35 rpm. The cover screw was positioned, and the site was closed with 3-0 Vicryl suture material.

Because the right sinus had descended toward the alveolar crest, leaving <5 mm of bone, simultaneous implant placement was not planned. A long incision to the palatal aspect of the ridge distal to tooth 14 into the tuberosity with a vertical releasing incision was performed, and a full-thickness flap was reflected to the buccal surface. The entire lateral wall of the maxilla was exposed, and the flap was secured with a retractor. With the handpiece at regular speed using a round diamond bur, the score line for the lateral access window to the sinus was drawn at 20,000 rpm under permanent irrigation with cold saline. The bur was used without any pressure describing brushing movements on the bone surface until the typical bluish hue of the underlying membrane was visible. The posterior and superior aspects of the lateral wall were already extremely thin due to the expanded sinus, and the membrane was partially shining through. Very little drilling was needed to outline the access window. With a slight tap, the window was released from the surrounding bone, and the membrane was pushed off the inner walls of the sinus cavity and elevated without lacerations or tears. A vertical septum in the anterior region of the sinus chamber required elevation of the membrane over the buttress, necessary to permit graft placement in this site. A collagenous sponge was used to push the membrane up and forward and was left in position as a membrane sealant. Elevation of the membrane to the anterior aspect of the sinus was only partially accomplished, as confirmed by the postoperative panoram-

ic. The sinus cavity was filled with a graft mixture of autogenous bone and resorbable HA (2 g), demineralized freeze-dried bone (2 cc), the buffy coat of freshly drawn patient's blood (40 mL), and injectable ampicillin. The sinus was densely packed to the lateral access window and covered with a second collagen membrane, which was tucked under the edges of the bony window. The crest was sutured with a continuous box-lock suture, and interrupted sutures were used for the vertical releasing incision with Vicryl. A postsurgical panoramic was taken, and the patient was discharged with the same instructions he had been given after the first surgery. The patient was specifically reminded to obey the nonsmoking period of 2 weeks.

Surgical and Postoperative Complications

No complications or problems were encountered. He was appointed for observation 3 days later, and no swelling or hematomas were apparent. He reported that he had not suffered pain since the day of surgery and that he had generally felt much better after this procedure compared with the first one. The sutures were removed on March 17, 1998, and the site was healing nicely.

Surgical Procedure for Implant at Sites 15 and 16

On June 23, 1998, the surgery for implant placement in the mandibular quadrant was performed. With the patient under conscious sedation (diazepam, 5 mg), posterior superior alveolar nerve blocks with palatal and buccal infiltration were completed. A midcrestal incision line was performed from the distal aspect of tooth 14 to the tuberosity.

The mucoperiosteal flap was deflected to the buccal, and the surgical stent was placed into the patient's mouth. With a 1.5-mm pilot drill, the future implant sites were marked through the surgical guide. The guide was removed, and the marked sites were enlarged step by step, increasing the drill size corresponding to the planned implant sizes. Site 16 was enlarged to 4.2 mm and site 1.5, to 3.5 mm. As the implant in site 16 would be exclusively seated in nonorganized graft material comparable to D4 bone, the protocol for D4 bone was used to prepare the implant sites. The drills were not inserted to the full depth of the implants but merely passed the cortical plate and the initial part of the underlying graft material. Site 15 was prepared only to a depth of 6 mm. Then, an osteotome with a concave top was inserted, and, by light tapping with a mallet, a greenstick fracture of the sinus floor was provoked (SA2 procedure). This was necessary because the subantral augmentation had been incomplete in the area of site 15, and a puncture of the membrane with the drill was likely to happen if precautions were not taken. The patient was asked to slowly blow out against the digitally closed nostrils to exclude a tear of the membrane. No air or bubbles were exiting the prepared site, which proved the integrity of the Schneiderian membrane. No threadformers were needed, and the implants were inserted with a slowly rotating handpiece. D4 implants were chosen according to the bone/graft quality of type D4. The attached straight hexed abutments were unscrewed from the implant bodies and replaced by cover screws. The straight abutments were cleaned, sterilized, and stored for utilization in the final restoration.

