The Use of Pterygomaxillary Implants in the Partially Edentulous Patient: A Preliminary Report

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One hundred eighty-seven implants were placed in the maxillary posterior areas of 44 partially edentulous patients (29 female; 15 male). The mean age was 62 years (range 36 to 82 years). Fifty-one of the 187 implants were placed in the pterygomaxillary area and further restored with fixed prostheses. The mean number of implants per prosthesis was 3.7 (range 1 to 6) for the maxillary posterior area. These 51 implants are the subject of this report. During stage II surgery and before loading, six implants were not osseointegrated and were removed. After a mean loading period of 12.6 months (range 1 to 63 months), one additional implant was lost. Seven of 51 implants were removed (13.7%). Failure rates according to implant size and bone quality were also analyzed. The average loss of marginal bone height was 1.3 mm on the mesial and 1.1 mm on the distal surfaces between 1 and 3 years of loading. This study demonstrates the possible and successful use of the pterygomaxillary site for implant placement.
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Key words: Brånemark implants, fixed partial prostheses, marginal bone height, osseointegration, pterygomaxillary

The high success rate of the Brånemark implant system originally reported for the treatment of completely edentulous jaws has been documented by longitudinal studies.[1–5] More recently, osseointegrated implants have been systematically applied to the treatment of partial edentulism. However, statistical evidence concerning the long-term success of these implants is more limited. Since Ericsson et al[6] reported the first result of osseointegrated implants in partially edentulous patients in 1986, other studies have been reported individually and from several treatment centers.[7–13]

A retrospective multicenter study[8] reported a failure rate of 8% in the mandible and 13% in the maxilla for implants observed 6 to 36 months after prosthetic reconstruction. Another multicenter study[10] analyzed 558 implants placed in partially edentulous arches. This study showed that a success rate equal to or better than that obtained with completely edentulous patients may be expected. Henry et al[13] reported that a cumulative implant survival rate of 92.5% of maxillary and 94.8% of mandibular implants was observed after 3 years of loading. Jaffin and Berman[14] reported specifically on implants placed in the maxillary posterior, noting a higher rate related to type IV bone.

The maxillary posterior area presents many limitations to implant placement. These anatomic factors include bone quality, quantity, location of the antrum, and physical accessibility to operate, especially in the tuberosity area. It was previously thought that this area was not ideally suitable for implants because of larger marrow spaces, frequently of a fatty consistency.

The magnitude of occlusal load is larger in the molar region than in the anterior area. Martel[15] reported masticatory forces of 150 psi in the incisor region, with comparative forces of 250 and 500 psi in the premolar and molar regions, respectively. Because of combined anatomic and biomechanical factors, the success rate of maxillary posterior implants could be lower than that in other sites of

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the mouth. To compensate for this possibility, Reiger[16] recommended using an increased number of implants. Langer et al[17] have also recommended using wider diameter implants to obtain greater surface area for initial trabecular bone contact and later cortical remodeling. Sinus-lift and bone-graft procedures have also been introduced to address some of these problems, but these procedures need longer healing time and may be prone to other complications.

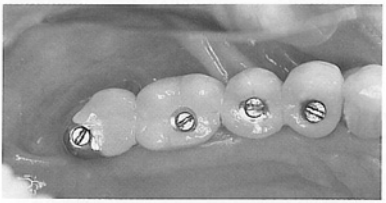

Fig 1a Occlusal view of 12-month-postoperative maxillary right and left abutments for tissue-integrated prosthesis.

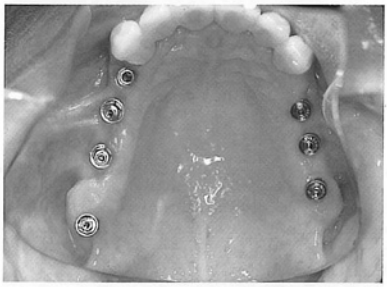

Fig 1b Healthy gingival condition around the abutment of pterygomaxillary implant.

