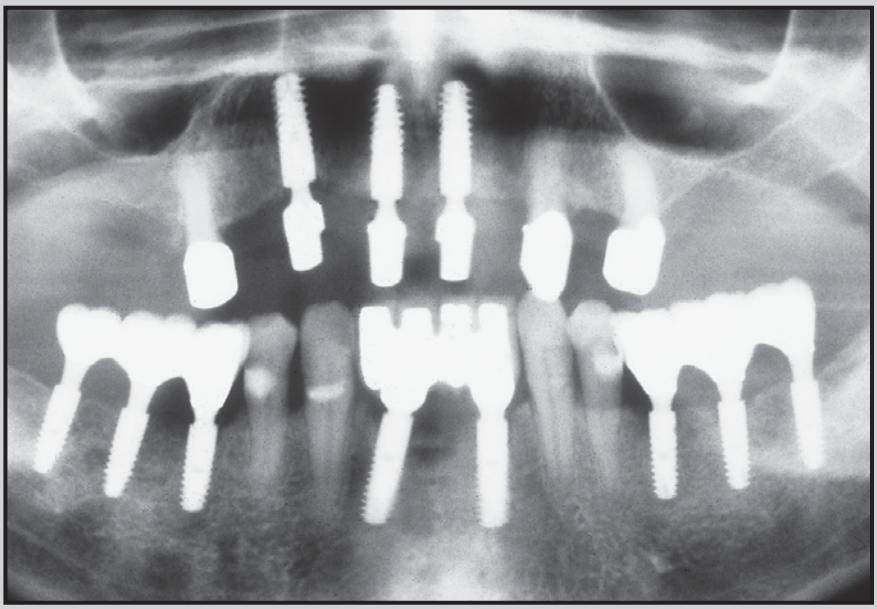
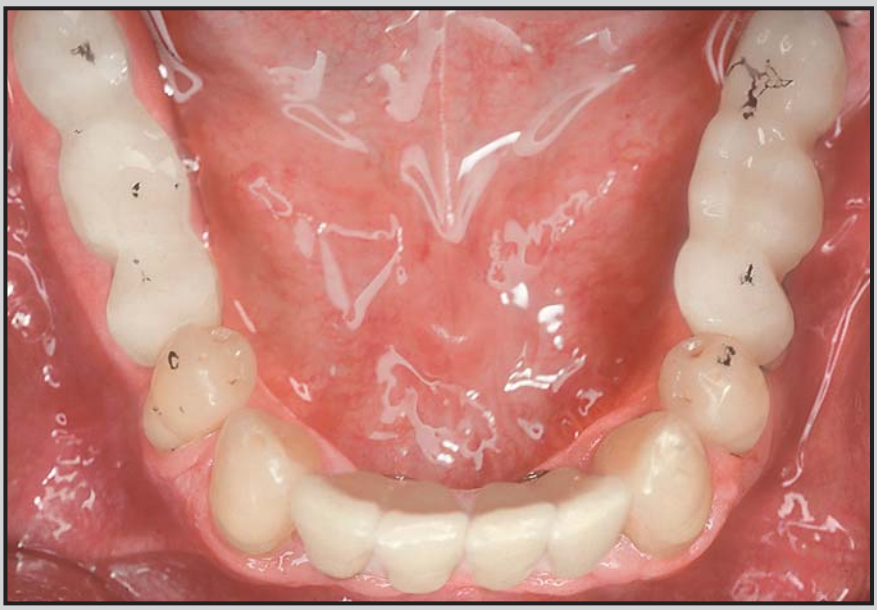
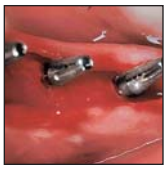




Immediate Versus Delayed Functional Loading of Implants in the Posterior Mandible: A 2-Year Prospective Clinical Study of 12 Consecutive Cases



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*Georg-Hubertus Nentwig, DMD, Dr Med Dent, PhD***

The aim of this investigation was to evaluate the clinical success of immediately loaded implants versus implants loaded in a delayed fashion in the posterior mandible. Three implants were placed distal to the canines bilaterally in the edentulous distal mandibular ridges of 12 patients. One side was randomly selected for placement of three implants (delayed loading; control sites) with a progressive thread design for submerged healing, and after 3 months the implants were exposed and loaded with provisional splinted crowns, which were replaced 6 weeks later by the definitive restorations. Three additional implants (immediately loaded; test sites), of the same size were placed in the contralateral side of the mandible. The test implants had abutments placed and were loaded immediately using the same protocol as the control implants. After a mean loading period of 25.3 months, the patients showed normal mean clinical values without significant differences (P < 0.05) for test and control implants, respectively, as follows: Plaque Index: 0.4 versus 0.8; Sulcus Bleeding Index: 0.5 versus 0.3; probing pocket depth: 1.9 mm versus 2.1 mm; width of keratinized mucosa: 2.5 mm versus 3.3 mm; Periotest value: -3.7 versus -3.2. Twenty-nine of the examined sites showed no bone loss. After 2 years of loading in the posterior mandible, test and control implants had the same prognosis. (Int J Periodontics Restorative Dent 2006;26:459-469.)

