Machined and sandblasted human dental implants retrieved after 5 years: A histologic and histomorphometric analysis of three cases

Giovanna Iezzi, DDS, PhD[1]/Giovanni Vantaggiato, DDS[2]/
Jamil A. Shibli, DDS, MS, PhD[3]/ Elisabetta Fiera, DDS[2]/
Antonello Falco, DDS[4]/Adriano Piattelli, MD, DDS[5]/
Vittoria Perrotti, DDS, PhD[6]

Objective: Human retrieved implants with an intact bone-implant interface play a pivotal role in validating data obtained from in vitro studies and animal experiments. This study presents a histologic and histomorphometric analysis of peri-implant tissue reactions and of the bone-titanium interface in three machined and sandblasted dental implants retrieved after a 5-year loading period. **Method and Materials:** Three implants, with an intact bone-implant interface, were found in the Archives of the Implant Retrieval Center of the Dental School of the University of Chieti-Pescara, Chieti, Italy. The three implants had been used in a two-stage submerged procedure and loaded as part of a small prosthetic restoration. One implant had been retrieved because of an abutment fracture, while there was a fracture of the connecting screw in the other two. One implant was in the maxilla (sandblasted surface), and two were in the mandible (one with a machined surface and the other with a sandblasted surface). All implants had been processed for histology. **Results:** All three implants presented mature, compact, lamellar bone at the interface. Many remodeling areas were present in the peri-implant bone, especially inside the implant threads. The bone was always in close contact with the implant surface. The bone-implant contact percentage of the machined implant was 92.7%, while the two sandblasted implants showed bone-implant contact percentages of 85.9% and 76.6%. **Conclusion:** The present histologic results confirmed that these implants with different surfaces maintained a good level of osseointegration over a 5-year loading period, with continuous remodeling at the interface, and showed high bone-implant contact percentages. *(Quintessence Int 2012;43:287–292)*

Key words: bone remodeling, human histology, implant surfaces, retrieved dental implants

Dental implants fail for many reasons.[1–7] In some of these cases, it is not easy to obtain meaningful information about the bone-implant interface.[1] Rarely is it possible to obtain implants, retrieved for various reasons, in which the interface with the mineralized bone is maintained. Implants retrieved from humans with intact bone-implant interfaces play a pivotal role in validating data obtained from in vitro studies and animal experiments.[8] Moreover, the bone response to different implant surfaces may be evaluated over a longer period in vivo.[8,9] It is also important to analyze whether modifications of the implant surface characteristics improve the phenomena at the interface,[10] with an increase in the rate and extent of mineralized bone formation.[10] Sandblasted surfaces have been produced by blasting the metal with different types of blasting or gritting agents.[11–13] This process was

[1]Researcher, Dental School, University of Chieti-Pescara, Chieti, Italy.

[2]Private Practice, Lecce, Italy.

[3]Head, Oral Implantology Clinic, and Associate Professor, Department of Periodontology, Dental Research Division, Guarulhos University (UnG), Guarulhos, SP, Brazil.

[4]Research Fellow, Dental School, University of Chieti-Pescara, Chieti, Italy.

[5]Professor, Oral Pathology and Medicine, Dental School, University of Chieti-Pescara, Chieti, Italy.

[6]Research Fellow, Dental School, University of Chieti-Pescara, Chieti, Italy.

Correspondence: Dr Vittoria Perrotti, Via Dei Vestini 31, 66100 Chieti, Italy. Email: v.perrotti@unich.it

