Restoration of Partially Edentulous Patients Using Dental Implants with a Microtextured Surface: A Prospective Comparison of Delayed and Immediate Full Occlusal Loading

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Purpose: *The aim of this study was to determine the clinical effectiveness of placing dental implants with microtextured surfaces into full occlusal loading at the time of placement in partially edentulous patients.* ***Materials and Methods:*** *Two demographically similar groups of 14 patients each were treated with a total of 92 Spline Twist implants (Centerpulse Dental, Carlsbad, CA). Test implants were placed into immediate full occlusal loading, and control implants were restored using a conventional delayed loading procedure. Otherwise, both groups of patients received similar therapy from the same treatment team. Radiographs, periodontal indices, and Periotest values were recorded every 6 months during routine clinical follow-up appointments. The mean loading time for all prostheses was 24 months at the time of this report.* ***Results:*** *No implants failed in the test group, and 1 implant failed before loading in the control group. Cumulative implant success was 98.9% for all implants placed (test group = 100%; control group = 92.9%). Periodontal measurements indicated no significant clinical differences between implants placed into immediate full occlusal loading and those loaded via a conventional delayed protocol.* ***Discussion:*** *Immediate full occlusal loading of partial prostheses supported by microtextured implants in partially edentulous patients demonstrated excellent clinical results, with no adverse periodontal effects after 24 months of function. Additional follow-up will provide invaluable information on the long-term effects of this technique.* ***Conclusion:*** *Immediate full occlusal loading of partial prostheses supported by microtextured implants can be successfully achieved for 24 months in highly motivated patients with excellent oral hygiene.* (INT J ORAL MAXILLOFAC IMPLANTS 2003;18:512–522)

Key words: *crowns, dental implants, fixed partial denture, immediate load, oral hygiene, surface properties*

Modern implant dentistry is based on well-documented guidelines for material selection and surgical techniques that still remain in use 30 years after their initial formulation.[1] The conventional 2-stage implant placement procedure was developed to ensure stabilization of the implant during the early stages of bone healing. The original concern was that any implant micromovement could result in failure to achieve osseointegration or might lead to fibrous tissue encapsulation of the implant as a reparative response to the physical trauma.[2–4] While the important contributions of these early researchers[1] should not be underscored, it is important to note that the delayed loading protocol was an empirical indication that had never been experimentally demonstrated.[4]

The documented high success rates and predictability of implant restorations have since led some clinicians to reassess the necessity for the 2-stage surgical procedure for achieving and maintaining clinical osseointegration.[5] During the 1970s, Ledermann[6,7] introduced the technique of immediately splinting and loading 4 transmucosal implants in the edentulous mandible with a bar-supported overdenture. The underlying theory was that rigid

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splinting of implants in the dense bone of the mandibular symphysis would prevent implant micromovement and allow effective healing and osseointegration to occur under immediate loading conditions. With immediate stress generated by the prosthesis, the simultaneous primary repair of bone in the implant area and the functional maturation process resulted in a particular functional ankylosis.[8]

In a 1986 study by Babbush,[9] 4 transmucosal implants were placed into the edentulous mandibular symphysis and splinted with a Dolder bar within 2 or 3 days. After 2 to 3 weeks, the treatment was completed with a permanent clip-retained overdenture.[9] The author placed 1,739 implants into 484 patients and reported a cumulative success rate of 88% after approximately 8 years of clinical functioning.[9] The following decade, Schnitman and coworkers[10] reported 85.7% success in the immediate splinting and loading of 28 conventional 2-stage implants in the edentulous mandible after 10 years of clinical follow-up.

In partially edentulous patients, clinical studies[11–17] of immediate/early provisionalization of dental implants with non-occluding transitional prostheses partially stabilized by adjacent teeth have reported high success rates. Although the transitional prostheses were not subjected to full occlusal loading, the implants were progressively loaded through a gradual increase in the application of force by the provisional prosthesis, adjacent anatomic structures, and parafunctional behaviors of the patients.[18] Little clinical data are currently available on the immediate/early full occlusal loading of implants in partially edentulous patients.

This article reports on the results of a prospective clinical study that compared immediate full occlusal loading and delayed occlusal loading of implant-supported restorations in partially edentulous patients.

MATERIALS AND METHODS

Preliminary Procedures

Patient Selection and Evaluation. The subjects for this prospective study were partially edentulous patients who presented with 1 or more missing teeth in the maxillary and/or mandibular jaw in a private dental practice. All patients were subjected to a preliminary evaluation that included careful review of their medical and dental histories, detailed clinical and radiographic examinations, evaluation of oral hygiene, and assessment of their ability to commit to a long-term treatment plan. Those patients with excellent oral hygiene and a firm commitment to follow-up visits were admitted into the study after signed informed consent was obtained.

A diagnostic workup was performed for each patient to evaluate the volume and location of available bone, the esthetic and functional needs of the case, and the desires of the patient. A diagnostic cast was fabricated and mounted on a semiadjustable articulator utilizing a facebow transfer and vertical registration to determine the jaw relationships, available occlusal dimension, proposed implant position, crown-root ratio, and potential complications. This allowed creation of a prosthetic waxup and fabrication of a surgical template to guide placement of the implants relative to the planned prosthesis.