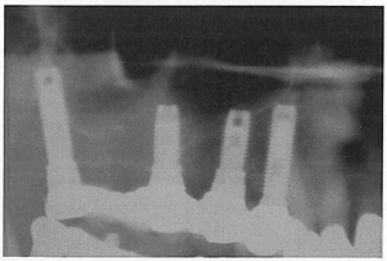

Fig 1c Panoramic radiographic view of four-unit tissue-integrated prosthesis.

If implants are carefully engaged in the compact bone of the pterygomaxillary plate and successfully osseointegrated, the prosthodontist can depend on them for prosthesis retention and elimination of posterior cantilevers generally necessary when only anterior implants are used. The improved biomechanical stability and load distribution of noncantilevered bone-anchored restorations should improve the long-term prognosis for these prostheses.

The purpose of this study was to examine all patients rehabilitated in our practice by means of fixed partial prostheses supported by Brånemark implants in pterygomaxillary sites and to analyze the various biologic and mechanical factors related to those implants.

Materials and Methods

Brånemark System implant components were used following a strict surgical and prosthodontic protocol (Nobelpharma AB, Gothenburg, Sweden). A total of 187 implants were placed in the posterior maxillary area of 44 patients (29 females and 15 males) with an age range from 36 to 82 years (average 62 years) and for whom 50 prostheses were fabricated. Of these, 51 implants were placed in the pterygomaxillary site, and abutments were connected after an undisturbed healing period of about 5 to 6 months. The overlying mucosa is generally thicker in this area, requiring a mean abutment length of 4.2 mm (range 3 to 7 mm).

The bone-anchored prostheses were all fabricated using porcelain fused to a high-gold-content alloy (Figs 1a to 1c). The mean number of implants per restoration was 3.7 (range 1 to 6). All of the prostheses were free-standing except one, which was connected to a natural tooth. One patient died 13 months after prosthesis delivery, with successful use of the prosthesis during the period of function.

Of the 51 implants, one was placed during a second surgical intervention to compensate for a previously failed implant. Table 1 depicts the implant types according to size, diameter, and design. Standard 15-, 13-, and 10-mm-long implants were used in 51%, 27.5%, and 11.8% of the implant sites, respectively.

In accordance with the classification of Lekholm and Zarb,[18] jaw bone quality was subjectively graded in four groups by the amount of compact bone and the density of trabecular bone. The bone quality of all the patients was recorded by one operator at the

Table 1 Frequency Distribution of Implant Design in Maxilla and Pterygomaxillary Site

Implant dimensions (mm)	Maxilla	Pterygomaxillary Site		Maxilla	Pterygomaxillary Site
Standard			*Self-tapping*		
7 × 3.75	3	0	10 × 3.75	3	1
8.5 × 3.75	2	0	13 × 3.75	1	
10 × 3.75	54	6	15 × 3.75	1	1
13 × 3.75	47	14	4-mm diameter		
15 × 3.75	62	26	7 × 4	2	
18 × 3.75	3	2	10 × 4	2	1
20 × 3.75	0	0	15 × 4	2	
3 × 10	1	0	5-mm diameter		
10 × 4.0	1	1	6 × 5		1
Total standard	171	48	8 × 5		2
Total	187	51			

Table 2 Clinical Features of Patients with Failed Pterygomaxillary Implants

Placement site	Age	Sex	Smoker	Bone quality	Implant length (mm)
1	61	F	No	4	15
16*	50	F	No	2	15
16	61	M	Yes	3	13
16	64	F	No	3	15
16	72	F	No	4	15†
16	52	M	Yes	4	18
16	36	F	Yes	4	15

*One implant with large diameter was replaced immediately.
†Self-tapping implant.

time of surgery. Tactile sensation during drilling procedures was used to determine the classification of bone. Radiographs played almost no role in determining bone quality. Bone quality was categorized as follows: 19.6% recorded as type II; 35.3% as type III; and 45.1% as type IV. Failed implants were categorized according to age, sex, bone quality, implant length, and smoking habit (Table 2). Partially edentulous conditions were noted according to the Applegate-Kennedy classification; 82% of the patients in this study were class II.

