

HISTOLOGIC EVALUATION OF 2 HUMAN IMMEDIATELY LOADED AND 1 SUBMERGED TITANIUM IMPLANTS INSERTED IN THE POSTERIOR MANDIBLE AND RETRIEVED AFTER 6 MONTHS

Marco Degidi, MD, DDS
Giovanna Petrone, DDS, PhD
Giovanna Iezzi, DDS
Adriano Piattelli, MD, DDS

KEY WORDS

Dental implants
Histology
Immediate loading

Immediate loading can be successfully used in implant dentistry. Many factors are thought to be of importance in obtaining mineralized tissues at the interface. One such factor is the implant surface characteristics. The authors retrieved, after a 6-month loading period, 2 immediately loaded implants and 1 submerged implant, each of which had been inserted in posterior mandibles. Histology showed that, in both immediately loaded implants, mineralized tissue was present at the interface, and the bone-implant contact percentage was about 65% to 70%. No gaps, fibrous tissue, or inflammatory infiltrates were present at the interfaces. In the submerged (control) implant, the bone-implant contact percentage was much lower (about 35%). Our results showed that immediate loading of dental implants, even in the posterior regions of the jaw bones, hadn't caused untoward effects on the formation of mineralized tissues at the interface, producing, on the contrary, a higher bone-implant contact percentage than in the control implant, and thus, immediate loading can be a possible alternative procedure in implant dentistry.

INTRODUCTION

Marco Degidi, MD, DDS, is a visiting professor; Giovanna Petrone, DDS, PhD, and Giovanna Iezzi, DDS, are research fellows; and Adriano Piattelli, MD, DDS, is a professor of Oral Medicine and Pathology, as well as dean and director of Studies and Research, at the Dental School of the University of Chieti in Chieti, Italy. Address correspondence to Dr Piattelli, Via F. Sciucchi 63, 66100, Chieti, Italy (e-mail: apiattelli@unich.it).

A stress-free healing period was thought to be a prerequisite for successful osseointegration and for the presence of a mineralized tissue interface around dental implants.^{1,2} A functional rest of 3 to 4 months in the mandible and 6 months in the maxilla was

thought to be necessary, and it was believed that an early loading of dental implants could produce a fibrous-tissue encapsulation.³⁻⁵ More recently, several clinical and histological reports have appeared in the literature, showing that, in man and experimental animals, immediate loading shows promising clinical results.⁶⁻⁴⁶ Moreover, the

necessity for not loading the implants was empirically based and not experimentally ascertained.¹² The classic 2-stage protocol is associated with long treatment time and high treatment costs, and elimination of the healing period offers advantages in terms of cost of treatment and convenience to patients,³⁶ and avoiding the need for complete dentures while undergoing implant therapy can be a distinct advantage.⁴⁴ Complete dentures may create functional and psychological problems.⁴³ It has been reported that, with immediately loaded implants, patients resumed function quickly and that masticatory function was uniformly judged to be superior to pretreatment time.²⁵ Any reduction in the number of the surgical procedures necessary or a decrease in the healing period is certainly very well welcomed by clinicians and patients.⁴⁵ Chow et al³⁵ reported a 1-year follow-up with a 98.3% overall implant survival rate in 115 immediately loaded implants. In Buchs et al³⁶ series, the implant survival rate was 93.7%. In the Chiapasco et al series,⁴³ the cumulative success rate of immediately loaded implants supporting mandibular overdentures was 97.5% after 2 years of functional loading. Randow et al¹⁰ found that Branemark implants can be successfully used in the interforaminal mandibular area even when immediately loaded; moreover, they reported that bone resorption is similar to that observed around 2-stage implants. No failures were reported by Ericsson et al³¹ in early loaded implants and all implants were working successfully after 5 years. Branemark et al³⁰ recently reported on a method for implant therapy of the edentulous mandible; in 50 patients, followed 6 months to 3 years, there was an overall survival rate of 98% and a prosthetic survival rate of 98%. Jaffin et al²⁷ reported an overall survival rate of 95%, while in a series by Ganeles et al,²⁵ the clinical success rate at the time of final abutment placement was 99.4%. In a Gatti et al²⁹ series, the success rate was 96%. Grunder⁴⁴ reported

