Marco Degidi
Giovanna Iezzi
Antonio Scarano
Adriano Piattelli

Immediately loaded titanium implant with a tissue-stabilizing/maintaining design ('beyond platform switch') retrieved from man after 4 weeks: a histological and histomorphometrical evaluation. A case report

Authors' affiliations:
Marco Degidi, Giovanna Iezzi, Antonio Scarano, Adriano Piattelli, Dental School, University of Chieti-Pescara, Chieti, Italy
Marco Degidi, Private Practice, Bologna, Italy

Correspondence to:
Prof. Adriano Piattelli, MD, DDS
Via F. Sciucchi 63
66100 Chieti
Italy
Tel.: + 00 39 0871 3554083
Fax: + 00 39 0871 3554076
e-mail: apiattelli@unich.it

Key words: conical abutment connection, crestal bone remodeling, dental implants, histology, immediate loading, microgap, Morse cone connection, platform switching

Abstract

Background: After implant insertion and loading, crestal bone usually undergoes remodeling and resorption. If the horizontal relationship between the outer edge of the implant and a smaller-diameter component ('platform switching') is altered, there seems to be reduced crestal bone loss. Immediate loading allows immediate restoration of esthetics and function, reduces morbidity, and facilitates functional rehabilitation.

Materials and methods: Three Morse cone connection implants were inserted in the right posterior mandible in a 29-year-old partially edentulous patient. The platform of the implant was inserted 2 mm below the level of the alveolar crest. After a 1-month loading period, the most distal mandibular implant was retrieved with a trephine bur for psychological reasons.

Results: At low-power magnification, it was possible to see that bone was present 2 mm above the level of the implant shoulder. No resorption of the coronal bone was present. No infrabony pockets were present. At the level of the shoulder of the implant, it was possible to observe the presence of dense connective tissue with only a few scattered inflammatory cells. Newly formed bone was found in direct contact with the implant surface. The bone–implant contact percentage was 65.3 ± 4.8%.

Conclusions: Abutments smaller than the diameter of the implant body (platform switching) in combination with an absence of micromovement and microgap may protect the peri-implant soft and mineralized tissues, explaining the observed absence of bone resorption. Immediate loading did not interfere with bone formation and did not have adverse effects on osseointegration.

Date:
Accepted 15 January 2007

To cite this article:
Degidi M, Iezzi G, Scarano A, Piattelli A. Immediately loaded titanium implant with a tissue stabilizing/maintaining design ('beyond platform switch') retrieved from man after 4 weeks: a histological and histomorphometrical evaluation. A case report.
Clin. Oral Impl. Res. **19**, 2008; 276–282
doi: 10.1111/j.1600-0501.2007.01449.x

Stable crestal bone levels are believed to be critical for the long-term implant success (Chou et al. 2004). After implant insertion and loading, crestal bone usually undergoes remodeling and resorption during the first year following prosthetic restoration, in two-piece implants (Hermann et al. 2000a). Crestal bone levels have been reported to be usually located about 1.5–2 mm below the implant–abutment junction (IAJ) after 1 year following implant restoration (Lazzara & Porter 2006). Cochran et al. (1997) and Hermann et al. (1997, 2000b, 2001) demonstrated that crestal bone remodels to a level about 2.0 mm apical to the IAJ. Several hypotheses have been offered to explain this remodeling. Some investigators have related this remodeling to a stress concentration at the crestal level, while others believe that the presence of a microgap and possible microleakage and micromovement could lead to a localized inflammation of the peri-implant soft tissues (Quirynen & Van Steenberghe 1993; Quirynen et al. 1994; Persson et al. 1996; Cochran et al. 1997; Hermann et al. 1997, 2000a, 2001; Jansen et al. 1997; Misch et al. 2001; Piattelli et al. 2001, 2003). The potential influence of implant design on peri-implant bone loss warrants additional research (Chou et al. 2004). The loss of crestal bone has also been reported to be influenced by the relationship of the IAJ to the crestal bone (Chou et al. 2004). Hermann et al. (2001) and Piattelli et al. (2003) have demonstrated that when the IAJ is positioned deeper within the bone, the resulting loss of vertical crestal bone height increases.

When a matching implant–abutment diameter is used, the inflammatory cell infiltrate (abutment ICT) is located at the outer edge of the IAJ close to crestal bone; this close proximity may explain partially the biologic and radiographic observations of crestal bone loss around restored two-piece implants (Lazzara & Porter 2006). On the other hand, if the horizontal relationship between the outer edge of the implant and a smaller-diameter component ('platform switching') is altered in addition to other favorable implant design conditions, there seems to be a reduced crestal bone loss (Lazzara & Porter 2006). This fact could be explained by an increased surface area created by the exposed implant seating surface with a reduction in the quantity of crestal bone resorption needed to expose a minimal amount of implant surface to which the soft tissues can attach (Lazzara & Porter 2006). Furthermore, the internal repositioning of the IAJ away from the external, outer edge of the implant and neighboring bone decreases the effects of the abutment ICT on surrounding tissues (Abrahamsson et al. 1998; Lazzara & Porter 2006). The reduced exposure and confinement of the platform-switched abutment ICT may result in a reduced inflammatory effect (Lazzara & Porter 2006). Additonally, the exposed horizontal part of the implant shoulder was also microroughened, and this enhances the chance of bone growth on top of this surface.