Loading time of the prostheses between abutment connection and the last follow-up visit ranged from 1 to 63 months. Marginal bone height around the implants was measured radiographically to 0.1 mm at the time of prosthesis placement and at intervals of 6 to 12 months. All radiographs taken were panoramic, because the anatomic position of the implants would not permit use of the standardized periapical method. Distortion of panoramic radiographs was taken into account, using known implant dimensions as the measurement rule. At the mesial and distal side of each implant, the distance from the implant/abutment junction to the bone crest was recorded. In the current analysis, only those implants that functioned between 1 and 3 years were selected for radiographic examination. Because of the limited number of changes in marginal bone height (CMBH) observed after 36 months, no further longitudinal analysis was conducted in this study.

Results

Osseointegration Failure Rate. Seven of 51 implants placed in pterygomaxillary sites were lost (13.7%); 6 at the abutment connection, one after loading. The cumulative failure rates are illustrated in Table 3.

Failure Rate According to Fixture Size. None of six 10-mm implants were lost (0%). One of fourteen 13 × 3.75 mm implants was lost (7.1%). Four of twenty-six 15 × 3.75 mm implants were lost (15.4%) and one self-tapping 15 × 3.75 mm implant, as well as one standard 18 × 3.75 mm implant, were lost.

Failure Rate Timetable. Six of the seven failed implants were mobile and removed at the time of abutment connection. One was removed because of continuous episodes of pain and discomfort reported by the patient following 3 months of functional loading. However, this implant appeared to be well

(7.0-mm) implants in thin trabecular bone supporting distal cantilevered pontics. Occlusal force in the molar region, especially for patients with parafunctional loading capabilities, also contributed to loss of osseointegration for these implants. The solution to this problem led us to conclude that implants smaller than 10 × 3.75 mm should not be used in type III or type IV bone in the posterior maxilla and that the use of cantilevered pontics should also be minimized.

The clinical postoperative course for the patients treated was not remarkable. Patients recorded no particular pain or discomfort, and minimal swelling was evident at the postoperative reevaluations. Because of the generally thick mucosal tissues in these areas, return of functional support for removable prostheses was generally uneventful. The successful osseointegration of Brånemark implants in the pterygomaxillary area provides a distinct advantage to the treatment of posterior maxillary edentulous areas by eliminating apparent detrimental loading forces on cantilevered posterior pontics and the adjacent implants.

In 1992, Balshi[22] reported a 4-year study of successful tuberosity implants. That same year Bahat[23] also reported a 93% success rate involving 72 tuberosity implants with an average loading time of 21.1 months. In this study, 15-mm implants were the most frequently used (50.9%), followed by 13-mm (27.5%), and 10-mm implants (11.8%), with success rates for each of 84.6%, 92.9%, and 100%, respectively. The high success rate for the shorter 10-mm fixtures may be related to the small number in the sample. The 3-mm-long abutments were the most commonly used (43.2%), followed by 4-mm (25%), 5.5-mm (22.7%), and 7-mm abutments (9.1%), respectively.

Thinning of the mucosal tissue was undertaken at several stage II surgeries to permit the placement of shorter abutments required to accommodate prosthetic components and obtain occlusal clearance. Bone quality in the maxillary posterior area was mostly type III and type IV (80.1%). Of the failed implants, 57.1% were located in type IV bone. Surgical placement of pterygomaxillary implants requires care and operative skill. "Feeling" the bone is an essential ingredient in stabilizing the implant and engaging the cortical plates at the apex. Long implant mounts are generally used to provide easier access for implant placement.

Failure rate on the left side (6) was definitely higher than that of the right side (1). The single clinician placing implants in this study was right-handed. Further analysis is necessary to determine if ergonomics and physical position of patient and operator may be factors effecting the success rate.