an overall success rate of 92.31%. Another important factor is the characteristics of the implant surfaces. Occlusal-force transmission schemes differ and a simple transposition of healing patterns from animal to man is not warranted and should be avoided,^{12,28} and moreover, it cannot be assumed a priori that immediately loaded implants will have identical bone healing and bone-implant interfaces.³² In the posterior areas of the jaws, and especially in the maxillae, several demanding preconditions require considering insufficient bone volume, poor bone quality, and high functional forces.⁴⁰ Glauser et al⁴⁰ believe that the posterior maxilla should be considered as a risk area. The aim of the present study was an evaluation of the peri-implant tissues, in man in 2 immediately loaded implants and 1 submerged implant inserted in the posterior mandible and retrieved after 6 months.

MATERIALS AND METHODS

Two patients participated in this study. One patient was a 53-year-old female, while the other was a 45-year-old male. The protocol was approved by the Ethics Committee of our University, and both patients gave their written informed consent. In the first patient, 8 XiVE implants (Friadent, Mannheim, Germany) were inserted in the edentulous mandible (Figures 1 and 2). It was planned to remove the most distal implants (mandibular left 2nd molar region and mandibular right 2nd molar region) with a 5-mm trephine after a 6-month loading period. Both implants were 3.8- × 9.5-mm implants. The last drill used for both implants had a diameter of 3.8 mm and the insertion torque had been 35 N. A full-arch immediate provisional prosthesis was placed and all the implants were loaded on the same day as the surgery (Figures 3 through 5). The postoperative period was uneventful. Before retrieval, both implants appeared to have become clinically osseointegrated, there was no mobility, and periapical radiographs showed that, in 1 implant,

no bone resorption was radiographically apparent, while in the other implant, 1 to 2 mm of vertical bone resorption was visible (Figure 6). The provisional temporary crowns were separated from the provisional bridge and the underlying implants were retrieved (Figure 7).

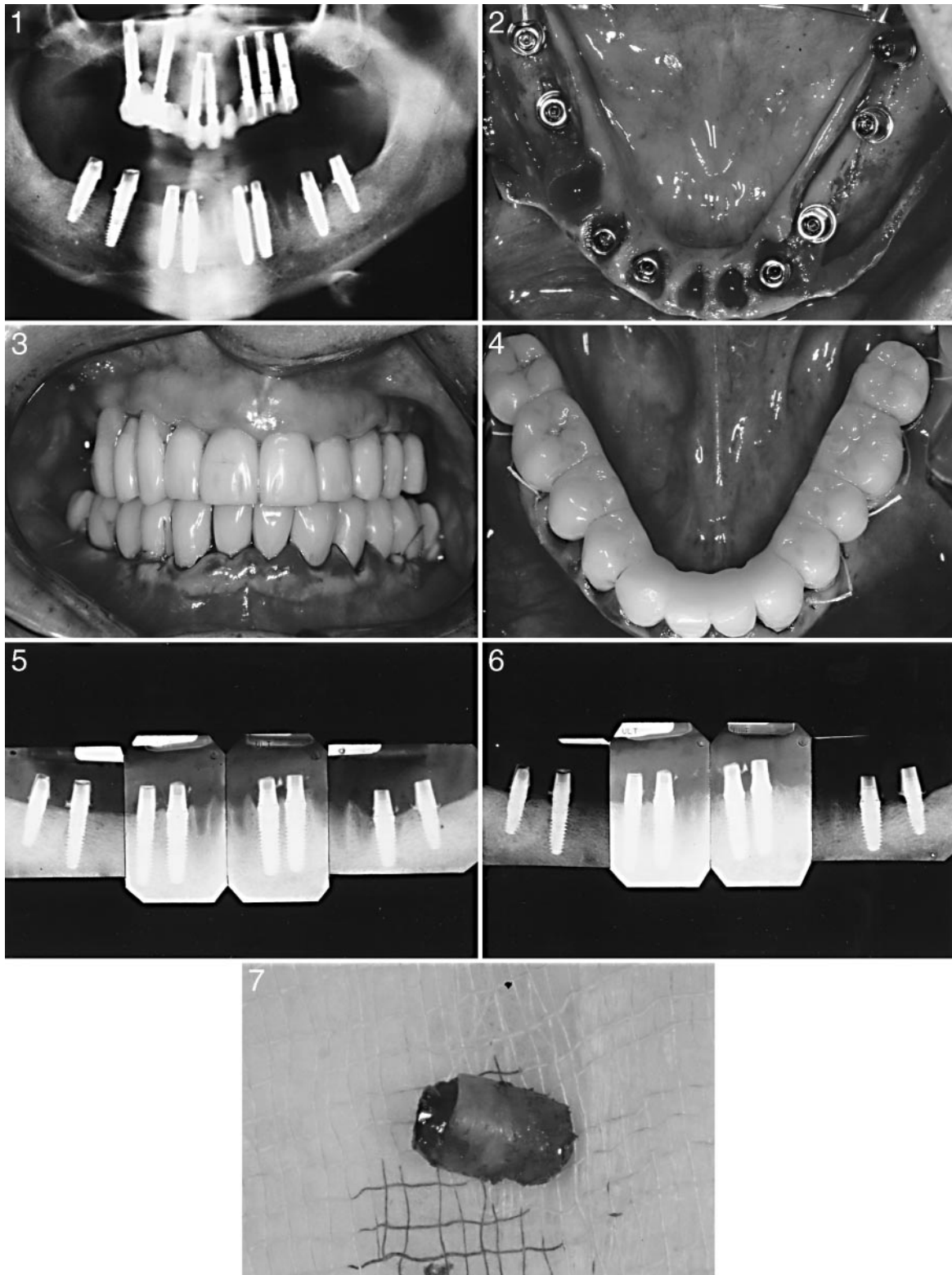
In the second patient, an edentulous mandible was rehabilitated with 8 XiVE implants, 7 of which were used for an immediately loaded provisional restoration, while 1 implant was left submerged. This was a 3.8- × 9.5-mm implant and had been inserted in the left mandibular 2nd molar region. The last drill used had a diameter of 3.8 mm and the insertion torque had been 35 N. After a 6-month healing period, this implant was retrieved.