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Implant placement in the posterior mandible is associated with many problems because of insufficient bone quality.[1–3] Moreover, anatomic limitations, which restrict the amount of bone available for implant placement in posterior locations, often mean that only shorter implants can be placed. Furthermore, biomechanical factors, such as increased loading forces in these locations, may be associated with higher failure rates,[4] and frequent occurrences of peri-implantitis have also been reported.[5]

Immediate loading of implants placed in the posterior mandible may be a high-risk clinical situation because loading immediately after surgery may result in micromotions at the interface, thus interfering with the healing process. If these micromotions are relatively small, the tissue has the capacity to differentiate into bone, similar to the healing pattern seen in fractured bones after stabilization with osteosynthesis plates. Larger micromotions, however, will lead to fibrous tissue formation at the interface,[6] which can result in scar tissue, as in nonstabilized fractured bones. The critical point for the clinician is to understand that the

amount of micromotion that might occur cannot be clinically evaluated during surgery.

In general, the concept of immediate loading in the fully edentulous mandible is a well-accepted treatment concept, with a cumulative success rate of 92% after a mean observation period of 7.23 years, when four primarily stable implants have been placed in the anterior part of the mandible, splinted with a bar, and loaded with a bar-retained overdenture.[7] Additional studies using the same treatment concept also found high success rates.[8,9] The placed implants were immobilized immediately after surgery by the bar restoration. Moreover, indirect immobilization of four implants placed in the anterior part of the mandible and connected with prefabricated telescopic crowns can be done if the dentures are placed immediately after implant placement and not removed in the first 2 weeks of healing.[10]

Further studies showed successful implant treatment when 6 to 10 implants were placed in the mandible and loaded by a fixed implant-supported restoration.[11–15] In such clinical procedures, the implant success rate seems to be high because the full-arch restoration placed immediately after implant placement minimizes micromotion as a result of adequate splinting of the implants in the arch and the significant reduction of bending moments. In some studies, immediately loaded implants that were later connected to submerged implants[12,13,15] presented high success rates.

From a biomechanical point of view, increased bending moments can occur when implants are placed in the posterior part of the jaw.[16] Clinical studies of immediate loading in the posterior mandible reported a high number of failures caused by the porous nature of the bone in these areas.[17–20] Other authors placed a high number of implants in the mandible (including the posterior mandible) and avoided the removal of the provisional restoration during the 4- to 6-month healing period. In addition, they recommended screw-retained provisional and noncemented restorations, which have the advantage of easy removal and do not cause macromovements during the healing period.[13] Because of the increased failures seen with immediately loaded implants placed in the posterior mandible, the aim of this study was to compare the success rate of immediately loaded implants versus implants loaded in a delayed protocol placed in the posterior part of the mandible in a prospective clinical study of 12 consecutive cases.

Method and materials

Twelve patients were selected for this prospective clinical study. Seven male and five female patients with a mean age of 50.75 (± 7.95) years were examined clinically and radiographically by means of panoramic radiographs before surgery. All patients were bilaterally edentulous in the mandible distal to the canines or first or second premolars. In eight patients, the maxilla had periodontally healthy teeth or fixed prosthetic reconstructions; the remaining four patients had removable prostheses in the maxilla. According to the selection criteria of this study, all included patients showed high levels of compliance with treatment and were in good general health. Alcohol-, drug-, or medication-dependent patients, postradiotherapy or postchemotherapy patients, and pregnant subjects were excluded from the study. Only those patients with sufficient bone (more than 11.0 mm in height and 6.0 mm in width) were selected for this study. Six patients were occasional smokers. The study was approved by the Ethics Committee of the Johann Wolfgang Goethe University, Frankfurt, Medical Faculty, according to the declaration of Helsinki (1964) (no. 91/99).

Three Ankylos implants (Dentsply Friadent CeraMed) were placed in each side of the partially edentulous posterior mandible. The Ankylos Implant System has a characteristic progressive thread design, which results in better retention, especially at its apical end (where bone often has poorer quality) and a conical, tight connection between the abutment and the implant.