Since the greater number of pterygomaxillary implants lost were placed in type IV bone, a new project was initiated to subsequently harvest autogenous bone from anterior implant sites. This particulate bone has been placed into the pterygomaxillary site prior to implant procedures. Fine surgical suction tips are used to remove the fatty marrow from the site. Autogenous bone, consisting of cortical, trabecular, and marrow tissue is then used to "reseed" the empty marrow space in the prepared site. Further analysis of this procedure will be required to determine its effect on the pterygomaxillary implant success rate.

Though not accurately measured, the apparent loss in marginal bone height (MBH) observed in this study is comparable to that resulting for implants supporting a complete bone-anchored restoration.[24] In contrast to the results found in this study, a multicenter study conducted by Henry et al[13] demonstrated increased bone in 34% of readings. This increase in bone height should probably be interpreted as corticalization around the loaded implants. Bone growth over cover screws has been noted in other locations of the jaws; however, this phenomena was not recorded in conjunction with any pterygomaxillary implants in this study.

Patient acceptance of distal and sometimes palatally positioned prosthetic components and bars was quite good. A low-profile connector is more easily tolerated than a complete anatomic tooth in many pterygomaxillary implant-supported prostheses. Oral hygiene[25] is more difficult in the posterior region. However, highly polished prostheses can be fabricated for optimal plaque control. None of the pterygomaxillary implants had associated mucosal inflammation.

Conclusion

The use of pterygomaxillary implants to assist in stabilizing bone-anchored prostheses in partially edentulous patients compares favorably with implants used in other areas of the maxilla. Successful elimination of a cantilever prosthesis in the maxillary posterior is thought to be beneficial in directing load force more favorably to the bone-implant interface, especially for implants placed immediately anterior or inferior to the maxillary antrum. Fifty-one of 187 implants were placed in the pterygomaxillary areas of 44 patients. Six of the seven that failed were removed at stage II surgery.

Surgical placement of pterygomaxillary implants is much more difficult than for those placed in the anterior maxilla or mandible. Engaging cortical bone is essential to initial stabilization and long-term success.

Table 3 Osseointegration Failure Rate of Pterygomaxillary Implants in Partially Edentulous Jaws

Time of failure	Implant at beginning interval	Failed implants during interval	Interval failure rate	Cumulative failure rate
Before abutment connection	51	0	0.0%	0.0%
Abutment connection	51	6	11.8%	11.8%
0–12 mos	45	1	2.2%	13.7%
13–24 mos	24	0	0.0%	*
25–36 mos	7	0	0.0%	*
>36 mos	2	0		*

*No change in cumulative failure rate.

osseointegrated. The etiology of the patient's symptom could not be initially identified, and the symptoms did not cease with implant removal. The patient was later diagnosed as having trigeminal neuralgia.

Failure Rate According to Bone Quality. Bone quality was recorded for the 51 implants placed in the pterygomaxillary area and was subjectively determined as previously stated. Ten implants were placed in type II bone, requiring some bone-thread tapping during placement. Only one of these implants failed to osseointegrate (10%). Eighteen implants were placed in type III bone and thread tapping was not required. Two of the eighteen (11.1%) were not osseointegrated at the time of stage II surgery. The remaining 23 implants were placed in type IV bone without thread tapping and four of these (17.4%) did not osseointegrate.

Change of Marginal Bone Height for Osseointegrated Implants. The criteria for implant success proposed by Albrektsson et al[4] included radiographic evaluation of bone loss periodically and calculation of the mean values over time. In 1981, Adell and coworkers[2] described two distinct bone-loss periods, and later similar periods were described by Cox and Zarb[19] and Lindquist.[20] Greatest bone loss occurred during the first year of healing and bone remodeling (first period), with loss ranging from 0.9 to 1.6 mm depending on the study. The second period described as the "follow-up," showed a marked decrease in bone loss ranging from 0.05 to 0.13 mm annually.

Twenty-three implants that were in function between 12 and 36 months could be measured. During that time, the average loss of marginal bone height was 1.3 mm on the mesial surface and 1.1 mm on the distal surface. Of the 23 implants analyzed in this study, 21 (91.3%) had bone loss of less than 2.0 mm (Table 4). This compares favorably with Brånemark implants placed in other areas of the jaw.