A total of 28 patients were selected as study participants: 14 men (mean age 36.57 years; range 20 to 62 years) and 14 women (mean age 39.21 years; range 18 to 72 years). Each participant was assigned to 1 of 2 groups consisting of 14 patients each (7 men, 7 women). Test group patients (mean age: 37.1 years) (Table 1) received occlusally loaded prostheses on the same day of implant placement, and control group patients (mean age: 38.6 years) (Table 2) were treated with the traditional 2-stage delayed loading protocol. Each group also included 7 patients with identified health risk factors: 3 patients who were moderate smokers, 1 patient with cardiac disease, 1 patient with hypertension, 1 patient with controlled type 2 diabetes, and 1 asymptomatic HIV-positive patient. Between January 1998 and March 1999, a total of 92 implants were placed: 28 mandibular (60.87%) and 18 maxillary implants (39.13%) that were immediately loaded, and 29 mandibular (63.04%) and 17 maxillary implants (36.95%) that were delayed in loading until after clinical osseointegration was confirmed. Study data were collected from the surgeon and the restoring dentist on data reporting forms and were closely monitored by a records assistant.

Implant Selection. The implant used in this study was a self-tapping screw with a microtextured surface (Spline Twist MTX; Centerpulse Dental, Carlsbad, CA). All of the implants were 3.75 mm in diameter and at least 13 mm in length.

Surgical Procedures

All patients were instructed in the use of chlorhexidine digluconate for the chemical control of plaque, which commenced 3 days prior to surgery and continued for 10 days postoperatively. Antibiotic prophylaxis involved daily administration of 2 g of amoxycillin and clavulanic acid, beginning 2 hours before surgery and continuing for 4 days thereafter.

On the day of surgery, the patient was anesthetized by local infiltration with articaine. A midcrestal incision was performed (Fig 1a), followed by

Table 1 Test Group Implant Placement Data: Immediate Loading

Patient data					Implant placement data			
		Missing anatomy						
Age	Medical risks	Quadrant	Tooth	Bone quality	Qty	Length (mm)	Diameter (mm)	Date placed
32	Smoker	Maxillary right	Canine	D2	1	18	3.75	Jan 1998
28	None	Maxillary left	First premolar Second premolar First molar	D2–D3	3	13	3.75	Jan 1998
47	None	Maxillary right	Lateral incisor Canine First premolar	D2	4	15	3.75	Feb 1998
	None	Maxillary left	Lateral incisor Canine First premolar	D2	2	13	3.75	
42	None	Mandibular left	Second premolar First molar	D2	3	13	3.75	Mar 1998
25	Smoker	Maxillary left	First molar	D2	2	13	3.75	Mar 1998
62	Diabetic	Mandibular left	Central incisor Lateral incisor Canine	D2	6	15	3.75	May 1998
	Diabetic	Mandibular right	Central incisor Lateral incisor Canine	D2	6	15	3.75	May 1998
20	None	Mandibular left	Second premolar	D2	1	13	3.75	Jun 1998
38	Hypertension	Maxillary right	Lateral incisor Canine	D2–D3	2	15	3.75	Jun 1998
33	None	Mandibular right	First molar	D1	1	13	5.0	Jul 1998
54	Cardiac disease	Mandibular left	Lateral incisor	D1	6	13	3.75	Jul 1998
			Second premolar	D2	6	13	3.75	Jul 1998
			First molar	D2	6	13	3.75	Jul 1998
		Mandibular right	Lateral incisor	D1	6	13	3.75	Jul 1998
			Second premolar	D2	6	13	3.75	Jul 1998
			First molar	D2	6	13	3.75	Jul 1998
25	None	Maxillary left	Second premolar First molar	D2–D3	3	13	3.75	Oct 1998
23	HIV+	Mandibular left	First premolar Second premolar First molar	D2	3	13	3.75	Dec 1998
55	None	Mandibular left	Lateral incisor Canine First premolar Second premolar First molar Second molar	D2	6	13	3.75	Jan 1999
		Mandibular right	Lateral incisor Canine	D2	2	13	5.0	Jan 1999
36*	Smoker	Maxillary left	First premolar	D2	1	13	3.75	Mar 1999

*Case presented in Figs 1 to 4.

