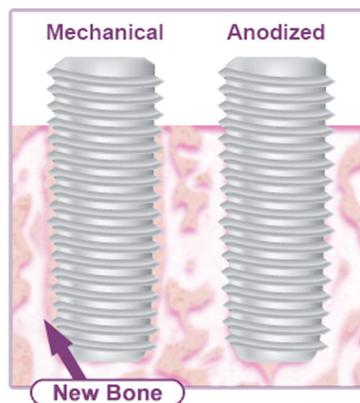


## Histological Comparison of Bone to Implant Contact in Two Types of Dental Implant Surfaces: A Single Case Study

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### Abstract

**Aim:** The purpose of this single case study was to evaluate the influence of different implant surfaces on human bone and osseointegration.

**Methods and Materials:** A 47-year-old partially edentulous woman received two experimental implants along with conventional implant therapy. Experimental implants placed in the mandibular ramus consisted of machined and anodized surfaces, respectively. After three months of healing, the experimental implants were removed and prepared for ground sectioning and histological analysis.

**Results:** The data demonstrate anodized implant surfaces present a higher percentage of osseointegration when compared to a machined surface in cortical human bone after a healing period of three months.

**Conclusion:** This single case study suggests an anodized implant surface results in a higher percentage of bone to implant contact when compared to machined surfaced implants when placed in dense bone tissue. However, further investigations should be conducted.

**Keywords:** Dental implants, implant microstructure, implant surfaces, titanium dental implants, osseointegration, wound healing, human histology

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## Introduction

Earlier investigations have recognized that implant surface topography, also called dental implants microstructure, is one of the most important factors for the achievement of osseointegration.<sup>1-3</sup> Consequently, several studies have focused their efforts in the search of an implant surface modification that promotes maximum bone-implant contact. Different dental implant microstructures can be achieved with either subtractive methods (sandblasting, acid etching, etc.) or additive methods (titanium plasma spray, hydroxylapatite coating, etc.). The anodic oxidation is a technique of dental implant surface modification that results in growth of an oxide layer to a thickness of 1 to 10  $\mu\text{m}$  with numerous pores of varying size.<sup>4-6</sup>

Few studies and case reports have been published evaluating the peri-implant bone response in humans with different microstructures.<sup>7-9</sup> Therefore, the quality of the human bone-to-implant interface around anodized surfaces after a short period of healing is still to be determined. The objective of this report was to evaluate the influence of different implant microstructures on bone-to-implant contact after an unloaded healing period of three months in a human jaw.

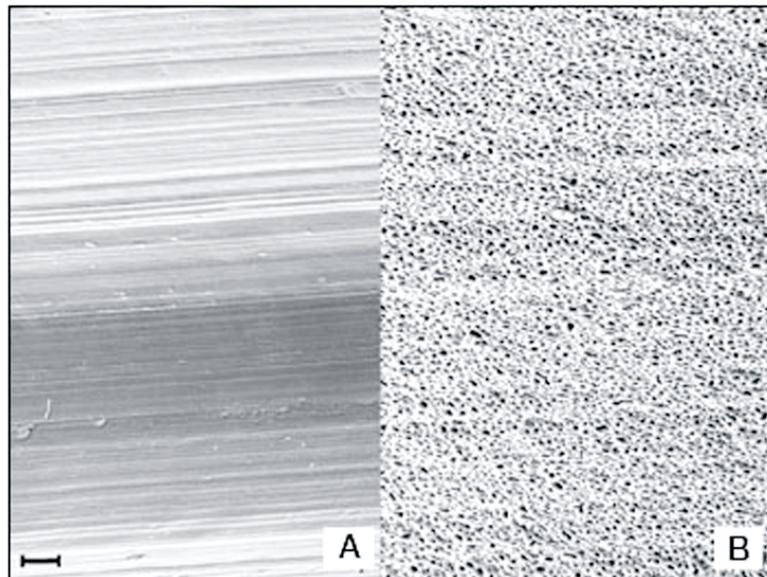
## Methods and Materials

A 47-year-old partially edentulous woman was admitted to the Department of Periodontology of Guarulhos University in Guarulhos, SP, Brazil for oral rehabilitation with dental implants. The patient was healthy and without a significant medical history. The subject responded to an informed consent, which was approved by the local Ethics Committee for Human Research.