influenced by the number and size of particles used. The blasting procedure served to increase the irregularities of the implant surface by using agents such as aluminum oxide (Al_2O_3) or titanium oxide (TiO_2). The large variability in surface appearance under scanning electron microscopy (SEM) of different implant surfaces is due to the different techniques employed in the blasting procedure. In in vitro studies, the sandblasted surfaces have shown higher adhesion, proliferation, and differentiation of cells.[14] In histologic studies that compared blasted and turned surfaces, higher bone-implant values were found in blasted surfaces.[11,13] Blasting procedures leave residual particles on the surface of the implant, however, and this could alter the healing process of the bone. Some researchers think that aluminum ions could impair bone formation by a possible competitive action to calcium, while others suggested that histologic data did not provide evidence to support the hypothesis that residual aluminum oxide particles on the implant surface could affect the osseointegration of titanium dental implants.[15] The bone growth pattern around blasted, rough surfaces has been said to be characterized by contact osteogenesis—ie, the osteoblasts start depositing osteoid matrix directly on the implant surface.[11,13] Around machined surfaces, the bone growth pattern has been termed *distance osteogenesis*, with bone growing from the host bone bed toward the metal surface.[11,13] The type of bone growth around blasted surfaces could produce an earlier and a higher quantity of bone at the implant interface.[11,13] Other types of surfaces have been reported in the literature. Sandblasted and acid-etched surfaces were obtained with a combined procedure of blasting (to produce a macrotexture) followed by acid-etching (to produce a final microtexture). The blasting is used to achieve a roughness optimal for mechanical fixation, while the etching serves to smooth some sharp peaks.[16] Sandblasted and acid-etched implants promoted higher bone-implant values at earlier time points compared with plasma-sprayed implants.[16] Sandblasted and acid-etched surfaces showed high osteoconductive properties and capabilities to induce cell proliferation.[16]

The aim of this study was to analyze, histologically and histomorphometrically the peri-implant tissue reactions and the bone-titanium interface in machined and sandblasted titanium dental implants with an intact bone-implant interface retrieved after a 5-year loading period.

METHOD AND MATERIALS

In the Archives of the Implant Retrieval Center of the Dental School of the University of Chieti-Pescara, Chieti, Italy, three retrieved implants (Implacil, De Bortoli) with an intact bone-implant interface and a loading history of 5 years were found. The protocol of the study was approved by the ethics committee of the University of Guarulhos (UnG), São Paulo, Brazil. The three implants had been retrieved from three different patients (two women and one man 53, 54, and 59 years of age, respectively). The medical history of all the patients was noncontributory. All implants had been used in a two-stage submerged procedure, and all implants had been loaded as part of a small prosthetic restoration. One implant had been retrieved because of a fracture of the abutment, while there was a fracture of the connecting screw in the other two. One implant was in the maxilla (sandblasted surface), and the other two were in the mandible (one with a machined and the other with a sandblasted surface). One implant had a machined surface, while the other two had a sandblasted surface. All these implants were stable before retrieval, and each was retrieved with a 5-mm trephine bur.

Specimen processing

All the specimens were washed in saline solution and immediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in 0.15 M cacodylate buffer at 4°C and pH 7.4 to be processed for histology. The specimens were processed to obtain thin ground sections with the Precise 1 Automated System (Assing).[17] The specimens were dehydrated in an ascending series of alcohol rinses and embedded in glycolmethacrylate resin (Technovit 7200 VLC, Kulzer).

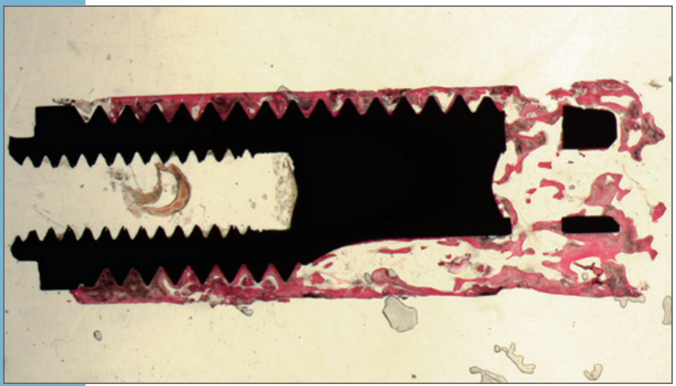

Fig 1 Compact and mature lamellar bone, with few marrow spaces in the apical portion, was present around the machined implant (toluidine blue and basic fuchsin, original magnification ×12).