Table 2 Control Group Implant Placement Data: Delayed Loading

Patient data					Implant placement data			
		Missing anatomy						
Age	Medical risks	Quadrant	Tooth	Bone quality	Qty	Length (mm)	Diameter (mm)	Date placed
38	Smoker	Mandibular left	Second premolar First molar	D2	3	13	3.75	Jan 1998
27	None	Mandibular left	First premolar Second premolar First molar	D2	3	13	3.75	Feb 1998
35*	Smoker	Maxillary left	First premolar	D2	1	15	3.75	Mar 1998
48	Cardiac disease	Mandibular left	Central incisor Lateral incisor Canine	D1	6	13	3.75	Mar 1998
		Mandibular right	Central incisor Lateral incisor Canine	D1	6	13	3.75	Mar 1998
44	None	Maxillary left	First premolar Second premolar	D2–D3	2	13	3.75	Apr 1998
18	Smoker	Mandibular right	First molar	D2	2	15	3.75	Apr 1998
33	Hypertension	Maxillary right	Canine First premolar Second premolar	D2–D3	4	13	3.75	May 1998
		Maxillary left	Canine First premolar Second premolar	D2–D3	2	15	3.75	May 1998
20	None	Mandibular right	First premolar Second premolar First molar	D2	2	13	5.0	Jun 1998
72	Diabetic	Maxillary right	First premolar Second premolar	D2	7	13	3.75	Jul 1998
		Maxillary left	First premolar Second premolar	D2	7	13	3.75	Jul 1998
		Mandibular right	Canine	D1	7	13	3.75	Jul 1998
		Mandibular left	Lateral incisor Canine	D1	7	13	3.75	Jul 1998
60	HIV+	Mandibular left	Second premolar First molar	D2–D3	3	13	3.75	Oct 1998
24	None	Mandibular left	Lateral incisor Canine	D1	4	18	3.75	Dec 1998
		Mandibular right	Lateral incisor Canine	D1	4	18	3.75	Dec 1998
37	None	Maxillary right	First premolar Second premolar	D2	2	13	3.75	Dec 1998
38	None	Maxillary left	Second premolar First molar	D2	2	13	3.75	Feb 1999
47	None	Mandibular right	Canine First premolar First molar	D2	3	13	3.75	Feb 1999

*Failed.

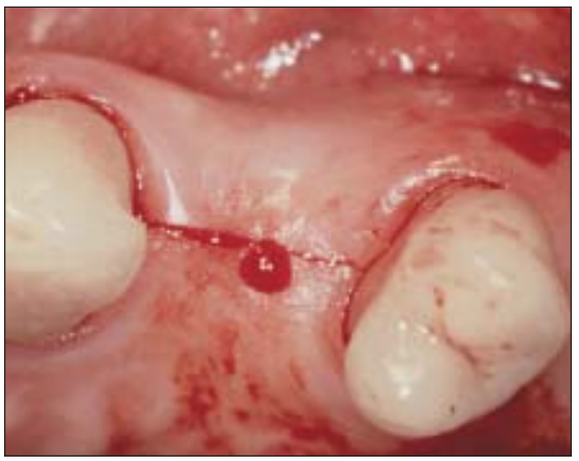

Fig 1a A midcrestal incision was made to gain access to the alveolus.

Fig 1b After preparation of the osteotomy, a self-tapping screw implant was threaded into place.

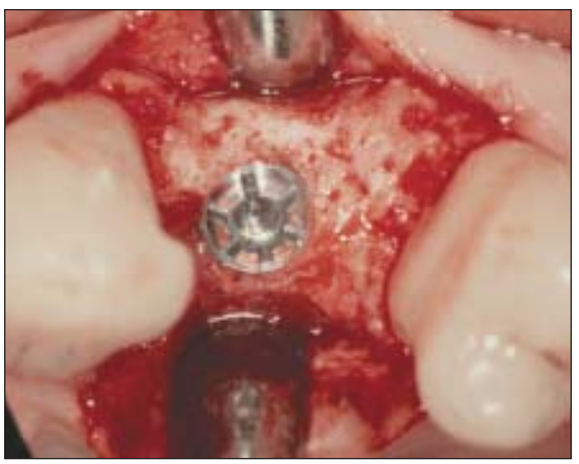

Fig 1c After the implant was seated, an impression was made to fabricate a working cast.

elevation of a mucoperiosteal flap that was kept small to preserve the periosteal vascular supply. The osteotomy was prepared with the aid of a surgical template, and the implant was placed according to the manufacturer's protocol (Figs 1b and 1c). For the 2 patients with heart disease and the 2 HIV-positive patients, 3-dimensional analysis of the ridge was made prior to surgery with the aid of computerized tomography (CT), and drilling was performed directly through the soft tissue without incisions or flap elevation to facilitate healing and minimize invasion, pain, edema, bleeding, and hematoma associated with conventional implant placement. All implants were placed into type 1, 2, or 3 bone quality according to the Lekholm and Zarb[19] classification.

Test Group. Prosthetic procedures were commenced immediately prior to suturing the soft tissues.

Control Group. The soft tissues were approximated and primary closure was achieved with 3-0 vicryl sutures (Ethicon, Somerville, NJ). One week later, the sutures were removed, and the implant was allowed an average submerged healing period of 3.5 months in the mandible and 4.5 months in the maxilla. To avoid loading of the surgical area, provisional partial dentures were not used. The surgical site was monitored every 3 days to ensure the area was free from infection and plaque until suture removal and soft tissue maturation. A removable partial denture was not utilized during the submerged healing period to minimize loading of the surgical area. Following the healing period, the patient was anesthetized via local infiltration with articaine, a midcrestal incision was made, and a mucoperisoteal flap was elevated to expose the implant. Clinical osseointegration was confirmed via manual testing[6] and radiographic evaluation. A healing cuff was attached to the implant, and the soft tissues were sutured (3-0 vicryl, Ethicon) around it according to conventional implant procedures. The sutures were removed after 1 week. Following complete soft tissue healing and maturation approximately 14 days after implant uncovering, the healing cuff was removed from the implant and prosthetic procedures were begun.