A Morse cone connection implant (Ankylos®, Dentsply-Friadent) has an in-built beyond platform switching and was designed with, among others, the following objectives:

(1) it should allow for optimum load distribution for permanent load stability during functional loading;
(2) it should facilitate soft-tissue stability due to the gap-free bacteria-proof tapered abutment connection with maximum mechanical stability and the lack of any micromovement (Nentwig 2004).

In a previous histological report of an immediately loaded Morse cone connection implant, retrieved from man after a 6-month loading period, we reported the presence of newly formed bone trabeculae at the most coronal portion on one side of the implant; these trabeculae were surrounded by osteoblasts actively secreting osteoid matrix with no osteoclasts present. We thought that the presence of this newly formed bone in the coronal peri-implant area was striking and we hypothesized that it could be related to the absence of a microgap due to the conical connection with no bacterial colonization and leakage at the implant–abutment interface (Degidi et al. 2004).

Photoelastic and finite element analysis studies have shown that the special thread design of this implant reduces the functional stresses at the crestal bone compared with other implant systems (Morris et al. 2004; Nentwig 2004). Load-induced cervical bone loss occurred in <20% of cases, and even in these cases, the amount of crestal bone loss was minimal (Nentwig 2004).

In a study, in 50% of the cases, X-ray examination after 1 year of prosthetic loading showed crestal bone at or slightly above the level of the implant shoulder (Doring et al. 2004).

Chou et al. (2004), in a study of over 1500 Morse cone connection implants, reported a total overall mean loss from implant placement to 36 months post-loading of only 0.6 or 0.2 mm/year, including the bone loss that can be attributed to surgical trauma.

Immediate loading of dental implants was thought to produce a fibrous repair at the interface (Brånemark et al. 1977; Adell et al. 1981; Carter & Giori 1991; Brunski 1991, 1992). Several histological reports, in man and experimental animals, have, on the contrary, shown mineralized tissues at the interface in early and immediately loaded implants (Linkow et al. 1992; Piattelli et al. 1993a, 1993b, 1997a, 1997b, 1997c, 1998; Trisi et al. 1993; Ledermann et al. 1999; Romanos et al. 2001; Testori et al. 2001; Romanos et al. 2002; Testori et al. 2002; Rocci et al. 2003; Siar et al. 2003; Degidi et al. 2004; Degidi et al. 2005a, 2005b; Traini et al. 2005a, 2005b; Neugebauer et al. 2006). Immediate loading allows immediate restoration of esthetics and functions, reduces the morbidity of a second surgical intervention, and facilitates the functional rehabilitation increasing patient acceptance and satisfaction. There is a need to investigate the bone healing processes at the interface, especially regarding which type of bone response is present around immediately loaded implants inserted in poorer quality bone (Degidi et al. 2005a, 2005c). An analysis of human biopsies of immediately loaded implants is the best way to ascertain the quality and quantity of the peri-implant hard tissues (Romanos et al. 2005). The role that implant surfaces play, especially on the early healing processes at the interface is also important. A sandblasted and acid-etched surface (Friadent® plus surface, Dentsply) was obtained with a novel grit-blasting and acid-etching technique and showed a regular microroughness with pores in the micrometer dimension overlaying a macroroughness structure caused by the grit blasting. (Papalexiou et al. 2004; Rupp et al. 2004). The spatial architecture showed a first level of roughness of 100 μm, a second level of grooves in the dimensions of about 12–75 μm, each of which embraced an arrangement of smaller round-shaped groups with diameters of about 1–5 μm (Papalexiou et al. 2004; Rupp et al. 2004).

The aim of this study was to evaluate the peri-implant soft and mineralized tissues around an immediately loaded implant, with a conical implant abutment connection, after a 1-month loading period.

Materials and methods

Three Morse cone connection dental implants (ANKYLOS® plus DENTSPLY-Friadent, Mannheim, Germany) were inserted in the right posterior mandible in

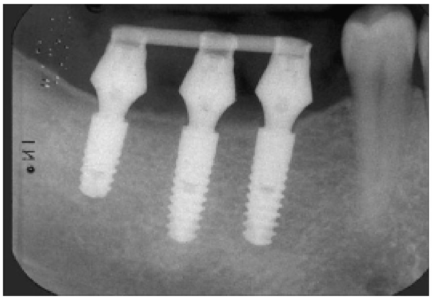

Fig. 1. Radiographic aspect of the implant.