Processing of specimens

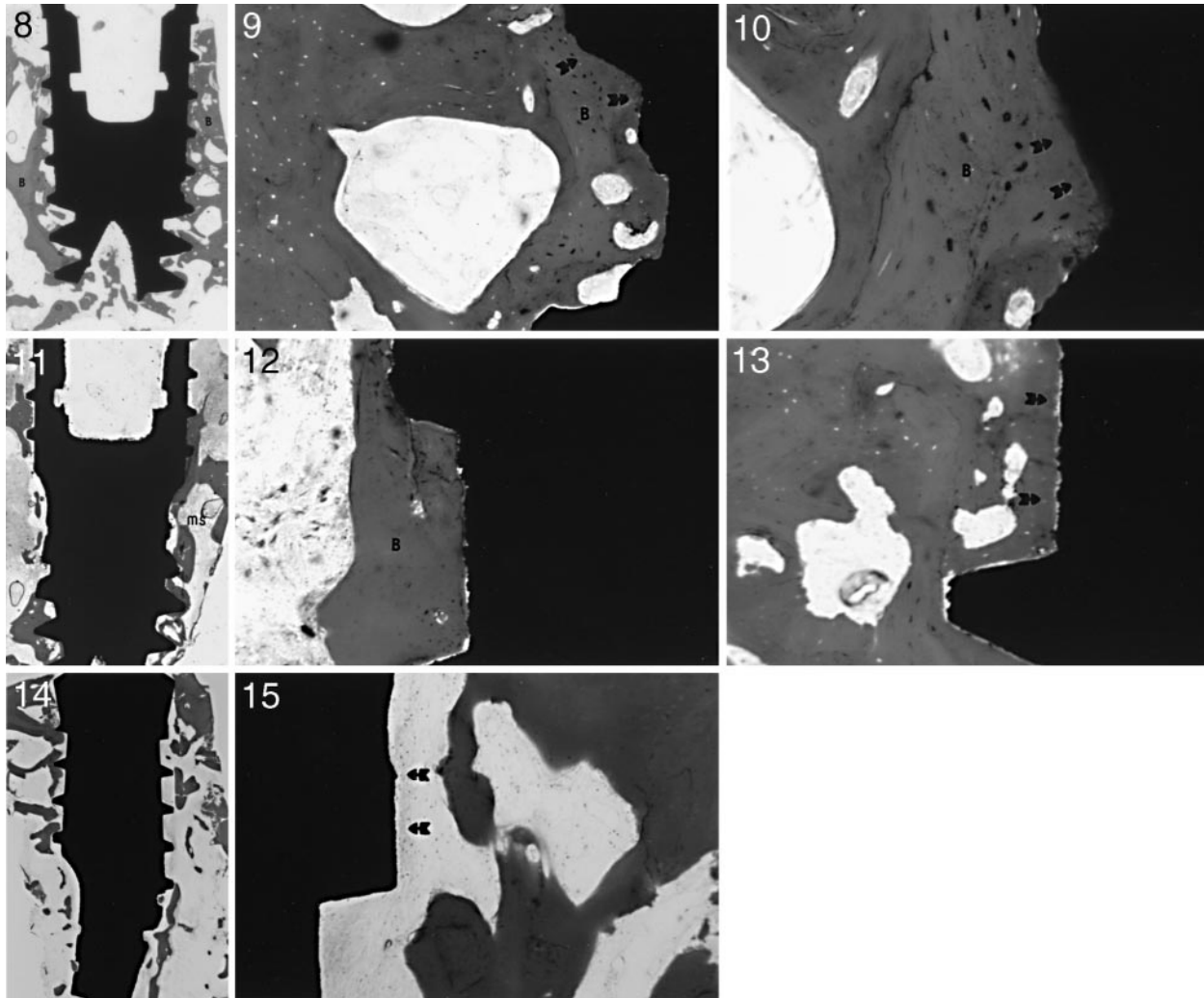
The implants and the surrounding tissues were fixed by immediate immersion in 10% buffered formalin and processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy).⁴⁷ The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC; Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned longitudinally along the major axis of the implants with a high-precision diamond disk at about 150 μm and ground down to about 30 μm. Three slides were obtained for each implant. The slides were stained with acid fuchsin and toluidine blue. A double staining was done with von Kossa's and acid fuchsin to evaluate the degree of bone mineralization, and after polishing, 1 slide per implant was immersed in AgNO₃ for 30 minutes and exposed to sunlight; the slides were then washed under tap water, dried, immersed in basic fuchsin for 5 minutes, and then washed and mounted.