Prosthetic Procedures

A pickup impression post was attached to the implant, and a full-arch polyether impression was made with a custom tray. After setting, the impression and post were removed and the implant site was thoroughly irrigated with sterile saline. An implant analog was attached to the post and the assembly was reinserted into the impression. The working cast was poured in dental stone, separated from the impression, and articulated using the previously

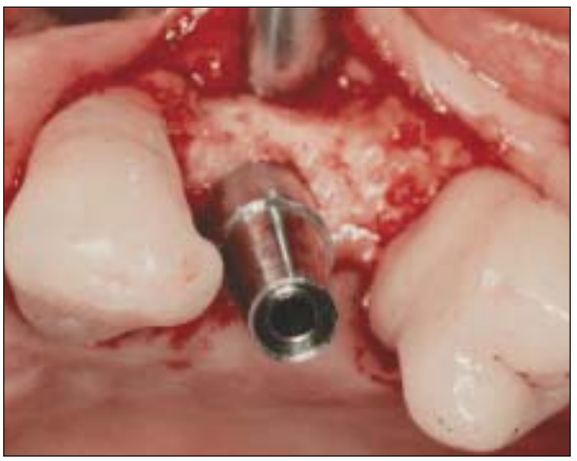

Fig 2a The finished provisional post and crown were attached to the implant within 3 hours of implant placement.

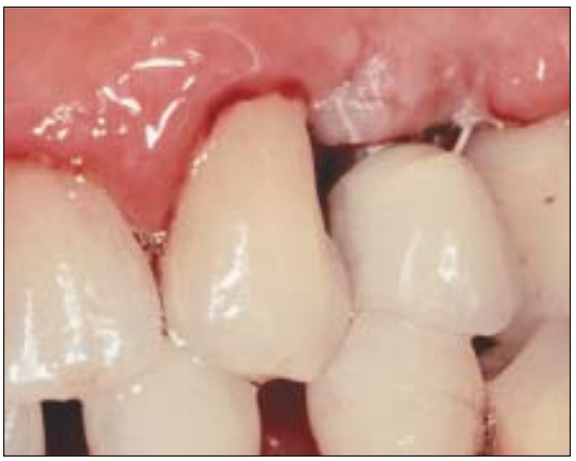

Fig 2b The soft tissues were sutured around the fully occluding provisional prosthesis.

Fig 3a After the healing period, the definitive abutment was fabricated on a working cast.

Fig 3b The framework for the definitive prosthesis was fabricated in noble alloy.

made opposing arch cast and interocclusal record. A fully occluding provisional prosthesis was fabricated on the working cast. The prepared abutment was sterilized, attached to the implant (Fig 2a), and tightened to 30 Ncm with a calibrated torque wrench.

Test Group. The provisional prosthesis was seated approximately 3 hours after implant placement and the soft tissues were sutured (3-0 vicryl, Ethicon) around it (Fig 2b). Full occlusal contact was immediately achieved and maintained throughout the entire period of provisionalization. To ensure the area was free from infection and plaque, the surgical site was monitored every 3 days until suture removal 1 week later and subsequent soft tissue maturation. Within 6 weeks of provisionalization, the implants were restored with fully occluding metal-ceramic crowns fabricated with low-fusing ceramic (Figs 3 and 4).

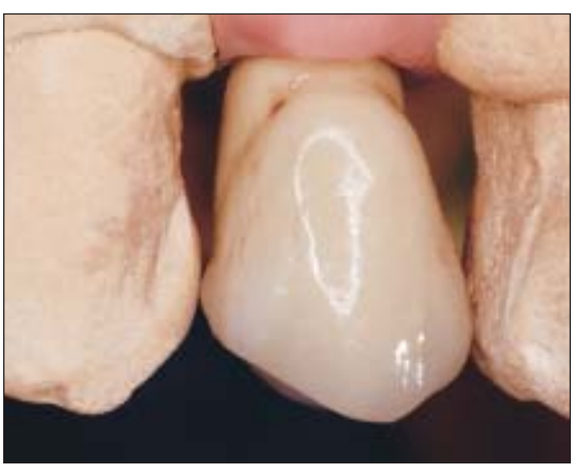

Fig 3c The definitive porcelain-fused-to-metal crown was prepared for delivery.