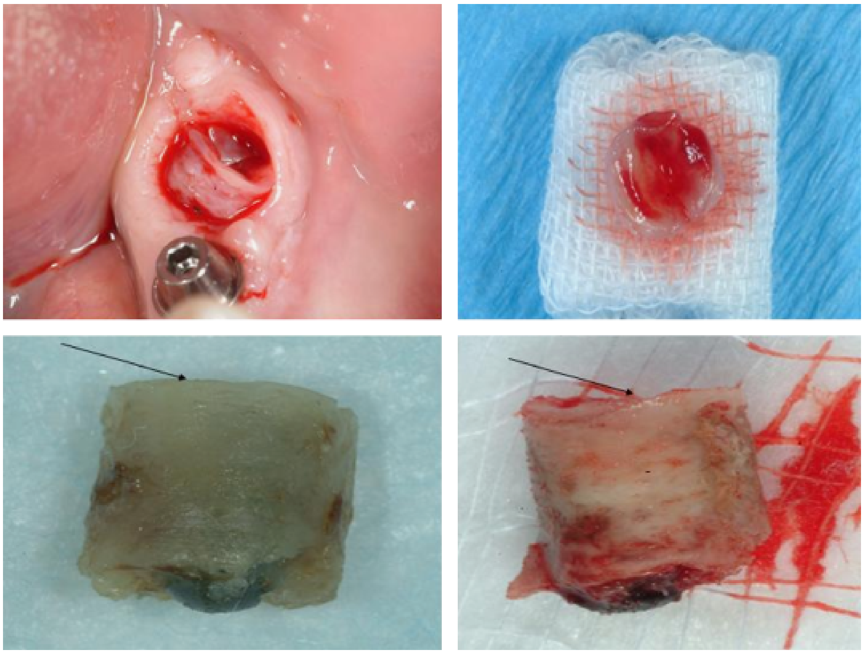

Fig. 2. The retrieved implant. The arrows show the coronal portion of the bone.

a 29-year-old partially edentulous patient. The platform of the implants was inserted 2 mm below the level of the alveolar crest, 1 mm deeper than the manufacturer's protocol (Fig. 1). The patient was a heavy smoker. All the implants were immediately loaded with a provisional resin restoration the same day of the implant surgery. After a 1-month loading period, the most distal mandibular implant was retrieved with a 5.5-mm trephine bur for psychological reasons (Fig. 2). The patient had developed, almost immediately after implant insertion, an aversion to this implant, thought that it was causing an inflammation that could lead to cancer development, and psychological counseling did not obtain any results. This implant was a 3.5 × 8 mm implant inserted in the D3 bone with an insertion torque of 23.8 N cm. The ISQ value was 63 at implant insertion and 66 before implant retrieval.

Specimen processing

The implant and surrounding tissues were washed in saline solution and immediately fixed in 4% para-formaldehyde and 0.1% glutaraldehyde in 0.15 M cacodylate buffer al 4 C and pH 7.4. The specimen was processed using the Precise 1 Automated System (Assing, Rome, Italy). (Piattelli et al. 1997d). The specimen was dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization the specimen was sectioned along its longitudinal axis with a high-precision diamond disk at about 150 μm and ground down to about 30 μm with a specially designed grinding machine. Three slides were obtained. These slides were stained with acid fuchsin and toluidine blue and examined with a transmitted light Leitz Laborlux microscope (Leitz, Wetzlar, Germany) and a Zeiss fluorescence microscope (Zeiss, Göttingen, Germany).

Histomorphometry of bone-implant contact percentage was carried out using a light microscope (Laborlux S, Leitz) connected to a high-resolution video camera (3CCD, JVC KY-F55B, JVC®, Yokohama, Japan) and interfaced to a monitor and PC (Intel Pentium III 1200 MMX, Intel®, Santa Clara, CA, USA). This optical system was associated with a digitizing pad (Matrix Vision GmbH, Oppenweiler, Germany) and a histometry software package with image-capturing capabilities (Image-Pro Plus 4.5, Media Cybernetics Inc., Immagini & Computer Snc, Milano, Italy).

Results

At low-power magnification, it was possible to see that bone was present 2 mm above the level of the implant shoulder (Fig. 3). In the first three coronal mm it was possible to observe the presence of lamellar cortical compact bone around the implant (Fig. 4). In this region, many areas of bone remodeling were present; bone remodeling units (BMU) were also present (Fig. 5). Areas of new bone formation were present, with osteoblasts depositing osteoid matrix. A rim of osteoblasts lined the marrow spaces found at the coronal level; these osteoblasts were depositing osteoid matrix. At the coronal level, osteoblasts were also found in direct contact with the implant surface; these osteoblasts were laying down osteoid matrix directly on the metal surface. No resorption of the coronal bone was present. No infrabony pockets were present. At the level of the shoulder of the implant, it was possible to observe the presence of a dense connective tissue with only a few inflammatory cells. Newly formed bone was found in direct contact with the implant surface. No fibrous connective tissue was found at the bone–titanium interface. No epithelial downgrowth was present. No active bone resorption was present in the middle and apical portion of the implant perimeter and osteoclasts were absent. All the interthread spaces were filled by newly formed bone with a thickness of 100–300 μm; it was possible to observe two lines of osteocytes. These osteocytes had their longest axis always parallel to the implant surface. In some portions of the implant surface, osteoblasts were depositing osteoid matrix. Many wide marrow spaces with many capillaries were present in the peri-implant bone. The bone near the implant appeared to be more mature than the bone found at a distance. No inflammatory cell infiltrate was found around the implant. In the apical portion, osteoblasts and newly formed bone were present. No osteoclasts