Histomorphometry

Histomorphometry of bone-implant contact percentage was done using a light microscope (Laborlux S; Leitz,



FIGURES 1–7. FIGURE 1. Postoperative panoramic radiography; 8 implants have been inserted in the mandible for an immediate temporary restoration. FIGURE 2. Postoperative view of the implants inserted in the mandible. FIGURE 3. The immediate restoration (frontal view). FIGURE 4. The immediate restoration (occlusal view). FIGURE 5. Periapical X ray (immediately postoperatively). Radiopaque cement is in close contact with the bone. FIGURE 6. Periapical X ray (6 months later). A crestal bone of about 2 mm is visible. FIGURE 7. One of the retrieved implants.



FIGURES 8–15. FIGURE 8. Implant 1 (immediately loaded implant at 6 months). There is bone (B) around the entire perimeter of the implant (toluidine blue and acid fuchsin, original magnification $\times 20$). FIGURE 9. Implant 1 (immediately loaded implant at 6 months). The newly formed bone (B) is in close contact with the implant threads (arrows; toluidine blue and acid fuchsin, original magnification $\times 50$). FIGURE 10. Implant 1 (immediately loaded implant at 6 months). There are no gaps and no fibrous tissue at the implant-bone interface (arrows). At higher magnification, it is possible to observe newly formed bone in contact with the implant surface (B; toluidine blue and acid fuchsin, original magnification $\times 100$). FIGURE 11. Implant 1 (immediately loaded implant at 6 months). The bone around the implant presents wide marrow spaces (MS; toluidine blue and acid fuchsin, original magnification $\times 50$). FIGURE 12. Implant 2 (immediately loaded implant at 6 months). This implant shows newly formed bone (B) all around its perimeter (toluidine blue and acid fuchsin, original magnification $\times 20$). FIGURE 13. Implant 2 (immediately loaded implant at 6 months). At higher magnification, a very intimate contact between implant and bone can be observed. No gaps are present at the interface (arrows; toluidine blue and acid fuchsin, original magnification $\times 50$). FIGURE 14. Control submerged implant (6 months). The bone-implant contact percentage is lower than in the immediately loaded implants (toluidine blue and acid fuchsin, original magnification $\times 20$). FIGURE 15. Control submerged implant (6 months). The bone is not in direct contact with the implant surface (arrows; toluidine blue and acid fuchsin, original magnification $\times 50$).