Four implants replaced first premolars, 20 implants replaced second premolars, 24 implants replaced first molars, 20 implants replaced second molars, and 4 implants replaced third molars. The implants were 11.0 mm long and 3.5 mm wide (A-11 implants) and were placed according to the experimental design of this study (Fig 1). In areas of compromised bone anatomy, one implant with a length of 9.5 mm and diameter of 4.5 mm (B-9.5 implants) was placed in each side of the mandible. No patients with more than one B-9.5 implant in either the

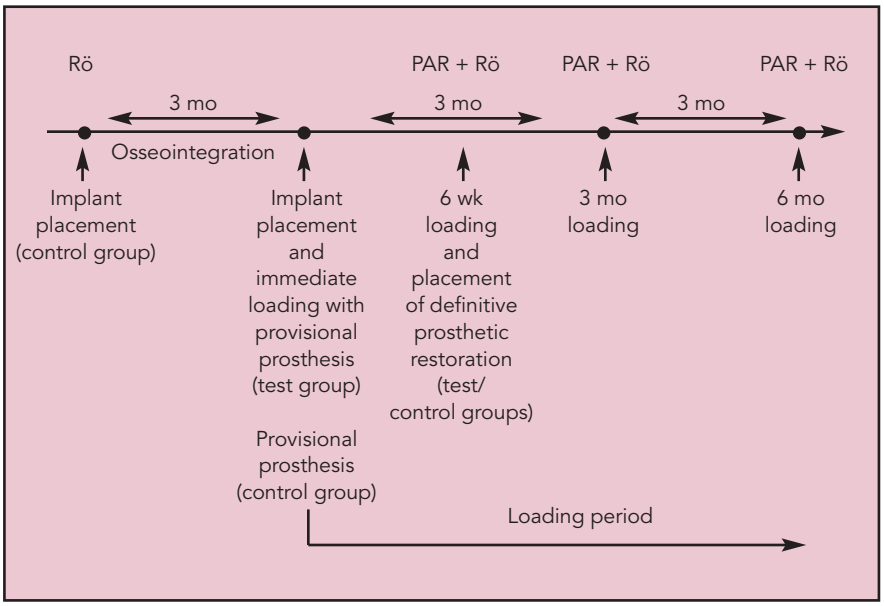


Fig 1 *Experimental outline of the study. PAR = periodontal measurements; Rö = radiographic examination.*

test or control groups were included in this study for statistical comparison. B-9.5 implants were always placed in symmetric positions for comparison purposes. A total of 66 A-11 implants and 6 B-9.5 implants were placed in this study using surgical guide splints fabricated after duplication of the setup in the study casts.

Surgical and prosthetic procedures

Evaluation of bone quality

Bone quality, which was evaluated during surgery, determined the technique of implant placement according to the following criteria:

- Hard: the implant was placed after tapping with the ratchet
- Normal: the implant was placed after tapping with the hand wheel
- Soft: the implant was placed without tapping

The 72 implants were placed in areas of different bone qualities. Of the control (delayed loading) implants, 7 were placed in soft bone, 2 in hard bone, and 27 in normal bone. Of the immediately loaded (test) implants, 7 were placed in soft bone, 3 in hard bone, and 26 in normal bone.

Control sites

After local anesthesia was induced with articaine (Ultracain DS, Aventis), a buccal incision was made and a mucoperiosteal flap was elevated. The implants were placed into predetermined positions according to the surgical guides (Fig 2) and the proposed surgical protocol published by Nentwig et al[21] for the Ankylos Implant System. The flaps were sutured using 4-0 silk (Resorba). The sutures were removed 7 to 10 days after surgery. The implants were allowed to heal and osseointegrate for 3 months after surgery; at this point second-stage surgery was performed and sulcus formers were placed. One week later, the healing abutments were replaced by straight or angulated (15-degree) standard abutments. Provisional acrylic resin crowns connecting the three implants together were fabricated chairside with Protemp (Espe) and cemented temporarily (Temp Bond, Kerr).

Test sites

Test implants were placed on the day that the control implants were loaded with provisional restorations. After a crestal incision was made and a mucoperiosteal flap was elevated, the implants were placed; provisional resin restorations were inserted to load implants immediately (Figs 3a and 3b). Suturing of the flap was performed with 4-0 silk. Provisional crowns, which splinted together the three implants on

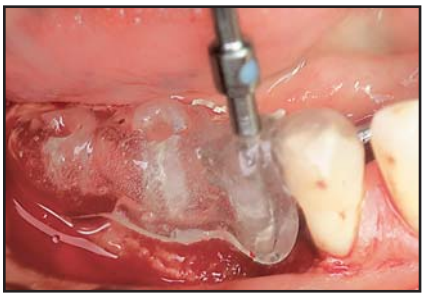


Fig 2 *The implants are placed using a surgical splint for guidance.*

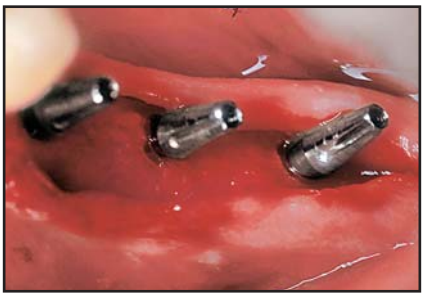


Fig 3a *Implants are placed for immediate loading.*

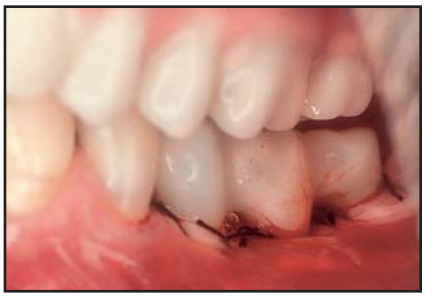


Fig 3b *The test implants are loaded immediately after surgery with acrylic resin crowns.*