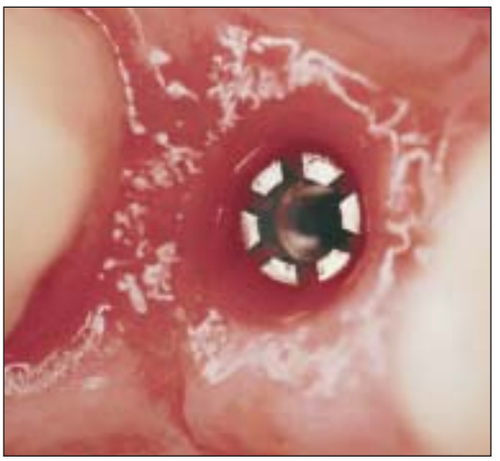

Fig 4a Immediate loading allowed the soft tissue to heal in the appropriate anatomic contour for the definitive prosthesis.

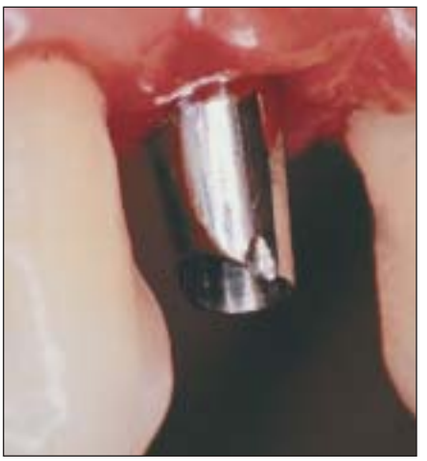

Fig 4b The definitive abutment was threaded into the implant and tightened to 30 Ncm.

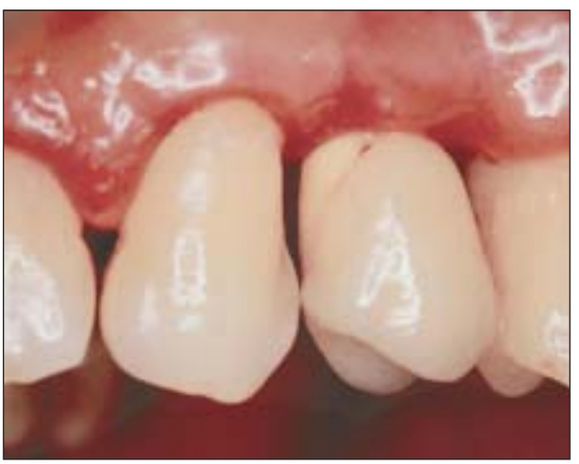

Fig 4c Clinical view of the definitive restoration revealed a natural-looking prosthesis that provided clinical function from the time of implant placement.

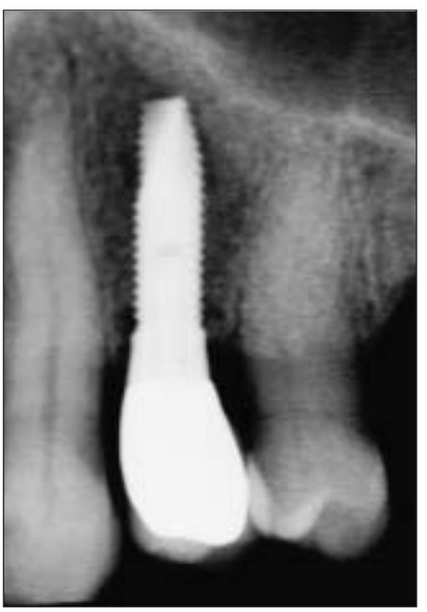

Fig 4d *(Right)* Radiographic view of the definitive restoration in place.

Control Group. The provisional prosthesis was cemented onto the post. Within 6 weeks of provisionalization, the implants were restored with metal-ceramic crowns fabricated with low-fusing ceramic.

Clinical Follow-up Protocol

A member of the treatment team recorded the following parameters 1 month after prosthesis seating (baseline) and every 6 months until conclusion of the study in June 2001.

Periotest Examinations. One clinician who was highly experienced with the technique made all Periotest measurements (Siemens, Bensheim, Germany) in the study. The measurements were recorded by lightly touching the tip of the instrument to the buccal side of the prosthesis. The end of the handpiece was kept perpendicular to the long axis of the abutment and parallel with the floor as the patient sat in an upright position. Four measurements were always made, and results achieved 2 or more times were considered valid. If the other results differed by more than 2 measurement points, the operation was repeated. Implants were considered osseointegrated when Periotest values (PTVs) ranged from –7 to 0, non-integrated when PTVs were over +6, and borderline when PTVs ranged from 0 to +5. It is important to note the differences in PTVs between the test and control groups during

the early stages of occlusal loading compared to the later stages. The Periotest measurements were taken after removal of the prosthesis superstructure at 1 month after prosthetic treatment and every 6 months subsequently.

Periodontal Examinations. Plaque, gingival depth, and probing depth indices were conducted as references for monitoring the health of the peri-implant mucosa.[20,21] Crevicular depth measurements were taken of the mesial, distal, lingual, and buccal sides using a periodontal probe (Hu-Friedy, Chicago, IL).