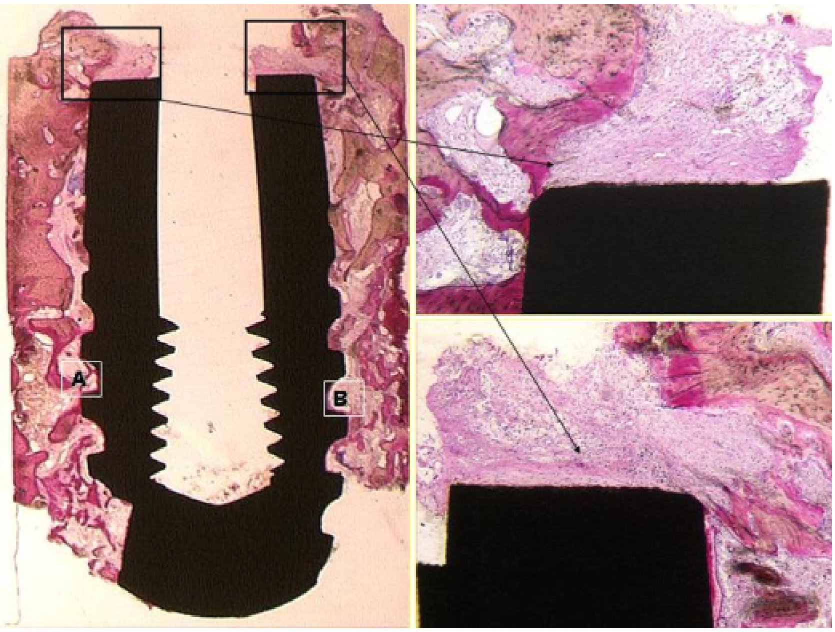

Fig. 3. Immediately loaded Morse cone connection implant, inserted in the posterior mandible and retrieved after 4 weeks. Low-power magnification on the left side. The bone–implant contact percentage was 65%. At higher magnification, on the upper right side it was possible to see a rim of osteoblasts lining the marrow spaces found at the coronal level: these osteoblasts were depositing osteoid matrix. At the coronal level, osteoblasts were also found in direct contact with the implant surface: these osteoblasts were laying down osteoid matrix directly on the metal surface. On the lower right side it was possible to observe a dense, fibrous connective tissue with a few scattered lymphocytes. Acid fuchsin–toluidine blue. Figure on the left-side magnification × 12. Figure on the upper right-side × 50. Figure on the right lower side × 50.

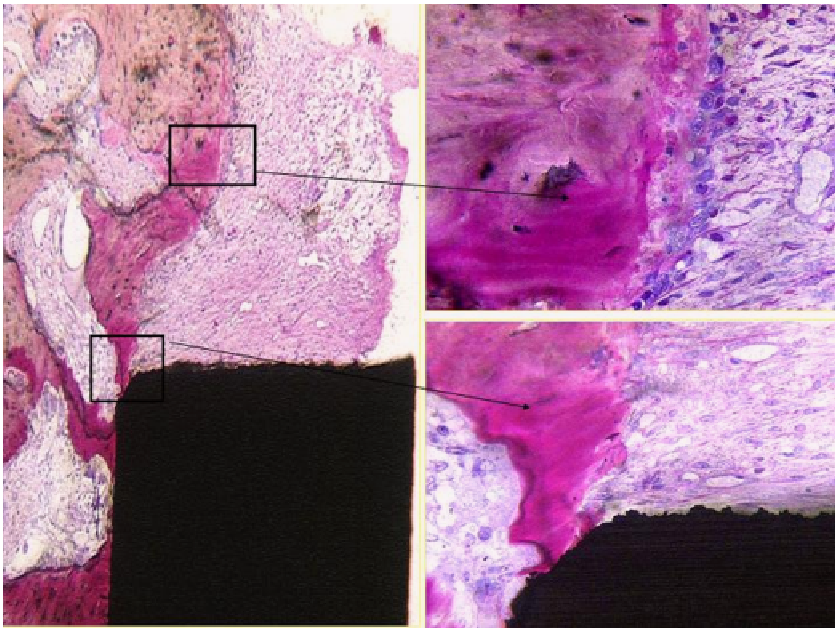

Fig. 4. At higher magnification, at the coronal level a rim of osteoblasts was producing osteoid matrix. Acid fuchsin–toluidine blue. Figure on the left side magnification × 50. Figure on the upper right side × 100. Figure on the right lower side × 100.

were present. Few marrow spaces were observed directly on the implant surface. The bone–implant contact percentage was 65.3 ± 4.8%.