Clinical Observation of Patients with Failed Implants. Of the seven patients with failed pterygomaxillary implants, two were males. The average age of female patients was 56.6 years (range 36 to 72 years). Both male patients were smokers and only one female patient smoked (Table 2).

Table 4 Marginal Bone Loss of Implants Loaded Between 12 and 36 Months

Bone loss (mm)	Number and percent of implants Mesial	Distal
0.1–0.5	4 (17.4%)	7 (30.4%)
0.6–1.0	9 (39.1%)	10 (43.5%)
1.1–2.0	8 (34.8%)	4 (17.4%)
>2.0	2 (8.7%)	2 (8.7%)
Total	23	23

Table 5 Medical Conditions and Medications for Patients With Failed Implants

	Patients						
	1	2	3	4	5	6	7
Postmenopausal	–	–	+	–	–	–	+
Estrogen therapy	–	–	–	–	–	–	–
Thyroid condition	–	–	–	–	–	–	–
Calcium supplement	+	–	–	–	–	–	–
Social alcohol use	–	+	–	+	+	+	–
Smoking	–	+	–	+	–	+	–
Diabetic	–	–	–	–	–	–	–
Hypertensive	–	–	+	–	–	+	–

In evaluating bone quality, three females had type IV bone and one had a combination of type II and type III. One male had type III bone; the other had type IV. All implants lost in females were 15 mm long; one was self-tapping. One implant in a female required bone-thread tapping during placement. Lost implants in male patients were 13 mm and 18 mm long and were placed without bone tapping.

In reviewing the general health and systemic condition of the five females with pterygomaxillary implant failures, it was noted that two were postmenopausal, none had had estrogen therapy, none had a thyroid condition, and one supplemented her diet with calcium. Two of the women admitted to

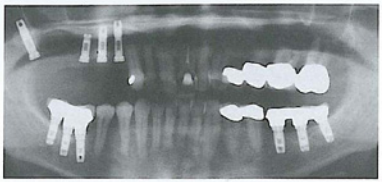

Fig 2a Pterygomaxillary implant with three additional implants prior to stage II surgery.

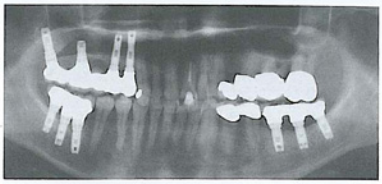

Fig 2b Definitive four-implant-supported prosthesis with a 4-mm-diameter pterygomaxillary implant.

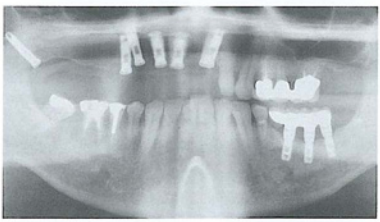

Fig 3a Pterygomaxillary implant on the left side and anterior implants prior to stage II surgery.

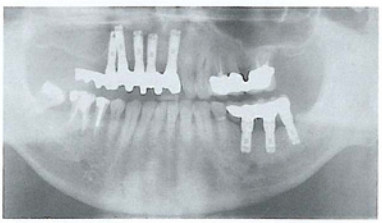

Fig 3b The nonintegrated pterygomaxillary implant was removed and an anterior implant-supported prosthesis with nonfunctioning premolar cantilevers was placed.

using alcohol socially. One woman had controlled hypertension. The male patients who lost pterygomaxillary implants were in good health. None had a thyroid condition, none used calcium supplements, and all used alcohol socially. One man had controlled hypertension (Table 5).

Analysis of the Seven Failed Implants

Patient 1. White female, age 50, premenopausal, diet supplemented with calcium and vitamin D. Both the pterygomaxillary implant and the 10 mm implant beneath the antrum failed to integrate after a 5-month healing period. Prosthetic treatment involved restoration of the two anterior implants with additional implants placed in the posterior region (Fig 2a). A wider-diameter implant replaced the failed 13 × 3.75 mm pterygomaxillary implant. Five months later, osseointegration was complete and the final prosthesis fabricated, uniting all four implants (Fig 2b).