Radiographic Examinations. Standardized vertical bitewing radiographs utilizing a positioning jig were taken for each implant at the time of placement and at all recall appointments. A transparent surgical template with a 1.0-mm grid (enlarged 25% to help compensate for radiologic distortion) was placed over each radiograph to calculate marginal bone changes relative to the top of the implant. Because of difficulty in measuring slight variations in the magnitude of 0.1 mm and an inability to control for exact radiologic distortion with this technique, bone loss was recorded in incremental ranges of 0 to 1 mm, 1 to 2 mm, 2 to 3 mm, 3 to 4 mm, and greater than 4 mm.

Radiographic Assessment of the Bony Ridge. Maintenance of the bone height is important to the scientific evaluation and the long-term prognosis of an osseointegrated implant. Both panoramic and intraoral radiographic examinations were performed. To provide a standard parameter for the intraoral radiograph, a commercially available film folder was used and customized by relining it with autopolymerizing acrylic resin. In this way faithful accordance of radiographs obtained on each occasion was achieved.

Success Criteria. This study defined success as the ability of an implant to function within the context of its prosthodontic application without fracture, mobility when tested, peri-implant radiolucency, pain, discomfort, infection, and/or marginal bone loss that could not be alleviated by clinical intervention. All clinically failed implants were removed from the patients and recorded in the database.

RESULTS

All patients were very well motivated and appeared at their checkup appointments as scheduled. The mean duration of prosthetic loading at the time of this study was 24 months for both groups.

Table 3 Distribution of Implants by Bone Quality and Occlusal Loading Time

Bone quality[19]	Immediate occlusal loading (%)	Delayed occlusal loading (%)
Type D1	6.5	28.3
Type D2	76	47.8
Type D2–D3*	17.4	23.9

*Bone quality was not clearly discernable.

Bone Quality

No implants were placed in type 4 bone in this study. A total of 17.4% of the test implants and 23.9% of the control implants were placed in type 2 or 3 bone (Table 3). The majority of implants in both groups were placed in type 2 bone (Table 3).

Implant Success

Implant success was 100% in the immediate occlusal loading (test) group and 97.8% in the delayed occlusal loading (control) group. In the latter, 1 implant in the location of a mandibular left central incisor failed in a 35-year-old woman 11 days after surgical placement because of an abscess. The symptoms began 6 days after placement and were probably the result of bacterial contamination of the new implant socket.

Surgical Complications

In 6% of the sites, some postoperative swelling was observed, and 5% developed dehiscence of the suture, but in no case did this prevent appropriate tissue healing. In 2 immediately loaded cases, there were some transient (about 40 days) disturbances in sensitivity related to temporary impairment of the neurovascular bundle of the mandibular socket, probably caused by the need to maximize the use of available bone to achieve as much primary stability as possible. For the same reason, there were 2 cases of perforation of the maxillary sinus where there had been an effort to obtain significant bicortical anchorage. The latter finding was strictly radiologic, with no manifestation of clinical problems.

Periotest Results

By maxillary and mandibular jaw location, mean PTVs at 24 months are presented in Table 4.

Periodontal Index Results

No substantial differences were noted between the study and control groups in the areas of plaque indices (Table 5), gingival indices (Table 6), or probing depth (Table 7). The regular checkups carried

Table 4 Periotest Values by Jaw and Prosthesis Type

Restoration type/location	Test group		Control group	
	Mean	Range	Mean	Range
All types				
Maxilla	–4.6		–4.8	
Mandible	–4.1		–4.2	
Multiple-unit splinted	–5.22	–7 to –2	–5.04	–7 to –3
Maxilla	–4.88	–7 to –4	–4.50	–7 to –3
Mandbile	–5.43	–7 to –4	–5.36	–7 to –3
Single-unit	–3.60	–6 to –2	–4.17	–7 to –2
Maxilla	–3.33	–5 to –2	–4.00	–5 to –2
Mandible	–3.78	–6 to –2	–4.26	–7 to –2

Multiple-unit splinted restorations: n= 6 for test group, n= 9 for control group. Single-unit restorations: n = 11 for test group, n= 10 for control group.

Table 5 Plaque Index[21,22] by Time and Group

Time/ group	Index 0		Index 1		Index 2	
	No.	%	No.	%	No.	%
01/98–10/98						
Test	21	67.8	8	25.8	2	6.4
Control	21	67.8	9	29	1	3.2
11/98–12/99						
Test	28	60.9	13	28.3	5	10.8
Control	30	66.7	15	33.3	—	—
01/00–12/00						
Test	33	71.7	12	26.2	1	2.1
Control	33	73.3	12	26.7	—	—
01/01–06/01						
Test	35	76.1	11	23.9	—	—
Control	32	71.1	13	28.9	—	—

No sites with a Plaque Index of 3 were observed at any time.

Table 6 Gingival Index[21,22] by Time and Group

Time/ group	Index 0		Index 1		Index 2	
	No.	%	No.	%	No.	%
01/98–10/98						
Test	20	64.5	8	25.8	3	9.7
Control	22	71	8	25.8	1	3.2
11/98–12/99						
Test	25	54.4	17	37	4	8.6
Control	30	66.7	13	28.9	2	4.4
01/00–12/00						
Test	28	60.9	15	32.6	3	6.5
Control	30	66.7	14	31.1	1	2.2
01/01–06/01						
Test	29	63	16	34.8	—	—
Control	30	66.7	15	33.3	—	—

No sites with a Gingival Index of 3 were observed at any time.