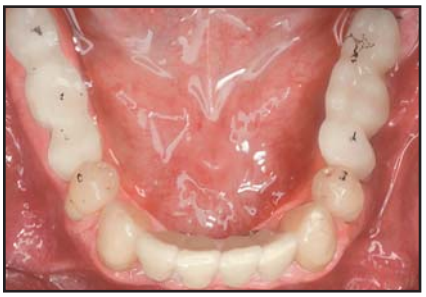


Fig 4 *Sufficient occlusal contact occurs immediately after placement of the test group implants (left side of the mandible).*

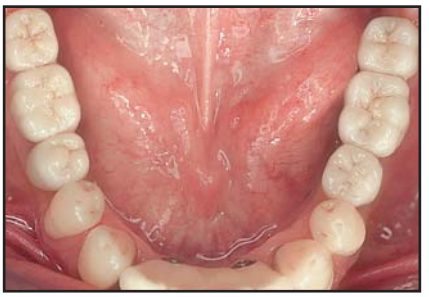


Fig 5a *The definitive reconstructions in the test (left mandible) and control (right mandible) sites.*

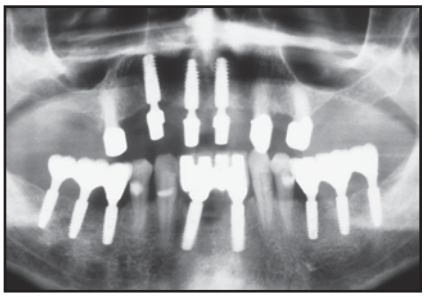


Fig 5b *Radiographic examination immediately after insertion of the definitive prostheses on both sides in the same patient.*

each side of the mandible, had occlusal contact only during maximal intercuspation (Fig 4). Eccentric contacts during lateral movements of the mandible were eliminated. Canine or anterior guidance was used in all clinical cases. One week after insertion of the provisional dentures, sutures were removed. The provisional prostheses stayed in place for a total of 6 weeks and were then replaced with metal-ceramic restorations.

Postoperative care

For postoperative care, chlorhexidine digluconate was prescribed until suture removal. Postoperative antibiotics were not administered. For pain reduction, analgesics were recommended (paracetamol/acetaminophen, 500 mg, three times per day). Patients were advised to adhere to a soft diet for the first 4 to 6 weeks of loading.

Definitive restorations

Two weeks after placement of the test implants, the provisional restorations were removed from all implants, and an impression was made on both sides of the mandible with polyether impression material (Impregum, Espe) using special Ankylos transfer caps. A facebow transfer and interocclusal registration was performed before master cast mounting in a SAM-2 articulator (SAM Präzisionstechnik). Definitive metal-ceramic restorations of high-gold alloy (Bioherador N, Heraeus) and porcelain (Omega 900, Vita) were fabricated in the dental laboratory and cemented 6 weeks after loading (Figs 5a and 5b).

Clinical and radiographic examinations

All implants were examined clinically and radiographically at different time intervals. Clinical periodontal measurements, including Plaque Index according to Silness and Löe,[22] Sulcus Bleeding Index according to Mühlemann and Son,[23] probing

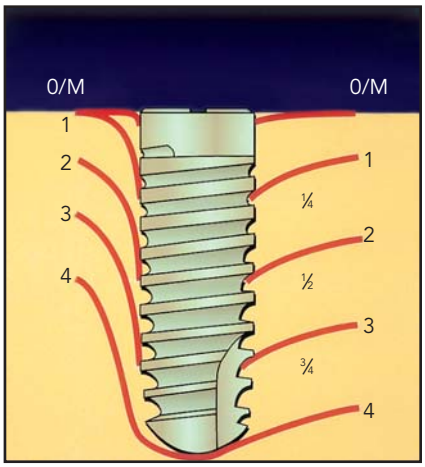


Fig 6 *Definition of horizontal and vertical bone loss according to the radiographic examination.*

pocket depth, width of the keratinized mucosa, and mobility values (Periotest, Medizintechnik Gulden) according to Olivé and Aparicio,[24] were obtained after removal of the prostheses at different time intervals. The Periotest device was placed at the middle of the buccal surface of each abutment after removal of the prosthetic restoration. Measurements performed during the second week of loading were defined as baseline (T_0). Additional measurements were obtained on the day of insertion of the definitive metal-ceramic restoration (after 6 weeks of loading). Further Periotest measurements were performed at 3, 6, 9, 12, 18, and 24 months after loading, following the removal of the prosthetic restoration. At the same time, panoramic radiographs were obtained to evaluate crestal bone levels around both test and control group implants (see following for method used to evaluate bone loss). To ensure fair comparison, all implants were placed and restored prosthetically by one clinician. The prosthetic restorations were fabricated by a limited number of dental technicians (only three), who were well instructed in the treatment concept. The same clinician (GR) evaluated all the implants clinically and radiographically. The mean loading period of the implants was 25.3 ± 4.7 months.