Wetzlar, Germany) connected to a high-resolution video camera (3CCD, JVC KY-F55B) and interfaced to a monitor and personal computer (Intel Pentium III 1200 MMX). This optical system was associated with a digitizing pad (Matrix Vision GmbH) and a histometry software package with image-capturing capabilities (Image-Pro Plus

4.5; Media Cybernetics Inc., Immagini and Computer Snc, Milano, Italy).

RESULTS

Implant 1 (immediately loaded)—right 2nd mandibular molar region

At low-power magnification, bone was present around the implant (Figure 8).

At higher magnification, the bone presented wide marrow spaces, with a few of these abutting on the implant surface. In some areas, newly formed bone was present at the interface. At the level of the crestal bone, on 1 side of the implant, there was no evidence of vertical bone resorption, while on the other hard, a 1.3-mm (± 0.2) crestal

bone resorption was present. Resorption signs were present in the most coronal bone, while no resorption was seen in the bone at the interface with the implant. Newly formed bone tended to grow down into the bottom of the threads of the implant (Figure 9). The bone-implant contact percentage was 72% ($\pm 2.9\%$). No gaps or fibrous tissue were present at the interface, nor where there any inflammatory cells (Figure 10), foreign body reaction, or epithelial downgrowth. Bone lamellae parallel to the threads were found between the threads: in the crestal and middle part of the implant, a higher deposition of new bone was found.

Implant 2 (immediately loaded)—left 2nd mandibular molar region

The bone was more trabecular, with large marrow spaces (Figure 11). The bone-implant contact percentage was 61% ($\pm 4.2\%$). A vertical bone resorption of about 2.3 mm (± 0.3) was present on both sides of the implant. No inflammatory cells or fibrous gaps were present at the interface (Figures 12 and 13). At the apical portion of the implants, only a few very thin bone trabeculae covered the metal surface of the implants.

Implant 3 (submerged control implant)—left 2nd mandibular molar region

At low-power magnification, it was possible to observe that the bone-implant contact percentage was lower than that observed around both loaded implants (Figure 14): a value of 35.5% ($\pm 3.9\%$) was recorded. No bone contact was observed in a large portion of the implant perimeter (Figure 15).

DISCUSSION

When immediately loaded implants reach a state of osseointegration clinically, they have a long-term predictability similar to those of conventionally loaded implants.²⁵ Moreover, immediate loading shortens the total rehabilitation time, with increased patient satisfaction and the avoidance of delays in the final rehabilitation with

the accompanying difficulty of wearing a conventional denture during the healing phase.²⁹ Immediate loading has been used in totally edentulous patients in order to improve the patient treatment acceptance and to increase their comfort, eliminating the need for removable dentures in the healing period.⁴⁶ Immediate loading has been used mostly with implants inserted between the mental foramina and supporting fixed prosthetic restorations in totally edentulous mandibles.⁴⁰ Immediately loaded implants have also been used to support successfully implant-retained overdentures.⁴⁰ In the anterior mandible, the bone quality is usually sufficient to achieve primary stability.³⁹ The role of bone quality is important for successful implant placement,²⁷ and most of the implant failures tended to occur in the posterior jaw quadrants.³⁹ Glauser et al⁴⁰ reported a higher failure rate in implants inserted in posterior maxilla and in implants inserted in bone quality 3 and 4. Thirty-four percent of the implants inserted in the posterior maxilla failed, compared with 9% of the other implants inserted in other portions of the jaws.⁴⁰ Grunder⁴⁴ found that, in his series, all failed implants were the most distal, and both implants placed in bone quality 4 failed, while 5 failures occurred in bone quality 3. A histologic evidence of osseointegration is needed for each different implant surface,²⁸ and this can be obtained only by histologic analysis of immediately loaded implants retrieved from man.²³ Only rarely, however, have human-retrieved immediately loaded implants been reported in the literature.^{16,21–24,28,33}