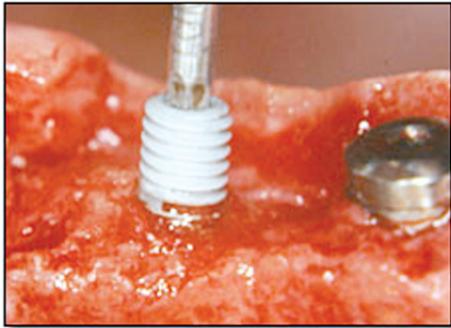
### Implant Preparation (Anodic Oxidation)

Two screw shaped implants made with Grade 4 titanium (Conexão Sistemas de Prótese, São Paulo, SP, Brazil) were prepared with two surface morphologies: one machined and the other anodized (Figure 1). Each micro-implant was 2.5 mm in diameter and 6.0 mm in length.

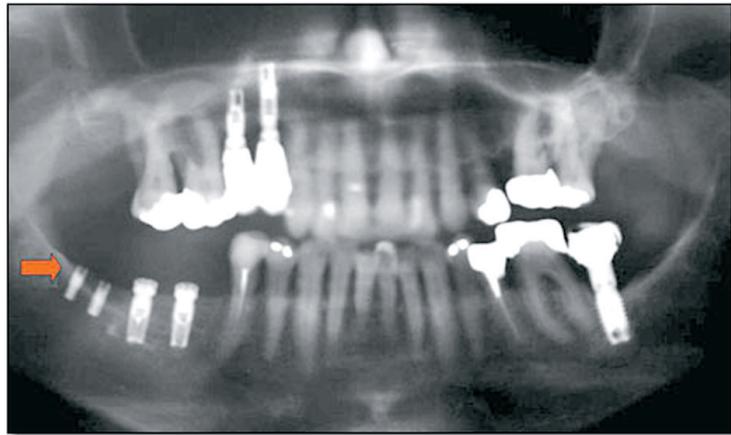
The anodic oxidation method used was the same as previously described by Zhu et al.<sup>10</sup> The titanium screws were ultrasonically rinsed in acetone then pickled with a mixture of HF and  $\text{HNO}_3$  (the HF/ $\text{HNO}_3$  mole ratio was 1:3) and finally rinsed with distilled water. Anodizing was performed using a regulated DC power supply in the constant current mode and an electrolyte consisting of calcium (Ca) glycerophosphate and Ca acetate. Both Ca glycerophosphate and Ca acetate are used as food stabilizers and food



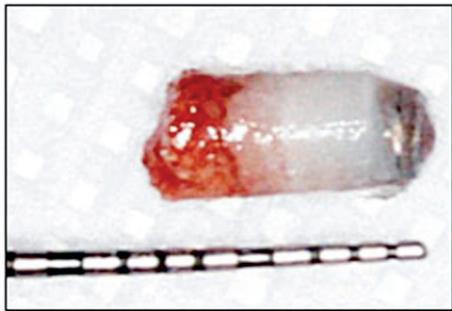
**Figure 1.** Scanning electron microphotograph showing the topography of the experimental implants (a) machined and (b) anodized surface (barr=10  $\mu\text{m}$ ).



**Figure 2.** Clinical view of the experimental implant being placed in the surgical site behind the conventional implant.



**Figure 3.** Radiographic view of the experimental implants (arrow).



**Figure 4.** Experimental implant retrieved after three months.

additives. They are nontoxic and contain calcium with almost no impurities. After being anodized, the experimental screws were rinsed with distilled water several times and dried.

