# Histologic Evaluation of Human Bone Integration on Machined and Sandblasted Acid-etched Titanium Surfaces in Type IV Bone

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The aim of this preliminary study was to evaluate the influence of a sandblasted acid-etched surface on bone-implant contact percentage (BIC%) as well as the bone density in the threads area (BD%) in type 4 bone after 2 months of unloaded healing. Five subjects (mean age = 42.6 years) received 2 microimplants each during conventional implant surgery in the posterior maxilla. The microimplants with commercially pure titanium surface (machined) and sandblasted acid-etched surface served as the control and test surfaces, respectively. After a healing period of 2 months, the microimplants and the surrounding tissue were removed and prepared for ground sectioning and histomorphometric analysis. One microimplant with a machined surface was found to be clinically unstable at the time of retrieval. Histometric evaluation indicated mean BIC% was 20.66 ± 14.54% and 40.08 ± 9.89% for machined and sandblasted acid-etched surfaces, respectively ($P = .03$). The BD% was 26.33 ± 19.92% for machined surface and 54.84 ± 22.77% for sandblasted acid-etched surface ($P = .015$). Within the limits of this study, the data suggest that the sandblasted acid-etched implant surface presented a higher percentage of bone-implant contact compared with machined surfaces, under unloaded conditions in posterior maxilla after a healing period of 2 months.

**Key Words: dental implants/microstructure, implant surface/titanium, osseointegration/ wound healing, human histology, type IV bone/posterior maxilla**

## Introduction

Several long-term investigations have documented the high predictability of dental implants in partially and completely edentulous patients.[1–3] However, studies have demonstrated that the survival data of dental implants placed in posterior maxilla are inferior to those placed in the anterior mandible, where the bone density is frequently higher.[4,5] The demand for improved dental implant survival at sites with lower bone quality prompted the search for dental implant microstructure properties that would enhance the bone-implant contact (BIC). Several authors have demonstrated higher BIC percentages and removal torque values for rough dental implant

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surfaces compared with machined implants as well as faster development of bone-implant integration.[6–8]

Different dental implant surface microstructures can be achieved with subtractive methods (sandblasting, acid etching) or additive methods (titanium plasma spray, hydroxylapatite coating). Thus, surface roughness achieved with the sandblasting technique is obtained by treating commercially pure titanium (cpTi) dental implant surfaces with an air and abrasive material spray of either aluminum oxide or titanium oxide for a certain period of time and under controlled pressure. After that, this surface is treated with acid solutions under different temperatures and for different periods of time. Consequently, these surface microstructures provide better mechanical stability between bone tissues and implant surfaces by producing greater contact area. The modified surface provides a configuration that properly retains the blood clot and stimulates the bone healing process, which allows implants with modified surfaces to be loaded earlier.[9–11] In the mandible, the healing time for good bone quality is 3 to 4 months; for the maxilla, the corresponding time is 5 to 6 months.[12] However, in areas with poor bone quality, such as the posterior maxilla, the healing time for machined implants can be longer (7 to 8 months).[4] Therefore, there is a lack of data on the bone-implant contact percentage (BIC%) of this implant microstructure in type 4 human bone after short healing periods.

The objective of this preliminary study was to evaluate the influence of sandblasted acid-etched surface on BIC% as well as the bone density in the thread area (BD%) in human posterior maxilla after 2 months of unloaded healing.

## Material and Methods

### Subject selection

Five partially edentulous subjects (3 women; 2 men) with a mean age of 42.6 years (range = 35 to 54 years) referred to Department of Periodontology, Dental Research Division, Guarulhos University, Brazil, for oral rehabilitation with dental implants, were included. Exclusion criteria included pregnancy, nursing, smoking, and any systemic conditions that could affect bone healing, such as osteoporosis and blood disorders. The local Ethics Committee for Human Clinical Trials approved the study protocol.