For each group (test/control) the implants were loaded for the following periods: 3 implants were loaded for 36 months; 6 implants were loaded for 30 months; 6 implants were loaded for 25 months, 12 implants were loaded for 24 months, 3 implants were loaded for 23 months, 3 implants were loaded for 21 months, and 3 implants were loaded for 18 months.

Peri-implant crestal bone loss was scored as follows: 0 = no bone loss; m = bone loss of less than 2.0 mm; 1 = bone loss less than one quarter of the implant length; 2 = bone loss of less than half of the implant length; 3 = bone loss of less than three quarters of the implant length. Horizontal and vertical bone loss was determined according to the angle between the long axis of the implant and the crestal bone margin. If this angle was greater than 45 degrees, the bone loss was designated as horizontal; if the angle was smaller than 45 degrees, the bone loss was deemed vertical (Fig 6).

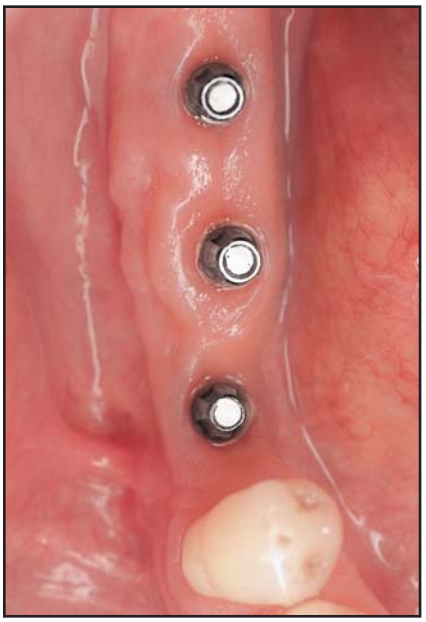
Results

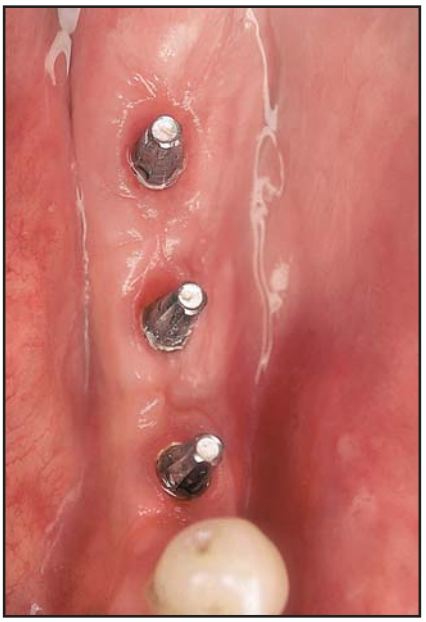
Healing was uneventful, and all implants osseointegrated successfully. No complications or postoperative infections were observed during the observation period (Figs 7a to 7c). No visible implant mobility was observed either immediately after surgery or during the loading period in either implant group after removal of the prosthetic restoration.

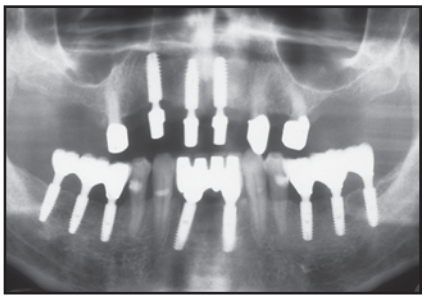
Clinical evaluation

The examined periodontal measurements are presented in Table 1.

After removal of the prosthetic restorations, Periotest values were calculated and evaluated statistically. The data analysis was performed using Program NCSS2000 (Number Cruncher Statistical Systems) and pre-







Figs 7a and 7b *Healthy soft tissue conditions are observed around delayed* (a, left) *and immediately* (b, center) *occlusal loaded implants 2 years after loading.*

Fig 7c (above) *Radiographic examination shows no bone loss around the implants of the test (left mandible) as well as control (right mandible) sites versus the baseline radiograph (see Fig 5b).*

sented a normal distribution. The median, minimum, and maximum Periotest values obtained at the different time intervals for the test and control sites are listed in Table 2.

The peri-implant clinical indices were compared statistically using the Mann-Whitney *U* test for comparison between the test and control groups. There were no statistically significant differences at the 5% level between the two groups ($P > .05$).