### Surgical Procedures

The two experimental implants (one with a machined surface and the other with an anodized surface) were surgically placed in the mandibular ramus at the same time when two conventional implants were placed (3.75 x 13 mm – Porous - Conexão Dental Implants, São Paulo, SP, Brazil). Following the incision, mucoperiosteal flaps were elevated and the conventional implants were placed. The recipient sites for the experimental implants were then prepared with a 2.0 mm diameter twist drill and inserted with a screwdriver (Figures 2 and 3).

All drilling procedures and implant placement were completed under profuse irrigation with sterile saline. Flaps were sutured with single

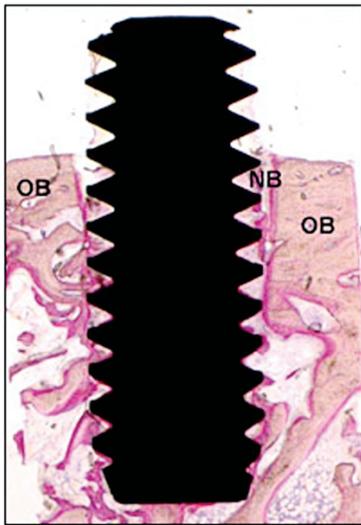
interrupted sutures, submerging all implants. Clindamycin was given twice a day for a week, in order to avoid post-surgical infection, while pain was controlled with paracetamol. The sutures were removed after ten days.

The experimental implants were removed three months later using an internal 3.25 mm wide trephine. The experimental implants together with surrounding bone tissue (Figure 4) were rinsed in sterile saline solution and fixed by immersion in 4% neutral formalin.

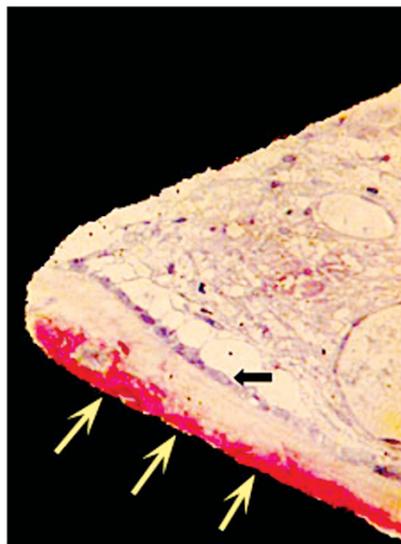
### Histological Processing and Evaluation

The experimental implants and surrounding bone tissue were processed to 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 Technovit® glycol methacrylate resin (7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned longitudinally along the major axis of the implant with a high-precision diamond disk at a thickness of approximately 150  $\mu\text{m}$  and then ground down to about 30  $\mu\text{m}$ .

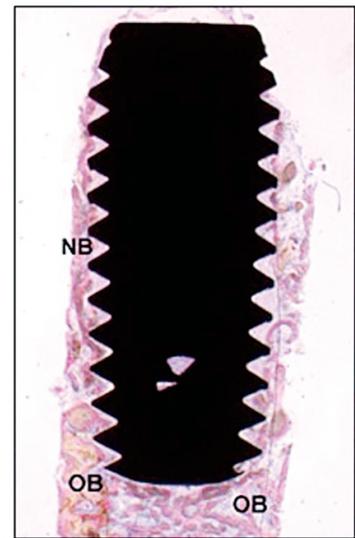
One slide was obtained for each micro-implant. Each slide was stained with basic fuchsin and toluidine blue. Histomorphometry of bone-to-implant contact percentage as well as the bone area within the limits of the implant threads were completed using a Laborlux S® light microscope (Leitz, Wetzlar, Germany) connected to a high-resolution JVC, 3CCD® video camera (JVC KY-F55B, Milan, Italy) and interfaced to a monitor



**Figure 5.** Ground section of anodized-surface screw showing old bone ( OB) and new bone (NB) (Acid fuchsin and toluidine blue, original magnification x20).



**Figure 6.** A thin layer of bone tissue in direct contact with anodized surface (yellow arrowheads) and osteoblasts (black arrow) suggesting osteogenesis of contact in the threads area (Acid fuchsin and toluidine blue, original magnification x100).