Patient 2. White male, age 52, heavy smoker, uses alcohol consistently. A periodontally failing molar abutment supporting a fixed prosthesis in the left maxilla was removed and the maxillary central incisors, left lateral, and canine were removed because of traumatic injury. Five Brånemark implants were placed in the anterior maxilla and one in the pterygomaxillary region (Fig 3a). Six months after placement, the pterygomaxillary implant was not osseointegrated and was removed. The prosthetic restoration was shortened with a distal cantilever extending from the five anterior implants. The two-tooth cantilever provided an esthetic facade with no occlusal function (Fig 3b).

Patient 3. White female, age 72. Two implants were placed in the left posterior maxilla, one in the area of the second premolar, the other in the pterygomaxillary region (Fig 4a). Prior to abutment connection, the panoramic radiograph indicated probable implant location in the antrum rather than in the region of the pterygoid plates. At second-stage surgery, the abutment initially appeared stable, but when the abutment was attached to the implant, mobility was identified. The implant was removed and the single premolar implant was restored using a CeraOne abutment. No additional prosthetic intervention was required (Fig 4b).

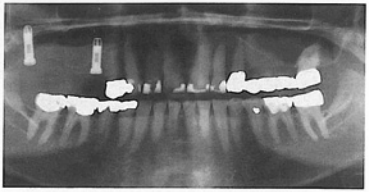

Fig 4a Posterior implant did not engage the pterygomaxillary cortical plates.

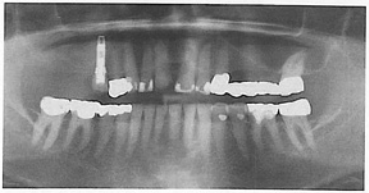

Fig 4b Following removal of the posterior implant, a CeraOne abutment was used to restore the anterior implant. No further treatment was required.

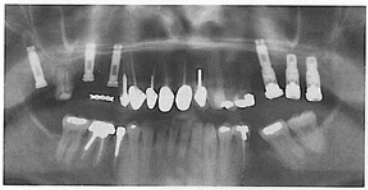

Fig 5a Pterygomaxillary implant was placed in anticipation of loss of the molar abutment tooth.

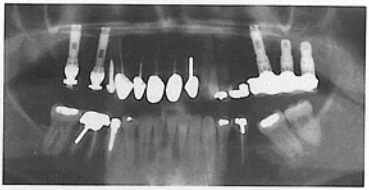

Fig 5b Both the pterygomaxillary implant and the molar were removed at stage II surgery.

Patient 4. White female, age 36, dental phobic. Even the most simple dental procedures required general anesthesia. Three implants were placed in the left posterior maxilla, including a 15 × 3.75 mm implant in the pterygomaxillary region. At second-stage surgery, the pterygomaxillary implant was mobile and removed (Fig 5a). The two anterior implants were osseointegrated and a long-term provisional restoration was placed on these to permit healing of the molar extraction site prior to fabrication of the final prosthesis (Fig 5b).

Patient 5. White female, age 61. Medical findings included allergy to all antibiotics and other medications. Four implants were placed; three between the right molar and canine, and one 15 × 3.75 mm implant in the pterygomaxillary region. Six months following placement, second-stage surgery was performed, involving the removal of both the nonintegrated pterygomaxillary implant and the natural first molar (Fig 6). A free-standing implant-supported fixed prosthesis was fabricated.

Patient 6. White male, age 61, heavy smoker. Three implants were placed in the maxillary left molar area. Five months after implant placement, the pterygomaxillary implant was not osseointegrated (Fig 7). The two remaining implants were integrated and a fixed prosthesis fabricated.