Stage II surgery

On February 1, 1999, stage II surgery was performed for all quadrants at the same time, except for the lower left quadrant, where the healing abutments were already in place. Midcrestal incisions were made from 15 to 17 at sites 24, 26, and 46. Releasing incisions were performed at the mesial and distal aspects of each implant. The cover screws were unscrewed and replaced by healing abutments. The resulting miniflaps were pushed apically and sutured to the adjacent soft tissue with interrupted sutures of 4-0 black silk. This technique increased the attached gingiva band, leaving small areas mesially and distally of each healing abutment for secondary healing through granulation.

The flaps on the labial aspect of the superior ridge were deflected to the area where the access windows had been. The lateral wall of the maxilla on both sides appeared intact and filled at sites of the access windows. The surface of the grafted site was of a hard consistency with good vascularization, and bleeding could be provoked with a probe. HA particles could still be identified but were found integrated into the agglomerate of new bone cells.

PROSTHETIC PROCEDURES

On February 15, 1999, teeth 13, 14, 22, 25, and 45 were prepared for crowns. Endodontic treatment of tooth 25 was necessary because, due to its palatal inclination, the pulp cavity had been exposed during tooth preparation. Tooth 45 was also endodontically treated due to its elongation, which had been caused by the lack of antagonists. Impressions of the maxilla and the mandible were taken with open custom trays made of acrylic. Gingival retraction cord was placed in the sulcus of each prepared tooth, and impression copings with long screws were connected to the implants after removing the healing abutments. The wash technique for impression making was used. A polyether impression material was used in two stages using light and medium body material. The tray was positioned in the patient's mouth, and moderate pressure was applied until it was seated in its final position with all impression post screws emerging from the access holes. When the material had set, the impression copings were unscrewed, and the tray was removed. The relation of the maxilla to the condylar axis was registered with a face bow, and a bite registration with Futar D was done. Impressions and registration were forwarded to the laboratory. Soft tissue models were poured, and