### Microimplants and surface preparation

Ten screw-shaped microimplants made of grade-4 titanium (Conexão Dental Implants, São Paulo, SP, Brazil) were prepared with 2 surface topographies: machined and sandblasted acid-etched surfaces. Each microimplant was 2.5 mm in diameter and 6 mm long. The microimplants with sandblasted acid-etched surface were blasted with 25 to 100 μm $TiO_2$ particles. After sandblasting, the specimens were ultrasonically cleaned with an alkaline solution, washed in distilled water, and pickled with a mixture of $HNO_3$ and HF.

Ten screw-shaped microimplants were used in this study. Five machined microimplants that served as controls and 5 sandblasted acid-etched surfaces served as test surface microimplants (Figure 1).

### Surgical procedures

All microimplants were placed in the posterior maxilla during the surgical procedures for conventional dental implant placement. After incision, mucoperiosteal flaps were raised, and the conventional implants were placed. Next, the 2 microimplants—1 with a machined and 1 with a sandblasted acid-etched surface—were placed in suitable areas, mostly the upper molar region, that is, posterior to the most distal conventional implant. The recipient microimplant sites were prepared with a 1.8-mm diameter twist drill, and implants were inserted with a screwdriver. Drilling procedures and dental implant placements were made under profuse irrigation with sterile saline. The flaps were sutured with single interrupted sutures to submerge all the dental implants, including the microimplants. Clindamycin was given twice a day for a week to avoid postsurgical infection, and pain was controlled with acetaminophen. The sutures were removed after 10 days.

A total of 10 microimplants (5 controls and 5 tests) were placed in 5 maxillae. After 2 months of healing, the microimplants were removed using an internal 4.0-mm wide trephine, and the microimplants, together with surrounding bone tissues, were rinsed in sterile saline solution and fixed by immersion in 4% neutral formalin.

### Specimen processing

To process the microimplants and surrounding bone tissues and obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy), the specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycol methacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned longitudinally along the major implant axis, with a high-precision diamond disk at about 150 μm, and ground down to about 30 μm. Two slides were obtained for each implant. The slides were stained with basic fuchsin and toluidine blue.

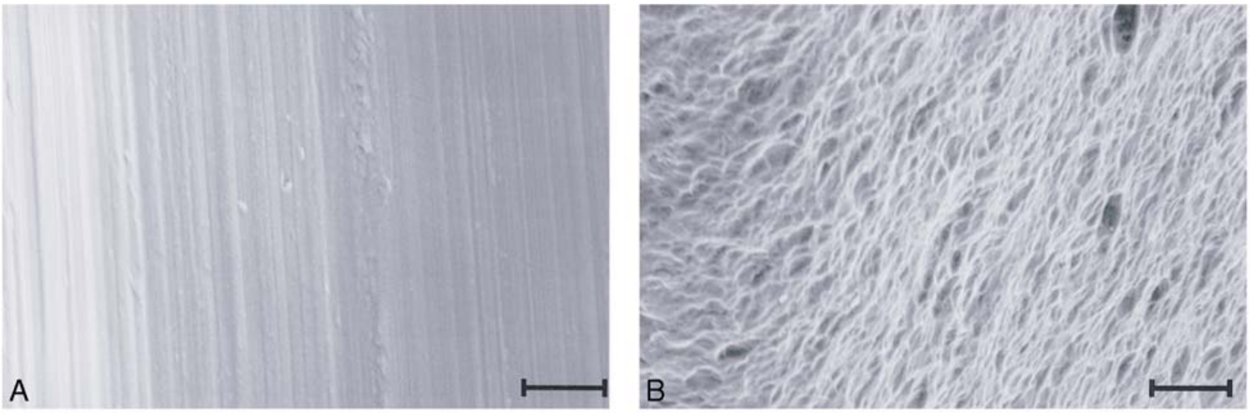



FIGURE 1. Scanning electron microphotograph of the implant surface topography. (1A) Machined implant surface. (1B) Sandblasted acid etched surface (bar = 10 μm).

Histomorphometry of bone-implant contact percentage, as well as the bone area within the limits of the implant threads, was performed with a light microscope (Laborlux S, Leitz, Wetzlar, Germany) connected to a high-resolution video camera (3CCD, JVC KY-F55B, Milan, Italy) and interfaced with a monitor and personal computer (Intel Pentium III 1200 MMX). This optical system was associated with a digitizing pad (Matrix Vision GmbH, Milan, Italy) and a histometry software package with image-capturing capabilities (Image-Pro Plus 4.5, Media Cybernetics Inc., Immagini & Computer Snc, Milan, Italy).