Patient 7. White female, age 64, excellent health. Four implants were placed in the left posterior maxilla, including a 15 × 3.75 mm implant in the pterygomaxillary area. The patient subsequently experienced intermittent episodes of myofascial pain and discomfort (Fig 8a). Eight months after initial implant placement and three months after functional loading, two of the posterior implants were removed at the patient's request, in spite of the fact that they were stable and appeared to be osseointegrated. The two remaining implants were stable and restored with a provisional restoration. Two months later, the patient continued to experience severe pain and insisted that the most posterior implant be removed. This implant was well osseointegrated and extremely difficult to remove. In addition, the first premolar, which had been endodontically treated, was also removed. The patient underwent neurologic testing and a diagnosis was made of trigeminal neuralgia. Eight months following removal of the premolar and the third implant, a CeraOne abutment was attached to the remaining single implant and a three-unit prosthesis consisting of an anterior and posterior

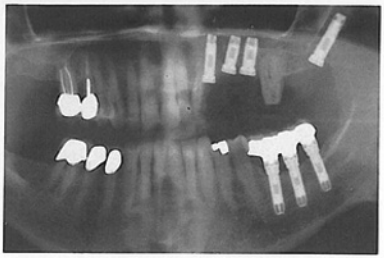

Fig 6 Pterygomaxillary implant placed anticipating its support to eliminate a posterior cantilever.

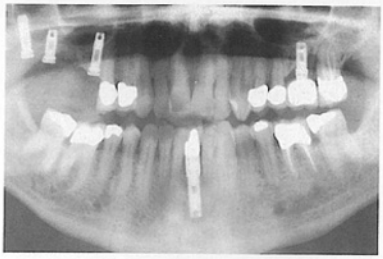

Fig 7 Three implants in the left posterior maxilla. The pterygomaxillary implant does not engage the pterygoid plate.

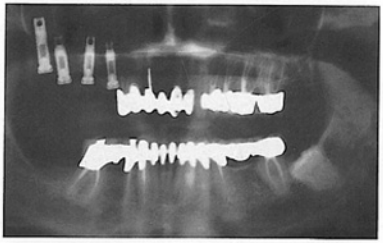

Fig 8a Four left maxillary implants, with one engaging the pterygomaxillary plate, prior to stage II surgery.

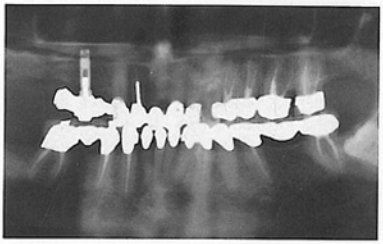

Fig 8b CeraOne abutment supports a three-tooth prosthesis with nonfunctioning cantilevers.

cantilever was placed (Fig 8b). This prosthesis was designed to serve primarily as an esthetic facade, with the only occlusal contact directly over the implant. Both cantilevered pontics were totally removed from occlusion.

Discussion

Clinically, the success of each implant was evaluated by means of mobility test, sound on percussion, and marginal bone loss seen on the panoramic radiograph. The success criteria suggested by Albrektsson et al[4] in 1986 were considered when evaluating all implants. However, even with marginal bone loss greater than 2 mm in the third year, the two affected implants remained stable in function and presented a healthy mucosal response.

In partially edentulous patients, there are several concerns using osseointegrated implants compared with those in completely edentulous patients supporting bone-anchored prostheses: *(1)* natural teeth may serve as a bacterial reservoir providing the pathogens associated with peri-implantitis; *(2)* there is no cross-arch stabilization; and *(3)* differences in mobility characteristics between implants and the natural teeth in situations where natural teeth are connected to the implants, creating a potential risk for biomechanical complication.

In this report, only implants placed in the pterygomaxillary region of partially edentulous patients were investigated. The success rate for pterygomaxillary implants was 86.3%, which compares favorably with the results of previous studies of maxillary implants. It is important to note that previous studies reporting success rates for maxillary implants analyzed primarily implants that were placed anterior to the antrum or beneath it, if bone volume permitted. The general quality of maxillary anterior bone is usually superior to that found in the posterior maxilla. Previously, implant loss in the maxilla[21] has been related to short

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