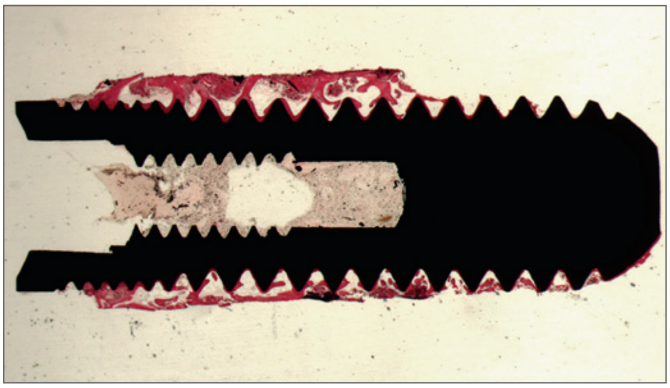

Fig 2 Lamellar bone with several marrow spaces was observed around the sandblasted implant (toluidine blue and basic fuchsin, original magnification ×12).

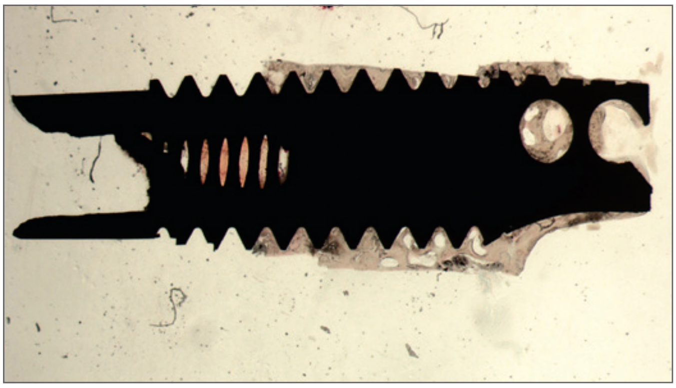

Fig 3 Compact, mature bone with small marrow spaces was present in the intermediate and apical portion of the sandblasted implant (toluidine blue and basic fuchsin, original magnification ×12).

After polymerization, the specimens were sectioned, along their 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. Two slides were obtained for each specimen. The slides were stained with basic fuchsin and toluidine blue. The slides were observed in normal transmitted light under a Laborlux microscope (Leitz) and polarized-light microscopy (Leitz).

Histomorphometry

Histomorphometry of the bone-implant contact percentages was carried out using a light microscope (Laborlux) connected to a high-resolution video camera (3CCD, JVC KY-F55B, JVC) and interfaced to a monitor and PC (Intel Pentium III 1200 MMX, Intel). This optical system was associated with a digitizing pad (Matrix Vision) and histometry software with image-capturing capabilities (Image ProPlus 4.5, Media Cybernetics).

RESULTS

All three implants presented mature, compact, lamellar bone at the interface (Figs 1 to 3). No differences were found in the pattern of bone growth between the machined and sandblasted surfaces. The structure of this bone was lamellar, and the lamellae were distributed in several directions. Many remodeling areas were present in the peri-implant bone, especially inside the implant

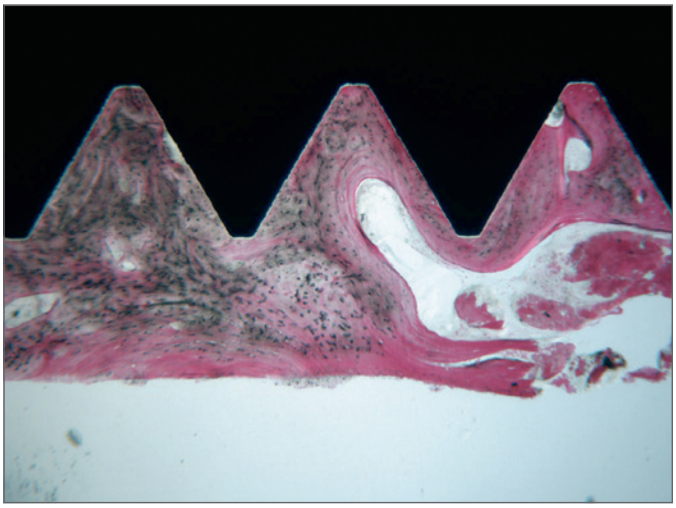

Fig 4 High-power view of the implant shown in Fig 1. Many remodeling areas were present in the peri-implant bone, especially inside the implant threads (toluidine blue and basic fuchsin, original magnification ×40).