Discussion

Only a few histological evaluations of immediately loaded implants retrieved from humans have been reported in the literature (Linkow et al. 1992; Piattelli et al. 1993a, 1997a, 1997c; Trisi et al. 1993; Ledermann et al. 1999; Testori et al. 2001, 2002; Rocci et al. 2003, 2005; Degidi et al. 2005a, 2005b, 2005c; Romanos et al. 2005; Traini et al. 2005a, 2005b).

In the present histologic study, the aim was to focus mainly on two aspects of the peri-implant tissues:

(1) the soft peri-implant tissues;
(2) the aspect and characteristics of the mineralized bone at the interface.

Because the emergence area of the shoulder region of this implant is considerably less than that in other systems that use conventional implant–abutment connections, the shoulder is positioned subcrestally into the bone to produce an optimal emergence profile (Doring et al. 2004). Placement of the implant deeper into the bone does not necessarily result in complications of the soft and hard tissues that have been reported for other implant systems (Doring et al. 2004). In fact, in the present specimen it was found that the bone had not undergone any resorption and was still located about 2 mm above the implant shoulder.

This could be due to the positive effects of a favorable load transmission to the bone via the special progressive threads of this implant, to a stable internal-tapered abutment connection with the absence of any microgap (Nentwig 2004) or micromovement, and, finally, to the presence of a thick layer of soft tissues in the narrowed neck of the smaller-diameter abutment (Doring et al. 2004). This collar of soft tissue, which has a wedge-shaped cross section, and which was found to be composed of thick, fibrous connective tissue with few scattered inflammatory cells, probably provides an additional protective function to the peri-implant bone (Doring et al. 2004). It must, moreover, be stressed that in this case the implants were inserted in the posterior mandible and, probably, the width of the ridge positively influenced the histological result. Also the inter-implant distance was found to be a relevant factor on crestal bone resorption. Tarnow et al. (2000) found that the crestal bone loss was lower for implants with a >3 mm distance between them. It can be hypothesized that the present results would have

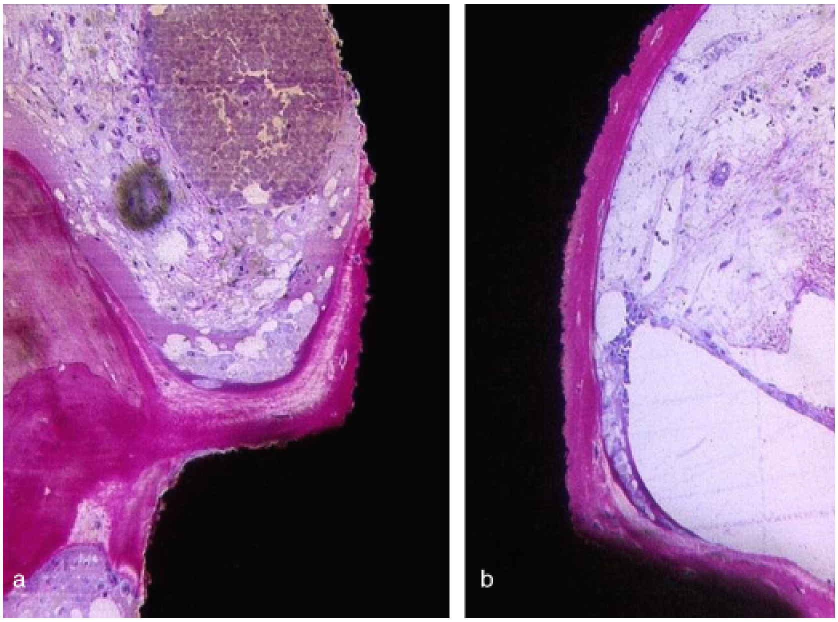

Fig. 5. Higher magnification of the areas (a and b) at the interface shown in Fig. 3. Woven bone was observed in direct contact with the implant surface; no gaps or connective tissue were present at the bone–implant interface. Newly formed bone was present in the concavities of all threads of the implant. No fibrous connective tissue was found at the bone–metal interface. No epithelial downgrowth was present. No active bone resorption was present in this region, and the osteoclasts were absent. No inflammatory cell infiltrate was present around the implant. Acid fuchsin–toluidine blue. Figure on the right side × 100. Figure on the left side × 100.

been different if the implants had been placed closer together.

The surface characteristics of an implant are important in determining the pattern of healing under loading, especially in particularly demanding situations such as immediate loading.