Our histologic data show that osseointegration can be obtained in very demanding situations, such as implant insertion in the posterior jaws, and that bone response was not disturbed by the stresses transmitted at the interface under these mechanical conditions and was comparable with that found around conventional delayed-loaded implants.⁴¹ Implant splinting decreases the amount of micromotion during the

healing phase, giving to the implant a higher tolerance to deleterious micromotion. Rigid splinting and minimal lateral forces are critical factors for success.^{25,43} Primary stability is a key factor in the success of immediately loaded implants because a high primary stability helps to resist micromotion, that is, the relative movements between the implant surface and surrounding bone during functional loading.^{39,40} Glauser et al⁴⁰ reported that primary implant stability is influenced by sufficient implant length, insertion torque, and bone quality as well as bicortical anchorage and modified surgical techniques. Moreover, the intimacy of initial fit and the percentage of implant surface in direct contact with bone influences the capability to withstand functional loads in early healing situations.⁴⁰ In our implants, we found the presence of a crestal bone resorption radiographically and histologically. It must be considered, however, that Szmukler-Moncler et al¹² have pointed out that the authors studying early loading did not evaluate the postloading bone remodeling phase. The previously reported differences in bone resorption around early loaded and nonloaded implants must be viewed in light of this remodeling and, probably, they do not necessarily need to be attributed to the early loading of the implants.¹² It must also be pointed out that, in one of the implants (Figures 5 and 6), the margin of the crown was probably positioned in a too low position (this is shown by the presence of the radiopaque cement) and very near to the bone. At last, also, the surface plays a relevant role in implant long-term success, particularly in very demanding situations like in immediate loading in posterior jaw regions, and the roughened surface of the implants described in this report probably helps to stabilize the initial blood clot and wound against the titanium surface, and that results in enhanced bone formation on the surface.⁴⁸ Moreover, this surface may stimulate cell differentiation of osteoblast-like cells, and the

larger dimensions of roughness created by the sandblasting may provide pockets of bony ingrowth that may function as a series of miniretentive grooves.⁴⁸ Striking is the fact that both loaded implants presented a higher bone-implant contact percentage than the submerged (control) implant. Our results are similar to those reported recently by Testori et al,⁴⁹ who found a bone-implant contact percentage of 38.9% in submerged healing and of 64.2% in immediately loaded implants. These results could be explained by the fact that functional loading stimulated bone apposition. Wolff formulated his theory according to the idea that there is a direct link between mechanical loading and bone formation; Wolff's law would imply that increased stresses act as a stimulus to new bone formation while reduced stress tends to produce bone loss.⁵⁰

It must, however, be borne in mind that the number of specimens that we studied is too small to draw definitive conclusions on the influence of loading on the peri-implant bone response. Additional studies, with a larger and significant number of implants, are certainly needed.

ACKNOWLEDGMENTS

This work was partially supported by the National Research Council (CNR), Rome, Italy, and by the Ministry of Education, University, and Research (MIUR), Rome, Italy.