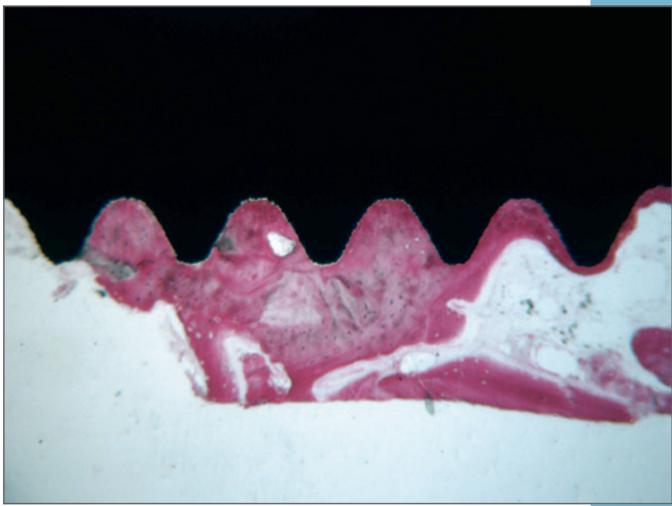

Fig 5 High-power view of the implant shown in Fig 2. The bone was always in close contact with the implant surface, with no gaps at the interface (toluidine blue and basic fuchsin, original magnification ×40).

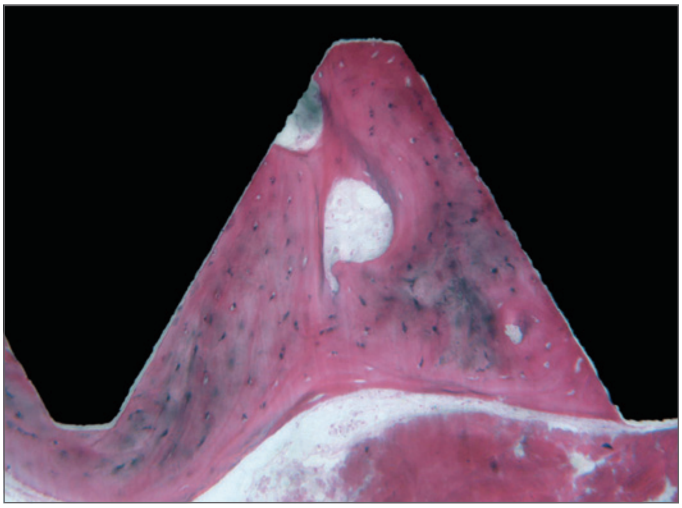

Fig 6 High-power view of the implant shown in Fig 1. No gaps or fibrous connective tissues were present at the bone-implant interface. Osteocytes can be observed inside the respective lacunae (toluidine blue and basic fuchsin, original magnification ×100).

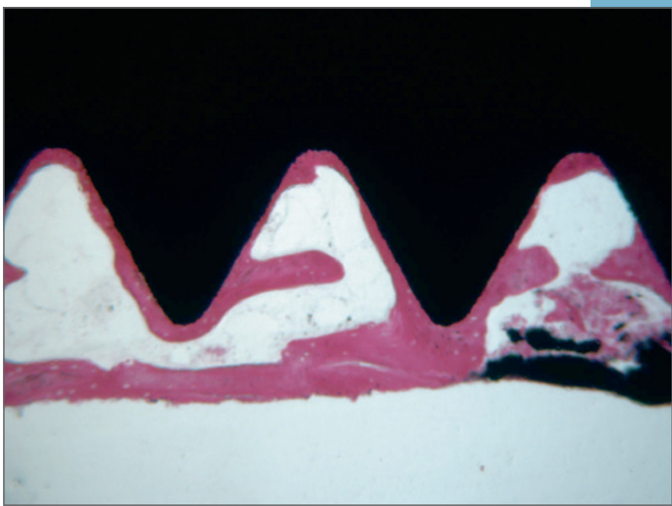

Fig 7 High-power view of the implant shown in Fig 2. The sandblasted surface appeared to be highly osteoconductive as newly formed bone can be observed in tight contact with the implant surface (toluidine blue and basic fuchsin, original magnification ×40).