The BIC and amount of bone area within the threads (from the lowest point of the microimplant head to the last apical thread) were calculated and expressed as BIC% and BD%, respectively. Mean and SD were calculated. Mann-Whitney *U* test was used to compare the different implant surface topographies. Significance test was 2-tailed and conducted at a 5% significance level.

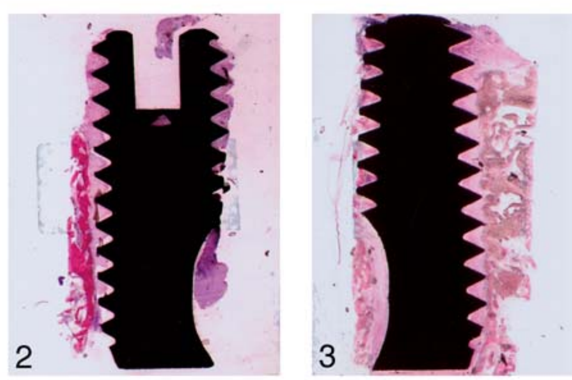
## RESULTS

### *Clinical observations*

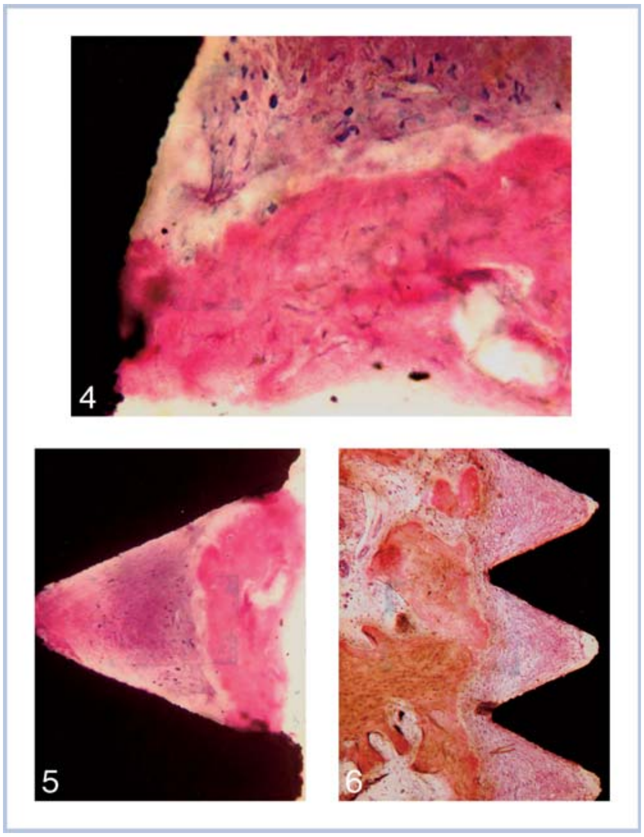
All microimplants, except for 1 machined microimplant, were found to be clinically stable at the time of retrieval. The 1 unstable microimplant was not included in the statistical evaluation. Neither of the microimplants presented with marginal bone resorption or surrounding infection. Retrieved microimplants with sandblasted acid-etched surfaces presented visibly more bone attached to implant surface compared with machined surface microimplants.

### *Histologic and histometric results*

The peri-implant bone from all microimplants appeared healthy. The old bone was lamellar and compact, and numerous osteocytes were presented in their lacunae, although areas of woven bone could be distinguished. The newly formed peri-implant bone exhibited early stages of maturation, mainly on the sandblasted surface (Figures 2 and 3). Osteoblasts were connected to newly formed peri-implant bone, showing ongoing bone formation, and minor apposition of new bone could be found, specifically inside the implant threads of the machined surface (Figures 4 and 5). In addition, some of the machined surface specimens showed a lack of connecting bridges




FIGURES 2–3. FIGURE 2. Immature bone is present around the machined implant. The peri-implant bone presents early stages of maturation (acid fuchsin and toluidine blue, original magnification ×16). FIGURE 3. Bone tissue is scarce around sandblasted acid-etched surface (Acid fuchsin and toluidine blue, original magnification ×16).