Radiographic evaluation

Bone loss was less than 2 mm around all test and control group implants (Table 3). A difference in bone loss between the test and control group implants was observed during the loading period. According to these data, the immediately functional loaded implants had no or minimal (2 mm or less) vertical or horizontal bone loss. In the control group, one site had bone loss of about 3 mm at the final follow-up evaluation (24 months).

Discussion

There are various general requirements for implant success in immediate functional loading. Implants with threads achieve better primary anchorage (mechanical stability) in bone immediately after surgery in comparison to cylindric implants without threads.[25] In addi-tion, there is an advantage for implant integration when the surface of the implant is rough, because bone

Table 1 Periodontal measurements of the patient sample

Time/site*	PI	SBI	PPD (mm)	KG (mm)
T_0				
Test	0.5 ± 0.5	0.5 ± 0.6	2.1 ± 0.6	3.3 ± 1.7
Control	0.2 ± 0.4	0.1 ± 0.2	2.1 ± 0.6	4.0 ± 1.2
T_1				
Test	0.3 ± 0.4	0.3 ± 0.4	1.6 ± 0.5	2.6 ± 1.5
Control	0.4 ± 0.5	0.3 ± 0.5	1.8 ± 0.4	3.7 ± 1.4
T_2				
Test	0.2 ± 0.4	0.5 ± 0.5	1.9 ± 0.4	2.4 ± 1.5
Control	0.1 ± 0.2	0.3 ± 0.4	1.8 ± 0.3	3.3 ± 1.4
T_3				
Test	0.3 ± 0.4	0.3 ± 0.5	1.7 ± 0.4	2.3 ± 1.5
Control	0.1 ± 0.1	0.2 ± 0.4	1.7 ± 0.4	3.2 ± 1.6
T_4				
Test	0.4 ± 0.6	0.5 ± 0.6	1.9 ± 0.2	2.5 ± 1.2
Control	0.8 ± 0.7	0.3 ± 0.5	2.1 ± 0.2	3.3 ± 1.4

*For each type of site (test/control), n = 36.
T_0 = after 2 weeks of loading; T_1 = after 6 weeks of loading; T_2 = after 3 months of loading; T_3 = after 6 months of loading; T_4 = follow-up evaluation (mean, 24 months of loading).
PI = Plaque Index[22]; SBI = Sulcus Bleeding Index[23]; PPD = probing pocket depth; KG = width of keratinized mucosa.

Table 2 Periotest values obtained at the different time intervals

Time/site*	Median	Minimum	Maximum
T_0			
Test	–3	–7	22†
Control	–3	–6	1
T_1			
Test	–3	–8	18†
Control	–4	–8	3
T_2			
Test	–3	–5	7
Control	–3.5	–7	0
T_3			
Test	–3	–8	2
Control	–3	–5	0
T_4			
Test	–3.7	–6	–1
Control	–3.2	–8	0

*For each type of site (test/control), n = 36.
†These Periotest values represent mobility values of an implant placed in an area with extremely poor bone quality.
T_0 = after 2 weeks of loading; T_1 = after 6 weeks of loading; T_2 = after 3 months of loading; T_3 = after 6 months of loading; T_4 = follow-up evaluation (mean, 24 months of loading).

Table 3 Distribution of vertical and horizontal bone loss in the test and control implant sites

Bone loss/site*	T_0	T_1	T_2	T_3	T_4
Vertical bone loss (n = 36)					
Test sites					
0	36	32	31	31	29
m	0	4	5	5	7
Control sites					
0	32	31	27	27	26
m	4	5	9	9	9
1	0	0	0	0	1
Horizontal bone loss (n = 36)					
Test sites					
0	35	31	33	33	28
m	1	5	3	3	8
Control sites					
0	33	30	30	30	23
m	3	6	6	6	13

*For each type of site (test/control), n = 36.
T_0 = after 2 weeks of loading; T_1 = after 6 weeks of loading; T_2 = after 3 months of loading; T_3 = after 6 months of loading; T_4 = follow-up evaluation (mean, 24 months of loading).
0 = no bone loss; m = less than 2 mm of bone loss; 1 = bone loss less than one quarter of of the implant length (and more than 2 mm).PI = Plaque Index[22]; SBI = Sulcus Bleeding Index[23]; PPD = probing pocket depth; KG = width of keratinized mucosa.

cells attach better to rough surfaces (biologic stability) and achieve osseointegration more quickly.[26,27] Clinical studies of immediate loading of implants with machined (relatively smooth) surfaces showed high success rates only in the mandible, not in the maxilla, because of the frequently compromised quality of maxillary bone.[28] A study performed by Tarnow et al[13] showed no differences in success rates between maxillary and mandibular arches. Gentle preparation of the implant bed without tapping, especially in areas of compromised bone quality, is necessary to increase primary stability. Further stabilization of the implants via splinting with a bar or a fixed restoration is mandatory to eliminate possible micromotion, which leads to fibrous tissue formation and prohibits osseointegration.[6] When a bar is fabricated or a provisional fixed prosthesis is attached, a precise fit is mandatory.[7] The magnitude of loading (masticatory) forces is also of great importance and must be minimized. This is possible if patients are selected carefully for this loading protocol. Bruxers or patients with hypertrophic masticatory muscles may need to be excluded. In addition, a soft or liquid diet is strongly recommended in immediate loading cases for the first 4 to 6 weeks of loading. Some authors prefer to avoid removing the cemented provisional prostheses during the first 6 weeks of healing,[13] because it may lead to loss of osseointegration of the implants.