threads (Fig 4). The bone was always in close contact with the implant surface (Fig 5). At higher magnifications, no gaps or fibrous connective tissue were present at the bone-implant interface (Fig 6). Within some of the threads, near the implant surface, it was possible to see small, secondary osteons with Haversian canals. Other osteonic structures, which had a direction perpendicular to the implant long axis, were visible. Many reversal lines were present in the areas of bone remodeling. Both surfaces appeared to be highly osteoconductive. Large marrow spaces were present near the implant surface (Fig 7). Osteocytes could be seen near the implant surface. No inflammatory cell infiltrates were present. No calculus, bacteria, or epithelial downgrowth was present. The bone-implant contact percentage of the machined implant was 92.7%, while the two sandblasted implants showed a bone-implant contact percentage of 85.9% and 76.6%.

DISCUSSION

Retrieval analysis of human dental implants is a valuable tool for the evaluation of both implant success and failure.[1,8] The bone-implant contact percentage has been used as an indicator of the success of a dental implant at different implantation times, and it is also possible to observe the behavior of the implant in the bone over time. Bone was found to be more mature and well organized around loaded implants, and many areas of remodeling and well-defined osteons were present. The implant loading also had an effect on the distribution of the collagen fibers of the bone tissue.[18,19] A Haversian-like structure running perpendicular to and along with the implants' long axis has been reported around root-form implants functionally loaded for long periods of time.[8] In the implants removed for implant or abutment fracture, a high bone-implant contact percentage (about 70%) was present, and the fractures usually occurred after some years (3 to 4).[1–3] The specimens retrieved after longer periods may contain important information about the host biologic reaction and the effects of the implant presence in bone-remodeling processes.[8] The capability of the bone to remain attached to implant surfaces, placed in function, may also help to demonstrate the performance of the micro- and macrostructure of the dental implants over time. Osteogenesis at the bone-implant interface seems to be influenced by several mechanisms.[10,16] The different implant surfaces and designs may affect a series of coordinated events, including protein adsorption, proliferation, and bone-tissue deposition.[10,16]

Due to ethical constraints, a limited sample of human retrieved implants is available, so each implant must be evaluated and reported on to improve knowledge of the healing and remodeling processes at the interface, especially after longer loading periods. Only in such a way can a larger quantity of human retrieved implants be assembled, corroborating the results from in vitro investigations, animal experimental studies, and clinical investigations in humans. The retrieved implants from the present study were removed for reasons other than a failure at the interface, so an intact mineralized tissue-titanium interface could be evaluated. No differences were found in the bone growth pattern (distance osteogenesis vs contact osteogenesis) around the implant with the machined surface and the implants with the blasted surface, even if the limited number of evaluated samples cannot, clearly, allow any definitive conclusion. Bone was found close to the surface of all three implants, and at higher magnification, no gaps or connective fibrous tissue was found at the interface.

Even if previous studies reported in the literature found that the blasted surfaces presented a higher bone-implant contact than machined surfaces, in the present specimens, it has to be noted that the bone-implant contact of the machined implants was higher than that of both blasted implants. This is just a single anecdotal observation, and certainly, no conclusions can be drawn from a single case. The bone-implant contact around all three implants was high, even after a loading period of 5 years. This fact could be explained by the evidence, as reported in the literature,[20–23] that higher bone-implant contact has been usually found around loaded implants. It can also be explained by the fact that all three implants were splinted, because they were part of small prosthetic reconstructions, so deleterious micromovements at the interface were limited. Bone remodeling, with areas of more recent, newly formed bone and osteonic Haversian structures, was found around all three implants. This bone remodeling, with the elimination of the areas of microfractures present in the peri-implant bone, and produced by the microstrains generated, is thought to be essential for the high long-term success rates of dental implants.

CONCLUSION

The present histologic results confirmed that these implants with different surfaces maintained a good level of osseointegration over a 5-year loading period, with a continuous remodeling at the interface, and showed a high bone-implant contact percentage.

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