REFERENCES

1. Adell R, Lekholm U, Rockler, Brånemark PI. A 15 year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg.* 1981;10:387-416.
2. Brånemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand Reconstr Surg.* 1977; 11(suppl 16):1-132.
3. Brunski JB. Forces on dental implants and interfacial stress transfer. In: Laney WR, Tolman DE, eds. *Tissue Integration in Oral, Orthopaedic, and maxillofacial Reconstruction.* Chicago, Ill: Quintessence; 1992:108-124.
4. Brunski JB. Influence of biomechanical factor at the bone-biomaterial interface. In: Davies JE, ed. *The Bone-Biomaterial Interface.* Toronto: Toronto University Press; 1991:391-405.
5. Carter DR, Giori NJ. Effect of mechanical stress on tissue differentiation in the bony implant bed. In: Davies JE, ed. *The Bone-Biomaterial Interface.* Toronto: University of Toronto Press; 1991:367-379.
6. 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 Implant Res.* 1997;8:48-57.
7. 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.
8. Schnitman PA, Wöhrle PS, Rubenstein JE, DaSilva JD, Wang NH. Ten-year results for Branemark implants immediately loaded with fixed prostheses at implant placement. *Int J Oral Maxillofac Implants.* 1997;12:495-503.
9. 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 Periodont Restorative Dent.* 1995;15:345-361.
10. Randow K, Ericsson I, Nilner K, Petersson A, Glantz PO. Immediate functional loading of Brånemark dental implants. An 18-month clinical follow-up study after 24 months. *Clin Oral Implant Res.* 1999;10:8-15.
11. Szmukler-Moncler S, Salama H, Reingewirtz Y, Dubruille JH. Timing of loading and effect of micromotion on bone-dental implant interface: review of experimental literature. *J Biomed Mater Res (Appl Biomater).* 1998;43:192-203.
12. Szmukler-Moncler S, Piattelli A, Favero GA, Dubruille JH. Considerations preliminary to the application of early and immediate loading protocols in dental implantology. *Clin Oral Implant Res.* 2000;11:12-25.
13. Chaushu 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. Lazzara RJ, Porter SS, Testori T, Galante J, Zetterquist LA. Prospective multicenter study evaluating loading of Osseotite implants two months after placement: one-year results. *J Esthet Dent.* 1998;6:280-289.
15. Misch CE. Non-functional immediate teeth in partially edentulous patients: a pilot study of 10 consecutive cases using the Maestro Dental Implant System. *Compendium.* 1998;19:25-36.
16. Linkow LI, Donath K, Lemons JE. Retrieval analyses of a blade implant after 231 months of clinical function. *Implant Dent.* 1992;1:37-43.
17. Trisi P, Emanuelli M, Quaranta M, Piattelli AA. Light microscopy, scanning electron microscopy and laser scanning microscopy analysis of retrieved blade implants after 7 to 20 years of clinical function. *J Periodontol.* 1993;64:374-378.
18. Piattelli A, Ruggeri A, Trisi P, Romasco N, Franchi MA. Histologic and histomorphometric study of the bone reactions to non submerged unloaded and loaded single implants in monkeys. *J Oral Implantol.* 1993;19:314-320.
19. Piattelli A, Corigliano M, Scarano A, Quaranta M. Bone reactions to early occlusal loading of two-stage titanium plasma-sprayed implants: a pilot study in monkeys. *Int J Periodontics Restorative Dent.* 1997;17:163-169.
20. Piattelli A, Corigliano M, Scarano A, Costigliola G, Paolantonio M. Immediate loading of titanium plasma-sprayed implants: a pilot study in monkeys. *J Periodontol.* 1998;69:321-327.
21. Piattelli A, Trisi P, Romasco N, Emanuelli M. Histological analysis of a screw implant retrieved from man: influence of early loading and primary stability. *J Oral Implantol.* 1993;19:303-306.
22. Piattelli A, Paolantonio M, Corigliano M, Scarano A. Immediate load-

ing of titanium plasma-sprayed screw-shaped implants in man: a clinical and histological report of two cases. *J Periodontol.* 1997;68:591–597.

23. Ledermann PD, Schenk R, Busser D. Long-lasting osseointegration of immediately loaded bar-connected TPS screws after 12 years of function: a histologic case report of a 95-year-old patient. *Int J Periodont Restorative Dent.* 1999;18:553–556.

24. Piattelli A, Scarano A, Paolantonio M. Immediately loaded screw implant removed for fracture after a 15-year loading period: histological and histochemical analysis. *J Oral Implantol.* 1997;23:75–79.

25. Ganeles J, Rosenberg MM, Holt RL, Reichman LH. Immediate loading of implants with fixed restorations in the completely edentulous mandible: report of 27 patients from a private practice. *Int J Oral Maxillofac Implants.* 2001;16:418–426.

26. Romanos G, Toh CG, Siar CH, et al. Peri-implant bone reactions to immediately loaded implants. An experimental study in monkeys. *J Periodontol.* 2001;72:506–511.

27. 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.

28. Testori T, Szmukler-Moncler S, Francetti L, et al. Immediate loading of Osseotite implants: a case report and histologic analysis after 4 months of occlusal loading. *Int J Periodont Restorative Dent.* 2001;21:451–459.

29. Gatti C, Hefliger W, Chiapasco M. Implant-retained mandibular overdentures with immediate loading: a prospective study of ITI implants. *Int J Oral Maxillofac Implants.* 2000;15:383–388.

30. Branemark PI, Engstrand P, Ohnrell LO, et al. Branemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. *Clin Implant Dent Related Res.* 1999;1:2–16.