However, this did not occur in the present 12 cases when we removed the cemented provisionals at 2 weeks.

Of great importance is the clinical evaluation of the implant placed at the second molar site that showed a Periotest value of +22 immediately after placement. This value was very high, and it does not correspond with high stability. The implant was splinted with the neighboring implants and showed a continuous reduction in Periotest values during loading. Specifically, this value was +3 at the time of the placement of the definitive restoration (after 6 weeks of loading); Periotest values were 0, –1, and –2 after 3, 6, and 9 months of loading, respectively. A negative Periotest value of –6 was finally achieved after 2 years of loading. In only 6 weeks of loading with splinting it was possible for the Periotest value to reach an acceptable level (less than +8, which is the highest level of acceptance). This validates the role of adequate splinting after surgery, when implants may not be stable because of poor bone quality in the area of placement.

Moreover, we used an implant system that has adequate macroscopic and microscopic properties and enables high primary stability in compromised bone. The good stability of this implant system and its increased anchorage within cancellous bone has been reported in previous in vitro photoelastic studies.[29] Furthermore, there is a large total surface area on this implant, with its special progressive thread design, which is similar to the total surface of a multirooted tooth[30]; this design has allowed the successful replacement of one molar with only one implant with high success rates and no complications.[31] Additional studies have shown increased initial stability, comparable with the stability seen after 3 months of healing, as assessed by Periotest measurements.[32]

In addition to the clinical biomechanical stability of the Ankylos Implant System, the peri-implant bone reactions around delayed and immediately loaded implants have been evaluated in an animal study. Histologic and histomorphometric observations and data have already been published[33,34] and showed no histologic differences in the two loading groups. Histomorphometric data showed a higher volume of mineralized tissue within the threads of the immediately loaded implants but no difference in bone-to-implant contact.[34] Clinical and radiologic findings in another study using monkeys also showed no statistically significant differences in the two groups.[35] Radiologic findings in the present clinical study revealed very low values for bone loss compared to baseline (only one site, in the control group, had more than 2 mm of bone loss at the time of the follow-up examination).

It should be noted that the lack of statistically significant differences between the two loading groups does not mean that the peri-implant conditions are the same, because the sample size in this study was relatively small. Further studies of immediate functional loading with a larger number of patients and with a longer follow-up in more compromised cases, eg, edentulous patients with insufficient bone quantity and quality, must be performed in the future to provide more data for clinical approval of this treatment concept in daily practice.

References

1. Von Wowern N. Variations in bone mass within the cortices of the mandible. Scand J Dent Res 1977;85:444–455.
2. Von Wowern N. Variations in structure within the trabecular bone of the mandible. Scand J Dent Res 1977;85:613–622.
3. Friberg B, Jemt T, Lekholm U. Early failures in 4641 consecutively placed Brånemark dental implants: A study from stage 1 surgery to the connection of completed prostheses. Int J Oral Maxillofac Implants 1991;6:142–146.
4. Jemt T, Lekholm U. Oral implant treatment in posterior partially edentulous jaws: A 5-year follow-up report. Int J Oral Maxillofac Implants 1993;8:635–640.
5. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (II) Etiopathogenesis. Eur J Oral Sci 1988;106:721–764.
6. Hansson HA, Albrektsson T, Brånemark P-I. Structural aspects of the interface between tissue and titanium implants. J Prosthet Dent 1983;50:108–113.
7. Ledermann PD. Über 20jährige Erfahrung mit der sofortigen funktionellen Belastung von Implantatstegen in der regio interforaminalis. Z Zahnärztl Implantol 1996;12:123–136.
8. Babbush CA, Kent JN, Misliek DJ. Titanium plasma-sprayed screw implants for the reconstruction of the edentulous mandible. J Oral Maxillofac Surg 1986;44:274–282.
9. Chiapasco M, Gatti C, Rossi E, Haefliger W, Markwalder TH. Implant-retained mandibular overdentures with immediate loading. A retrospective multicenter study on 226 consecutive cases. Clin Oral Implants Res 1997;8:48–57.
10. May D, Romanos G. Immediate implant-supported mandibular overdentures retained by conical crowns: A new treatment modality. Quintessence Int 2002;33:5–12.
11. Salama H, Rose LF, Salama M, Betts NJ. Immediate loading of bilaterally splinted titanium root-form implants in fixed prosthodontics. A technique reexamined: Two case reports. Int J Periodontics Restorative Dent 1995;15:345–361.
12. Balshi TJ, Wolfinger GJ. Immediate loading of Brånemark implants in edentulous mandibles: A preliminary report. Implant Dent 1997;6:83–88.
13. Tarnow DP, Emtiaz S, Classi A. Immediate loading of threaded implants at stage 1 surgery in edentulous arches: Ten consecutive case reports with 1- to 5-year data. Int J Oral Maxillofac Implants 1997;12:319–324.
14. Randow K, Ericsson J, Nilner K, Petersson A, Glantz P-O. Immediate functional loading of Brånemark dental implants. An 18-month clinical follow-up study. Clin Oral Implants Res 1999;10:8–15.
15. Horiuchi K, Uchida H, Yamamoto K, Sugimura M. Immediate loading of Brånemark system implants following placement in edentulous patients: A clinical report. Int J Oral Maxillofac Implants 2000;15:824–830.
16. Rangert B, Krogh B, van Roekel N. Bending overload and implant fracture: A retrospective clinical analysis. Int J Oral Maxillofac Implants 1995;10:326–334.
17. Schnittman PA, Rubenstein JE, Wöhrle PS, DaSilva JD, Koch GG. Implants for partial edentulism. J Dent Educ 1988;52:725–736.
18. DaSilva JD, Wöhrle P, Rubenstein JE, Koch G, Schnitman PA. Four-year survival for 137 two-stage implants in partially edentulous patients [abstract 1277]. J Dent Res 1990;69:268.
19. Schnitman PA, Wöhrle PS, Rubenstein JE. Immediate fixed interim prostheses supported by two-stage threaded implants: Methodology and results. J Oral Implantol 1990;16:96–105.
20. Schnitman PA. Brånemark implants loaded with fixed provisional prostheses at fixture placement. Nine-year follow-up. J Oral Implantol 1995;21:235.