FIGURES 4–6. FIGURE 4. Ground section of sandblasted acid-etched surface presenting osteoblasts connected to newly formed bone tissue (acid fuchsin and toluidine blue, original magnification ×100). FIGURE 5. Histologic ground section of sandblasted acid-etched surface presenting apposition of newly formed bone tissue in the thread area (acid fuchsin and toluidine blue, original magnification ×100). FIGURE 6. Lack of connecting bridges between the bone trabeculae and the turned (commercially pure titanium) implant surface (acid fuchsin and toluidine blue, original magnification ×100).

between the thin bone trabeculae and the implant surface (Figure 6).

Histometric analyses are presented in Figures 7 and 8. Both histometric variables were significantly higher in the sandblasted acid-etched surface group ($P < .05$).

## DISCUSSION

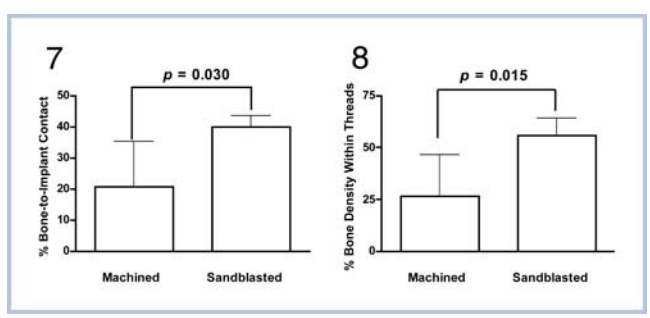
The objective of this study was to evaluate the BIC at different dental implant surfaces in human type 4 bone after a 2-month healing period. The sandblasted acid-etched implant surface exhibited a considerable percentage of mineralized bone contact compared with the machined surface implants. Geometric surface properties produce mechanical restrictions on the cytoskeletal cell components that are involved in cell spreading and migration.[13] Bone cell proliferation and differentiation have been reported to be enhanced by implant surface topography roughness.[14,15] In addition, it has been suggested that acid treatment enhanced early bone-implant integration to a level similar to that observed around more complex surfaces, such as surfaces sprayed with titanium plasma and surfaces coated with hydroxylapatite.[16–18]

Because implant placement in type 4 bone, particularly in the posterior maxilla, is less successful than in areas with better bone quality,[4,5] the histometric results of the present study suggest that implants with sandblasted surface roughness could enhance osseointegration. This finding is in agreement with previous studies performed in animal[6,8,19–22] and human bone tissues.[9,11]

In addition, the machined (cpTi) dental implant surface data are in agreement with the statement that this surface does not provide a strong implant anchorage in bone, particularly in compromised sites with poor bone density, such as the posterior maxilla, after longer times; this may explain the increased failure rates.[3–5]

On the other hand, some studies demonstrated that anchorage of machined dental implant is time dependent.[19,20] The percentage of BIC for machined surface, however, was 17.19% after 2 months of healing, whereas previous studies have reported BIC% between 10% to 11% after 6 months of healing.[23,24] These histometric data may suggest that although the implant surface could be important for osseointegration, the presence of soft bone at the placement site can jeopardize the success of dental implants.

In conclusion, the histomorphometric data in the present study suggest that sandblasted acid-etched microimplant surfaces present higher %BIC compared with machined surfaces in soft bone tissue. However, these results should be considered with caution and further investigations must be conducted.




FIGURES 7–8. FIGURE 7. Mean and SD of bone-implant contact percentage for machined and sandblasted and acid-etched surfaces (n = 5 subjects). Mann-Whitney *U* test ($P < .05$). FIGURE 8. Mean and SD of bone density in the thread area for machined and sandblasted and acid-etched surfaces (n = 5 subjects). Mann-Whitney *U* test ($P < .05$).

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