The histological data obtained from the present study confirm that immediate loading did not have an adverse effect on osseointegration, and the early bone healing was not disturbed by the stresses transmitted at the interface even if the implant had been inserted in soft bone (D3). The very high bone-to-implant contact percentage found in the present implant (about 65%) after a healing period of only 4 weeks is striking. This fact could be explained by the microstructure of this surface that has been shown to have a hierarchical surface structure due to surface-modifying blasting and etching processes, resulting in a wettable surface (Rupp et al. 2004). This unique wettability characteristic has been hypothesized to determine an increased adhesion to this surface of non-collagenous proteins like sialoprotein and osteopontin, which are the forerunners of contact osteogenesis (Rupp et al. 2004). Moreover, higher adsorbed amounts of fibronectin may improve host responses such as osteoblast adhesion (Rupp et al. 2004). At last, the three-dimensional fibrin grid found on this surface could produce a more favorable structure for the *in vivo* three-dimensional movement (from bone-to-implant surface) of osteogenic differentiating cells (Di Iorio et al. 2005).

Rocci et al. (2003) reported very high bone–implant contact, (84.2%), with apparent undisturbed healing in implants that had been inserted in bone quality sites 3 or 4 and that had been biomechanically challenged. The present results, moreover, confirm those reported by Testori et al. (2002). Immediately loaded splinted implants inserted in the posterior mandible can osseointegrate with a peri-implant response similar to that of delayed loaded implants. (Degidi et al. 2004, 2005a, 2005b, 2005c).

Conclusion

The use of an abutment smaller than the diameter of the implant body ('platform switching') can help to protect the peri-implant mineralized tissues. This fact could, probably, partially explain the absent or reduced rate of bone resorption reported for this type of implant connection, and observed in the present histological case report.

The bacteria-proof seal, the lack of micromovements due to the friction grip, and the minimally invasive second-stage surgery without any major trauma for the periosteal tissues are also important factors in preventing the cervical bone loss. (Morris et al. 2004; Nentwig 2004). The platform-switching concept most probably could have a significant impact on the implant treatment in esthetic areas. Care should be taken in extrapolating the results provided in this paper to the esthetic zone.

The present results show that a high percentage of bone contact can be obtained even in immediately loaded implants inserted in soft bone, after a very short healing period (4 weeks). Immediate loading did not interfere with bone formation and did not have adverse effects on osseointegration.

Acknowledgements: This work was partially supported by the National Research Council (C.N.R.), Rome, Italy, by the Ministry of Education, University, and Research (M.I.U.R.), Rome, Italy, and by AROD (Research Association for Dentistry and Dermatology), Chieti, Italy.

References

Abrahamsson, I., Berglundh, T. & Lindhe, J. (1998) Soft tissue response to plaque formnation at different implant systems. A comparative study in the dog. *Clinical Oral Implants Research* **9**: 73–79.

Adell, R., Lekholm, U., Rockler, B. & Brånemark, P-I. (1981) A 15 year study of osseointegrated implants in the treatment of the edentulous jaw. *International Journal of Oral Surgery* **10**: 387–416.

Brånemark, P.I., Hansson, B.O., Adell, R., Breine, U., Lindstrom, J., Hallén, O. & Ohman, A. (1977) Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period.. *Scandinavian Journal of*

Plastic and Reconstructive Surgery **11** (Suppl. 16): 1–132.

Brunski, J.B. (1991) Influence of biomechanical factor at the bone-biomaterial interface. In: Davies, J.E., ed. *The Bone–Biomaterial Interface*, 391–405. Toronto: Toronto University Press.

Brunski, J.B. (1992) Forces on dental implants and interfacial stress transfer. In: Laney, W.R. & Tolman, D.E., eds. *Tissue Integration in Oral, Orthopaedic and Maxillofacial Reconstruction*, 108–124. Chicago: Quintessence.

Carter, D.R. & Giori, N.J. (1991) Effect of mechanical stress on tissue differentiation in the bony implant bed. In: Davies, J.E., ed. *The Bone–Biomaterial Interface*, 367–379. Toronto: University of Toronto Press.

Cochran, D.L., Hermann, J.S., Schenk, R.K., Higginbottom, F.L. & Buser, D. (1997) Biologic width around titanium implants. A histometric analysis of the implanto-gingival junction around unloaded and loaded nonsubmerged implants in the canine mandible. *Journal of Periodontology* **68**: 186–98.

Chou, C.T., Morris, H.F., Ochi, S., Walker, L. & DesRosiers, D. (2004) AICRG, Part II: crestal bone loss associated with the Ankylos implant–loading to 36 months. *Journal of Oral Implantology* **30**: 134–143.

Degidi, M., Scarano, A., Piattelli, M. & Piattelli, A. (2004) Histologic evaluation of an immediately loaded titanium implant retrieved from a human after 6 months in function. *Journal of Oral Implantology* **30**: 289–296.

Degidi, M., Scarano, A., Piattelli, M., Perrotti, V. & Piattelli, A. (2005a) Bone remodeling in immediately loaded and unloaded titanium implants: a histologic and histomorphometric study in man. *Journal of Oral Implantology* **31**: 18–24.

Degidi, M., Scarano, A., Iezzi, G. & Piattelli, A. (2005b) Histologic and histomorphometric analysis of an immediately loaded implant retrieved from man after 14 months of loading. *Journal of Long Term Effects of Medical Implants* **15**: 489–498.