**Figure 7.** Ground section of machined-surface screw showing old bone (OB) and lack of contact between the new bone (NB) and the implant surface (Acid fuchsin and toluidine blue, original magnification x20).

and personal computer (Intel Pentium III 1200 MMX). This optical system was associated with a digitizing pad (Matrix Vision GmbH, Milan, Italy) and Image-Pro Plus® 4.5 histometry software (Media Cybernetics Inc., Immagini & Computer Snc, Milan, Italy) with image-capturing capabilities. The bone-to-implant contact and the amount of bone area within the threads (from the lowest point of the experimental implant head to the last apical thread) were calculated and expressed as a percentage of bone-to-implant contact and percentage of bone area, respectively.

### Results

The peri-implant bone from both experimental implants appeared healthy. The old bone was compact and numerous osteocytes were present in their lacunae. Areas of woven bone could also be seen (Figure 5). The newly-formed peri-implant bone exhibited early stages of remodeling and maturation mainly on the anodized surface.

In some cases osteoblasts were connected to newly formed peri-implant bone, indicating ongoing bone formation. Minor apposition of new bone could be found; specifically, inside the implant threads of the machined surface implant (Figures 6 and 7).



**Figure 8.** Ground section of the machined surface showing connective tissue (CT) between the new bone (NB) and the implant surface (Acid fuchsin and toluidine blue, original magnification x160).

In addition, some specimens of the machined surface depicted a lack of connecting bridges between the thin bone trabeculae and the implant surface (Figure 8).

Both histometric variables were higher on the anodized surface. Histometric analyses

demonstrated a bone-to-implant contact percentage of  $26.8 \pm 2.32$  for the machined surfaces and  $38.47 \pm 1.96$  for the anodized surfaces, respectively. The percentage of bone area within the threads was  $11.11 \pm 1.62\%$  for the machined surface and  $33.60 \pm 2.01\%$  for the anodized surface.

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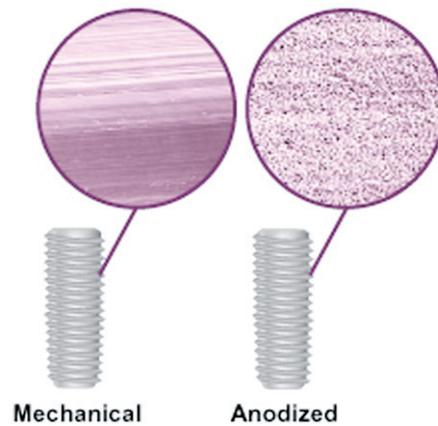
### Discussion

This single case study describes the histologic evaluation of cortical human bone on two different implant surfaces following a three month healing period. The anodized surfaced implant exhibited a higher percentage of mineralized bone contact when compared to the machined surfaced implant after initial healing.

The geometric properties of the anodized surface may produce mechanical restrictions on the cytoskeletal cell components, which are involved in the spreading and locomotion of the cells.<sup>11</sup> The proliferation and differentiation of bone cells has been reported to be enhanced by roughness of the implant topography surface.<sup>12-13</sup> It has also been suggested anodic oxidation treatment enhances early bone-implant integration to a level

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similar to that observed around the more complex surface, such as titanium plasma sprayed or hydroxylapatite coated-surface.<sup>3,5-6</sup>

The data obtained from the present case study agrees with the statement that machined surfaced dental implants do not provide a strong anchorage in bone when compared with the anodized surface.<sup>14</sup> So far, the machined surface seems to present lower degrees of bone implant contact. These results suggest machined surfaced implants placed in compromised sites with poor bone density, such as in the posterior maxilla, may present an increase in failure rates as reported in the literature.<sup>15-17</sup>

### Conclusion

This single case study suggests anodized implant surfaces results in a higher percentage of bone to implant contact when compared to machined surfaced implants when placed in dense bone tissue. However, further investigations should be conducted.

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