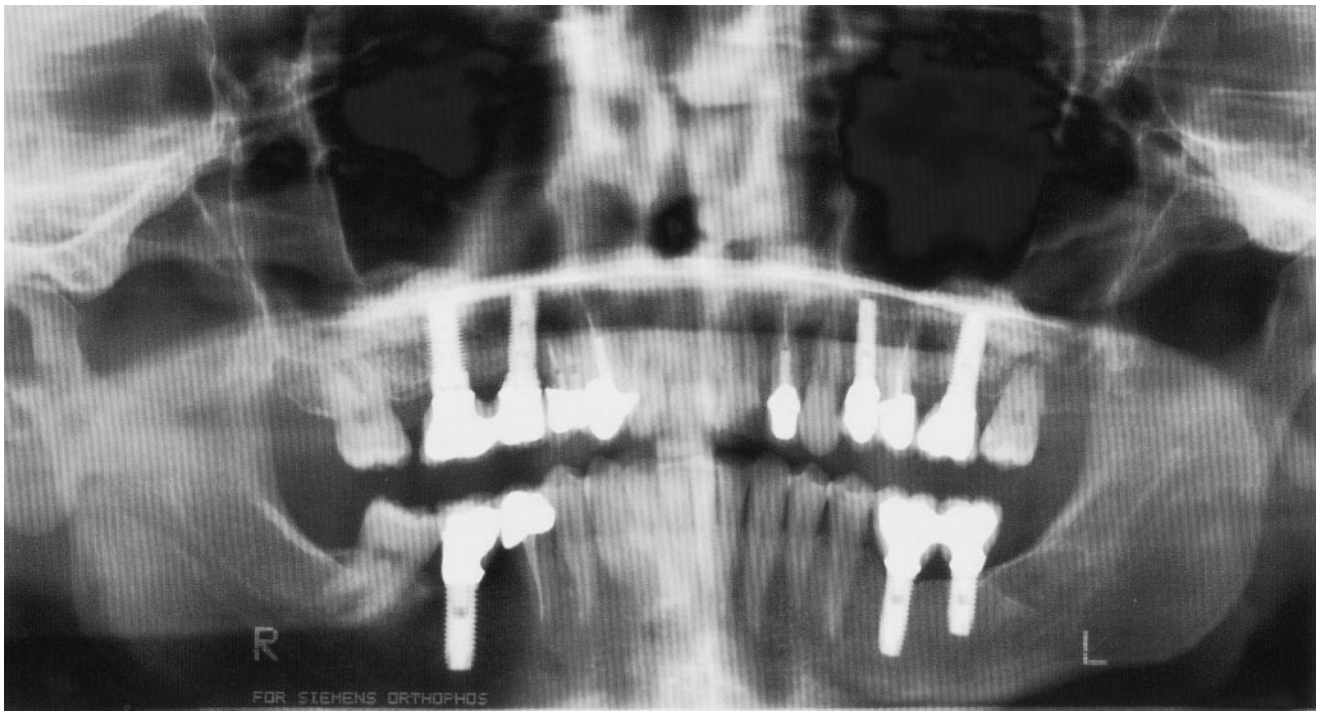

FIGURE 5. Panoramic X-ray of the completed case.

semiprecious metal cast abutments plus the metal bases for the crowns and bridges were fabricated. The laboratory had chosen UCLA-type abutments for implants 36, 37, 47, 24, and 26. As the implants already come with straight hexed abutments for cemented crowns, those were sent to the lab, where a very well-defined and finished chamfer was prepared. For implants 24 and 26, straight-locking cement on crown abutments were chosen. At the metal try-in session on March 3, 1999, an impression over the metal base was taken, and a new work model was fabricated. Once again, the bite was registered with Futar, and the maxillary position was verified with a face bow registrar. Temporary crowns were made for abutments 15 and 16.

A ceramic try-in visit was scheduled for March 15 to check the occlusion. A decision was made to cover the cervical part of crowns 16, 26, 36, 37, and 46 with pink porcelain to improve esthetics, as the crown lengths were a little increased due to a height discrepancy between the crown-abutment junction (CAJ) and the cemento-enamel junction of the adjacent teeth.

On March 22, 1999, the finished crowns were delivered (Fig 5). The porcelain fused to metal crowns for the natural abutments were cemented with a glas-ionomer luting cement. The maxillary implant restorations were cemented on the titanium abutments, which previously had been inserted and secured with a torque wrench at 30 N/cm. A temporary cement was used to maintain retrievability. The restorations of the mandible were screwed in and also torqued down with 30 N/cm. The access holes for the abutment screws were filled with a light-cured temporary filling material on the bottom and with a microfilled composite resin (heliomolar) at the occlusal aspect for better esthetics and wear resistance.

CLINICAL RESUME

The patient presented with partially edentulous arches and with several natural abutments missing due to advanced decay. Esthetically and functionally distressed, the patient desired fixed prostheses on implants in the edentulous areas. After clinical and radiographic examination, a situation unfavorable for implant placement in the maxilla was diagnosed due to the very low position of the sinus floors bilaterally. A bilateral antral augmentation was indicated. Tooth 38 was extracted, and teeth 45 and 25 were endodontically treated to achieve an appropriate occlusal plane.

Some complications were encountered after the first surgery (suture line dehiscence), which were treated with thorough wound management. No other complications occurred during the entire period of treatment.

The patient accepted the finished prostheses as esthetically and functionally satisfying. He was instructed on the special hygiene of the CAJ and the prostheses, which, if performed as demonstrated, would increase the long-term prognosis of the restorations. ■