Degidi, M., Scarano, A., Iezzi, G. & Piattelli, A. (2005c) Histologic analysis in man of an immediately loaded implant retrieved after 8 weeks. *Journal of Oral Implantology* **31**: 247–254.

Di Iorio, D., Traini, T., Degidi, M., Caputi, S. & Piattelli, A. (2005) Blood clot organization on different implant surfaces in man: an in vitro study. *Journal of Biomedical Materials Research Part B: Applied Biomaterials* **74B**: 636–642.

Doring, K., Eisenmann, E. & Stiller, M. (2004) Functional and esthetic considerations for single-tooth Ankylos implant-crowns: 8 years of clinical performance. *Journal of Oral Implantology* **30**: 198–209.

Hermann, J.S., Buser, D., Schenk, R.K. & Cochran, D.L. (2000a) Crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged and submerged implants in the canine mandible. *Journal of Periodontology* **71**: 1412–1424.

Hermann, J.S., Buser, D., Schenk, R.K., Higginbottom, F.L. & Cochran, D.L. (2000b) Biological width around titanium implants. A physiologically formed and stable dimension over time. *Clinical Oral Implants Research* **11**: 1–11.

Hermann, J.S., Cochran, D.L., Nummikoski, P.V. & Buser, D. (1997) Crestal bone changes around titanium implants: a radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. *Journal of Periodontology* **68**: 1117–1130.

Hermann, J.S., Schofield, J.D., Schenk, R.K., Buser, D. & Cochran, D.L. (2001) Influence of the size of the microgap on crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged implants in the canine mandible. *Journal of Periodontology* **72**: 1372–1383.

Jansen, V.K., Conrads, G. & Richter, E.J. (1997) Microbial leakage and marginal fit of the implant-abutment interface. *International Journal of Oral & Maxillofacial Implants* **12**: 527–40.

Lazzara, R.J. & Porter, S.S. (2006) Platform switching: a new concept in implant dentistry for controlling postrestorative crestal bone levels. *International Journal Periodontics and Restorative Dentistry* **26**: 9–17.

Ledermann, P.D., Schenk, R. & Buser, D. (1999) 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. *International Journal Periodontics and Restorative Dentistry* **18**: 553–556.

Linkow, L.I., Donath, K. & Lemons, J.E. (1992) Retrieval analyses of a blade implant after 231 months of clinical function. *Implant Dentistry* **1**: 37–43.

Misch, C.E., Bidez, M.W. & Sharawy, M. (2001) A bioengineered implant for a predetermined bone cellular response to loading forces. A literature review and case reports. *Journal of Periodontology* **72**: 1276–1281.

Morris, H.F., Ochi, S., Creum, P., Orenstein, I.H. & Winkler, S. (2004) AICGR, Part I: a 6-year multicentered, multidisciplinary clinical study of a new and imnnovative implant design. *Journal of Oral Implantology* **30**: 125–133.

Nentwig, G.N. (2004) The Ankylos implant system: concept and clinical application. *Journal of Oral Implantology* **30**: 171–177.

Neugebauer, J., Traini, T., Thams, U., Piattelli, A. & Zoeller, J.E. (2006) Peri-implant bone organization under immediate loading state: circularly polarized light analyses. *Journal of Periodontology* **77***: 152–160.*

Papalexiou, V., Novaes, A.B., Grisi, M.F.M., Souza, S.S.L.S., Taba, M. & Kajiwara, J.K. (2004) Influence of implant microstructure on the dynamics of bone healing around immediate implants placed into periodontally infected sites. A confocal laser scanning microscopic study. *Clinical Oral Implants Research* **15**: 44–53.

Persson, L.G., Lekholm, U., Leonhardt, A., Dahlen, G. & Lindhe, J. (1996) Bacterial colonization on internal surfaces of branemark system implant components. *Clinical Oral Implants Research* **7**: 90–95.

Piattelli, A., Corigliano, M., Scarano, A., Costigliola, G. & Paolantonio, M. (1998) Immediate loading of titanium plasma-sprayed implants: a pilot study in monkeys. *Journal of Periodontology* **69**: 321–327.

Piattelli, A., Corigliano, M., Scarano, A. & Quaranta, M. (1997b) Bone reactions to early occlusal loading of two-stage titanium plasma-sprayed implants: a pilot study in monkeys. *International Journal Periodontics and Restorative Dentistry* **17**: 163–169.

Piattelli, A., Paolantonio, M., Corigliano, M. & Scarano, A. (1997c) Immediate loading of titanium plasma-sprayed screw-shaped implants in man: a clinical and histological report of two cases. *Journal of Periodontology* **68**: 591–597.

Piattelli, A., Ruggeri, A., Trisi, P., Romasco, N. & Franchi, M. (1993b) A histologic and histomorphometric study of the bone reactions to non submerged unloaded and loaded single implants in monkeys. *Journal of Oral Implantology* **19**: 314–320.