31. Ericsson I, Randow K, Nilner K, Peterson A. Early functional loading

of Branemark dental implants: 5-year clinical follow-up study. *Clin Implant Dent Relat Res.* 2000;2:70–77.

32. Degidi M, Piattelli A. Immediate functional and non functional loading of dental implants: a 2 to 60 months follow-up study of 646 titanium implants. *J Periodontol.* 2003;74:225–241.

33. Degidi M, Petrone G, Iezzi G, Piattelli A. Histologic evaluation of a human immediately loaded titanium implant with a porous anodized surface. *Clin Implant Dent Related Res.* 2002;4:110–114.

34. Siddiqui AA, Ismail JY, Kukunas S. Immediate loading of dental implants in the edentulous mandible: a preliminary case report from an international prospective multicenter study. *Compend Contin Educ Dent.* 2001;22:867–870.

35. Chow J, Hui E, Liu J, et al. The Hong Kong bridge protocol. Immediate loading of mandibular Branemark fixtures using a fixed provisional prosthesis: preliminary results. *Clin Implant Dent Related Res.* 2001;3:166–174.

36. Buchs AU, Levine L, Moy P. Preliminary report of immediately loaded Altiva natural tooth replacement dental implants. *Clin Implant Dent Related Res.* 2001;3:97–106.

37. Hui E, Chow J, Li D, et al. Immediate provisional for single-tooth implant replacement with Branemark system: preliminary report. *Clin Implant Dent Related Res.* 2001;3:79–86.

38. Bohsali K, Simon H, Kan JY, Redd M. Modular transitional implants to support the interim maxillary overdenture. *Compend Contin Educ Dent.* 1999;20:975–978.

39. Romanos GE, Toh CG, Siar CH, Swaminathan D, Ong AH. Histologic and histomorphometric evaluation of peri-implant bone subjected to immediate loading: an experimental study with *Macaca fascicularis*. *Int J Oral Maxillofac Implants.* 2002;17:44–51.

40. Glauser R, Rée A, Lundgren AK, et al. Immediate occlusal loading of Branemark implants applied in various jawbone regions: a prospective, 1-year clinical study. *Clin Implant Dent Related Res.* 2001;3:204–213.

41. Rungcharassaeng K, Kan JYK. Immediately loaded mandibular bar overdenture: a surgical and prosthodontic rationale. *Int J Periodont Restorative Dent.* 2000;20:71–79.

42. Ericsson I, Nilner K. Early functional loading using Branemark dental implants. *Int J Periodont Restorative Dent.* 2002;22:9–19.

43. Chiapasco M, Abati S, Romeo E, Vogel G. Implant-retained mandibular overdentures with Branemark system MKII implants: a prospective comparative study between delayed and immediate loading. *Int J Oral Maxillofac Implants.* 2001;16:537–546.

44. Grunder U. Immediate functional loading of immediate implants in edentulous arches: two-year results. *Int J Periodont Restorative Dent.* 2001;21:545–551.

45. Payne AG, Tawse-Smith A, Kumara R, Murray, Thompson WM. One-year prospective evaluation of the early loading of unsplinted conical Branemark fixtures with mandibular overdentures immediately following surgery. *Clin Implant Dent Relat Res.* 2001;3:9–19.

46. Wohrle PS. Single-tooth replacement in the aesthetic zone with immediate provisionalization: fourteen consecutive case reports. *Pract Periodont Aesthet Dent.* 1998;10:1107–1114.

47. Piattelli A, Scarano A, Quaranta M. High-precision, cost-effective system for producing thin sections of oral tissues containing dental implants. *Biomaterials.* 1997;18:577–579.

48. Cochran DL, Buser D. Bone response to sandblasted and acid-attacked titanium implants: experimental and clinical studies. In: Davies JE, ed. *Bone Engineering*. Toronto: Em Squared Incorporated; 2000:391–398.

49. Testori T, Smukler-Moncler S, Francetti L, et al. Healing of Osseotite implants under submerged and immediate loading conditions in a single patient: a case report and interface analysis after 2 months. *Int J Periodont Restorative Dent.* 2002;22:345–353.

50. Hansson S. The implant neck: smooth or provided with retention elements. A biomechanical approach. *Clin Oral Implant Res.* 1999;10:394–405.