Table 7 Implant Area Pocket Probing Depth by Group

Time (mo)/ group	0 to 1 mm		1 to 2 mm	
	No.	%	No.	%
6				
Test	46	100	—	—
Control	45	100	—	—
12				
Test	46	100	—	—
Control	43	95.6	2	4.4
18				
Test	45	97.8	1	2.2
Control	42	93.3	3	6.7
24				
Test	45	97.8	1	2.2
Control	42	93.3	3	6.7

Figures shown are the mean of 4 sites.

out during the entire tissue healing period showed the absence of plaque and gingival inflammation in a very high proportion of the cases. Probing depth averages of the 4 sites (buccal, lingual, mesial, and distal) indicated a difference between the 2 groups only in the period prior to placement of the prosthesis (Table 7). Two days after placement of the prosthesis, 32.6% of the implant sites subjected to immediate loading showed a mean probing depth of 3 to 4 mm, as compared with 13% of those loaded after the traditional functional rest period, but within a few months there was no significant difference between the 2 groups. In this study, the marginal bone level always remained within stable values and never exceeded 4 mm in depth, beyond which it would have become impossible to perform oral hygiene.[22,23]

Radiographic Results

Marginal bone loss at 24 months of clinical follow-up for all restorations was 0 to 1 mm for 95.7% (n = 44) of the test group and 93.3% (n = 42) of the control group (Table 8). Further bone loss in the range of 1 to 2 mm was also found in 4.3% (n = 2) and 6.7% (n = 3) of the groups, respectively (Table 8). The crater-type peri-implant resorption pattern that frequently develops after the first few months of occlusal loading was not observed with the immediately loaded implants. Among single-tooth restorations, bone loss of 0 to 1 mm ranged from 92.8% (test group, n = 13) and 86.7% (control group, n = 13) in the mandible to 88.9% (test group, n = 8; control group, n = 8) in the maxilla (Table 8).

DISCUSSION

In both the test and control groups, patients received the same medication regimen and treatment protocol by the same surgeon and restorative team, so that the delayed and immediate full occlusal loading protocols could be studied uniformly and objectively. Contrary to concerns that immediate full occlusal loading of restorations would generate excessive stress that would compromise implant survival, the clinical results obtained with the microtextured-surface implant in this study were comparable between the test and control groups.

While some disagreement exists about the use of the Loe and Silness[21] gingival index as a criterion for implant success, there is no doubt that tissue in the implant area should be healthy and free from inflammation. For 6 months prior to surgery, the patients had checkups every 3 weeks and were instructed on how to perform effective oral hygiene at home. Hygiene education was begun early so that each patient's learning curve could be completed prior to seating of the prosthesis.

The original surgical-prosthetic protocol for obtaining osseointegration invariably provided for implant submergence and delayed loading, which has been generally accepted as axiomatic by many dentists. Pushed by demands for treatment changes, clinical practitioners have often found themselves ahead of the research community in experimenting with alternative approaches in the absence of adequate materials and methods. Consequently, the available data on immediate loading are often uncontrolled and retrospective in scope. It is for these reasons that the authors sought to study the matter using a test group and a control group that were equivalent as far as possible. The patients were evaluated over time according to generally accepted factors that are used to determine the long-term success of osseointegrated implants.

After 24 months of clinical loading, cumulative marginal bone loss was 0 to 1 mm for 95.7% of the test group and 1 to 2 mm for the remaining 4.3% of the test group. These results were comparable to the control group (93.3% = 0 to 1 mm; 6.7% = 1 to 2 mm). After 42 months of clinical follow-up, only 1 implant failed (control group), which left a cumulative survival rate of 98.9% for all implants placed. This study thus achieved very high predictability with microtextured implants, especially in patients who were well motivated and subjected to periodic checkups.

Table 8 Peri-implant Marginal Bone Loss by Occlusal Loading Protocol: All Restorations

Loading time (mo)	Immediate occlusal loading (n and %)		Delayed occlusal loading (n and %)	
	0–1 mm	1–2 mm	0–1 mm	1–2 mm
All restorations				
Baseline*	46 (100)	—	45 (100)	—
6	46 (100)	—	43 (95.6)	2 (4.4)
12	45 (97.8)	1 (2.2)	42 (93.3)	3 (6.7)
18	45 (97.8)	1 (2.2)	42 (93.3)	3 (6.7)
24	44 (95.7)	2 (4.3)	42 (93.3)	3 (6.7)
Mandibular single-tooth restorations				
Baseline*	14 (100)	—	15 (100)	—
6	14 (100)	—	13 (86.7)	2 (13.3)
12	13 (92.8)	1 (7.1)	13 (86.7)	2 (13.3)
18	13 (92.8)	1 (7.1)	13 (86.7)	2 (13.3)
24	13 (92.8)	1 (7.1)	13 (86.7)	2 (13.3)
Maxillary single-tooth restorations				
Baseline*	9 (100)	—	9 (100)	—
6	9 (100)	—	9 (100)	—
12	9 (100)	—	8 (88.9)	1 (11.1)
18	9 (100)	—	8 (88.9)	1 (11.1)
24	8 (88.9)	1 (11.1)	8 (88.9)	1 (11.1)

*Measurements taken at prosthesis delivery.
No sites showed more than 2 mm of marginal bone loss.