Piattelli, A., Scarano, A. & Paolantonio, M. (1997a) Immediately loaded screw implant removed for fracture after a 15-year loading period: histological and histochemical analysis. *Journal of Oral Implantology* **23**: 75–79.

Piattelli, A., Scarano, A., Paolantonio, M., Assenza, B., Leghissa, G.C., Di Bonaventura, G., Catamo, G. & Piccolomini, R. (2001) Fluids and microbial penetration in the internal part of cement-retained versus screw-retained implant–abutment connections. *Journal of Periodontology* **72**: 1146–1150.

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

Piattelli, A., Trisi, P., Romasco, N. & Emanuelli, M. (1993a) Histological analysis of a screw implant retrieved from man: influence of early loading and primary stability. *Journal of Oral Implantology* **19**: 303–306.

Piattelli, A., Vrespa, G., Petrone, G., Iezzi, G., Annibali, S. & Scarano, A. (2003) Role of the microgap between implant and abutment: a retrospective histologic evaluation in monkeys. *Journal of Periodontology* **74**: 346–352.

Quirynen, M., Bollen, CM., Eyssen, H. & van Steenberghe, D. (1994) Microbial penetration along the implant components of the Branemark system – An in vitro study. *Clinical Oral Implants Research* **5**: 239–44.

Quirynen, M. & van Steenberghe, D. (1993) Bacterial colonization of the internal part of two-stage implants. An in vivo study. *Clinical Oral Implants Research* **4**: 158–161.

Rocci, A., Martignoni, M., Burgos, P.M., Gottlow, J. & Sennerby, L. (2003) Histology of retrieved immediately and early loaded oxidized implants: light microscopic observations after 5 to 9 months of loading in the posterior mandible. *Clinical Implant Dentistry & Related Research* **5** (Suppl.): 88–98.

Romanos, G., Degidi, M., Testori, T. & Piattelli, A. (2005) Histological and histomorphometrical findings from human retrieved immediately functional loaded implants. *Journal of Periodontology* **76**: 1823–1832.

Romanos, G.E., Toh, C.G., Siar, C.H., Swaminathan, D. & Ong, A.H. (2002) Histological and histomorphometric evaluation of peri-implant bone subjected to immediate loading: an experimental study with Macaca Fascicularis. *International Journal of Oral & Maxillofacial Implants* **17**: 44–51.

Romanos, G., Toh, C.G., Siar, C.H., Swaminathan, D., Ong, A.H., Donath, K., Yaacob, H. & Nentwig, G.H. (2001) Peri-implant bone reactions to immediately loaded implants. An experimental study in monkeys. *Journal of Periodontology* **72**: 506–511.

Rupp, F., Scheideler, L., Rehbein, D., Axmann, D. & Geis-Gerstorfer, J. (2004) Roughness induced dynamic changes of wettability of acid etched titanium implant modification. *Biomaterials* **25**: 1429–1438.

Siar, C.H., Toh, C.G., Romanos, G., Swaminathan, D., ong, A.H., Yaacob, H. & Nentwig, GH. (2003) Peri-implant soft tissue integration of immediately loaded implants in the posterior macaque mandible: a histomorphometric study. *Journal of Periodontology* **74**: 571–578.

Tarnow, D.P., Cho, S.C. & Wallace, S.S. (2000) The effect of inter-implant distance on the height of inter-implant bone crest. *Journal of Periodontology* **71**: 546–549.

Testori, T., Szmukler-Moncler, S., Francetti, L., Del Fabbro, M., Scarano, A., Piattelli, A. & Weinstein, R.L. (2001) Immediate loading of Osseotite implants: a case report and histologic analysis after 4 months of occlusal loading. *International Journal of Periodontics and Restorative Dentistry* **21**: 451–459.

Testori, T., Szmukler-Moncler, S., Francetti, L., Del Fabbro, M., Trisi, P. & Weinstein, R.L. (2002) Healing of Osseotite implants under submerged and immediate loading conditions in a single patient: a case report and interface analysis after 2 months. *International Journal Periodontics and Restorative Dentistry* **22**: 345–353.

Traini, T., Degidi, M., Caputi, S., Strocchi, R., Di Iorio, D. & Piattelli, A. (2005a) Collagen fiber orientation in human peri-implant bone of immediately loaded titanium dental implants. *Journal of Periodontology* **76**: 83–89.

Traini, T., Degidi, M., Strocchi, R., Caputi, S. & Piattelli, A. (2005b) Collagen fiber orientation near dental implants in human bone: do their organization reflect differences in loading? *Journal of Biomedical Materials Research Part B: Applied Biomaterials* **74B**: 538–546.

Trisi, P., Emanuelli, M., Quaranta, M. & Piattelli, A. (1993) A light microscopy, scanning electron microscopy and laser scanning microscopy analysis of retrieved blade implants after 7 to 20 years of clinical function. *Journal of Periodontology* **64**: 374–378.