21. Nentwig G-H, Moser W, Mairgünther R. Das Ankylos-Implantatsystem: Konzept, Klinik, Ergebnisse. Implantologie 1993;3: 225–237.
22. Silness J, Löe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. Acta Odontol Scand 1964;22:121–135.
23. Mühlemann HR, Son S. Gingival sulcus bleeding: A leading symptom in initial gingivitis. Helv Odontol Acta 1971;15: 107–113.
24. Olivé J, Aparicio C. The Periotest method as a measure of osseointegrated oral implant stability. Int J Oral Maxillofac Implants 1990;5:390–400.
25. Szmukler-Moncler S, Salama H, Reingewirtz Y, Dubruille JH. Time of loading and effect of micromotion on bone-dental implant interface: Review of experimental literature. J Biomed Mater Res 1998;43: 192–203.
26. Chehroudi B, Gould TR, Brunette DM. Effects of a grooved titanium-coated implant surface on epithelial cell behavior in vitro and in vivo. J Biomed Mater Res 1989;23:1067–1085.
27. Martin JY, Schwartz Z, Hummert TW, et al. Effect of titanium surface roughness on proliferation, differentiation, and protein synthesis of human osteoblast-like cells (MG 63). J Biomed Mater Res 1995;29: 389–401.
28. Jaffin RA, Kumar, A, Berman, CL. Immediate loading of implants in partially and fully edentulous jaws: A series of 27 case reports. J Periodontol 2000;71: 833–838.
29. Nentwig G-H, Moser W, Knefel T, Ficker E. Dreidimensionale spannungsoptische Untersuchungen der NM-Implantatgewindeform im Vergleich mit herkömmlichen Implantatgewinden. Z Zahnärztl Implantol 1992;8:130–135.
30. Nentwig G-H, Reichel M. Vergleichende Untersuchungen zur Mikromorphologie und Gesamtoberfläche enossaler Implantate. Z Zahnärztl Implantol 1994;10:150–154.
31. Romanos GE, Nentwig GH. Single molar replacement with a progressive thread design implant system: A retrospective clinical report. Int J Oral Maxillofac Implants 2000;15:831–836.
32. Morris HF, Winkler S, Ochi S. The Ankylos endosseous dental implant: Assessment of stability up to 18 months with the Periotest. J Oral Implantol 2000;26: 291–299.
33. Romanos GE, Toh CG, Siar CH, et al. Periimplant bone reactions to immediately loaded implants. An experimental study in monkeys. J Periodontol 2001;72: 506–511.
34. Romanos GE, Toh CG, Siar CH, Swaminathan D, Ong AH. Histological and histomorphometrical implant bone subjected to immediate loading. An experimental study with Macaca fascicularis. Int J Oral Maxillofac Implants 2002;17:44–51.
35. Toh CH, Romanos GE, Siar CH, Swaminathan D, Ong AH. Immediate loading of implants with splinted crowns: A clinical and radiographic evaluation in a monkey model [abstract 1546]. J Dent Res 2000;79: 337.