CONCLUSION

The clinical and radiologic results of this study showed no significant differences between delayed and immediate full occlusal loading of implant-supported restorations in partially edentulous patients.

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REFERENCES

1. Brånemark P-I, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg 1977;11 (suppl 16):1–132.
2. Brunski JB. Biomechanical factors affecting the bone-dental interface. Clin Mater 1992;10:153–201.
3. Bidez MW, Misch CE. Force transfer in implant dentistry: Basic concepts and principles. Implant Dent 1992;1(4): 289–294.
4. Pilliar RM, Deporter D, Watson PA. Tissue-implant interface: Micro-movements effects. In: Vincenzini P (ed). Advances in Science and Technology. Vol 12: Materials in clinical applications: Proceedings of Topical Symposium VIII on Materials in Clinical Applications of the 8th CIMTEC World Ceramic Congress and Forum on New Materials, Florence, Italy, June 28 to July 4, 1994. Faenza, Italy: Techna, 1995:569–579.

5. Pilliar RM, Lee JM, Maniatopoulos C. Observations of the effect of movement on bone ingrowth into porous-surface implants. Clin Orthop 1986;208:108–113.
6. Ledermann PD. Stegprothetische Versorgung des zahnlosen Unterkiefers mit Hilfe von Plasma-beschichteten Titanschrauben-implantaten. Dtsch Zahnarztl Z 1979;34:907–918.
7. Ledermann PD. Die plasmabeschichtete Titanschraube als enossales Implantat. Methodic der Implantaten und der postoperativen Versorgung. Dtsch Zahnarztl Z 1980;35:577–579.
8. Schroeder A, van der Zypen E, Stich H, Sutter F. The reaction of bone, connective tissue and epithelium to endosteal implant with sprayed titanium surfaces. J Oral Maxillofac Surg 1981;9:15–25.
9. Babbush CA. Titanium plasma spray screw implant system for reconstruction of edentulous mandible. Dent Clin North Am 1986;30:117–131.
10. Schnitman PA, Wöhrle PS, Rubenstein JE, DaSilva JD, Wang N-H. Ten-year results for Brånemark implants immediately loaded with fixed prostheses at implant placement. Int J Oral Maxillofac Implants 1997;12:495–503.
11. Kupeyan HK, May KB. Implant and provisional crown placement: A one stage protocol. Implant Dent 1998;7:213–219.
12. Hui E, Chow J, Li D, Liu J, Wat P, Law H. Immediate provisional for single-tooth implant replacement with Brånemark System: Preliminary report. Clin Impl Dent Rel Res 2001;3:79–86.
13. Chashu G, Chaushu S, Tzohar A, Dayan D. Immediate loading of single-tooth implants: Immediate versus non-immediate implantation. A clinical report. Int J Oral Maxillofac Implants 2001;16:267–272.
14. Wöhrle PS. Single-tooth replacement in the aesthetic zone with immediate provisionalization: Fourteen consecutive case reports. Pract Periodontics Aesthet Dent 1998;10:1107–1114.
15. Steveling H, Roos J, Rasmusson L. Maxillary implants loaded at 3 months after insertion: Results with Astra Tech implants after up to 5 years. Clin Impl Dent Rel Res 2001;3:120–124.
16. Cooper L, Felton DA, Kugelberg CF, et al. A multicenter 12-month evaluation of single-tooth implants restored 3 weeks after 1-stage surgery. Int J Oral Maxillofac Implants 2001;16:182–192.
17. Gomes A, Lozada JL, Caplanis N, Kleinman A. Immediate loading of a single hydroxyapatite-coated threaded root form implant: A clinical report. J Oral Implantol 1998;24(3):159–166.
18. Van Blarcom CW (ed). The Glossary of Prosthodontic Terms. J Prosthet Dent 1999;81:39–110.
19. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark P-I, Zarb GA, Albrektsson T (eds). Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence, 1985:199–209.
20. Loe H, Silness J. The gingival index, the plaque index, and the retention index system. J Periodontol 1967;38:610–616.
21. Silness J, Loe H. Periodontal disease in pregnancy. Correlation between oral hygiene and periodontal condition. Acta Odontol Scand 1964;22:121–135.
22. Stefani LA. The care and maintenance of the dental implant patient. J Dent Hygiene 1988;62:447–466.
23. Rams TE, Slots J. Comparison of two pressure sensitive periodontal probes and a manual periodontal probe in shallow and deep pockets. Int J Periodontics Restorative Dent 1993;13:521–529.