

Histological Evaluation of a Bimodal Titanium Implant surface . A Pilot Study in the Dog Mandible.

Luiz A Salata¹, Paulo EP Faria¹, Marconi G Tavares¹, Neil Meredith^{2,3} and Lars Sennerby⁴

¹Dept. Oral & Maxillofacial Surgery, Faculty of Dentistry of Ribeirao Preto, The University of Sao Paulo, Brasil

²University of Bristol, Bristol, UK

³Neoss Ltd, Harrogate, UK

⁴Dept Biomaterials, Institute of Clinical Sciences, Sahlgrenska Academy, Göteborg University, Sweden

This histological pilot study revealed a favourable bone tissue response to a novel bimodal titanium implant surface after four months of healing, with no apparent differences from TiO-blasted and oxidized control implants.

INTRODUCTION

New implant systems with different geometries and surface topographies are continually being launched on the market. It is important to evaluate critically each implant surface in both experimental models and in clinical follow-up studies. One prerequisite for a successful clinical outcome with osseointegrated titanium implants is secure bone integration immediately following surgery (Albrektsson et al. 1981). In essence, the surgical trauma initiates a healing process which includes the formation of a blood clot, migration and differentiation of cells, formation of a granulation tissue and, finally, bone formation and remodelling. In the presence of a titanium surface, healing results in formation of direct bone-implant contacts (BICs) and the number and extent of BICs increase with time (Johansson et al. 1987, Sennerby et al. 1993). The peak torque required to achieve implant removal increases with time in parallel with increased BICs (Johansson et al. 1987). The first generation of osseointegrated implants had either a minimally rough surface (machined/turned surface) or a very rough surface produced by titanium plasma spraying (TPS)(Brånemark et al. 1969, Schroeder et al. 1976). On the basis of further clinical and experimental research it is currently believed that moderately rough implant surfaces are preferable (Albrektsson & Wennerberg 2006); such as surfaces produced by blasting, anodic oxidation, acid etching or combinations of these techniques. Experimental research has generally demonstrated a stronger bone tissue response to surface modified implants than to smoother control surfaces, indicating more rapid integration (Albrektsson & Wennerberg 2006).

The aim of the present pilot study was to analyse the bone tissue response to a novel implant surface (Bimodal surface, Neo Implant System™) in comparison with two well-documented and commercially available implant surfaces (TiOblast™ surface and TiUnite™ surface).

MATERIALS AND METHODS

Implants

A total of eight test implants, 9 mm long and 3.5 mm in diameter (Neo Implant System™, Neoss Ltd, Harrogate, UK) (NE implants) were used in the study. These implants had a bimodal surface created by blasting with 100 to 300 µm diameter ZrO₂ spheres and subsequent blasting with irregularly shaped TiO-based particles, 75 to 150 µm wide (Fig. 1a). Eight control implants were also used; four implants with a TiO₂-blasted surface, 9 mm long and 3.5 mm in diameter (MicroThread™, AstraTech AB, Mölndal, Sweden) (AT implants)(Fig. 1b), four implants with an oxidized surface, 10 mm long and 3.75 mm in diameter (Brånemark System™, MKIII, TiUnite, Nobel Biocare Ab, Gothenburg, Sweden) (NB implants)(Fig 1c).

Animals and anaesthesia

Four mongrel male dogs weighing between 20 and 25 kg were used in the study. The animals were pre-anaesthetized with xilazine (Ronpum®, Brazil, 20 mg/Kg I.M.) and ketamine 1g (Dopalen®, Brazil, 0,8 g/Kg I.M.) and anaesthetized with thionembutal 1 g (Tiopental®, Brazil, 20 mg/Kg I.V.). The animals

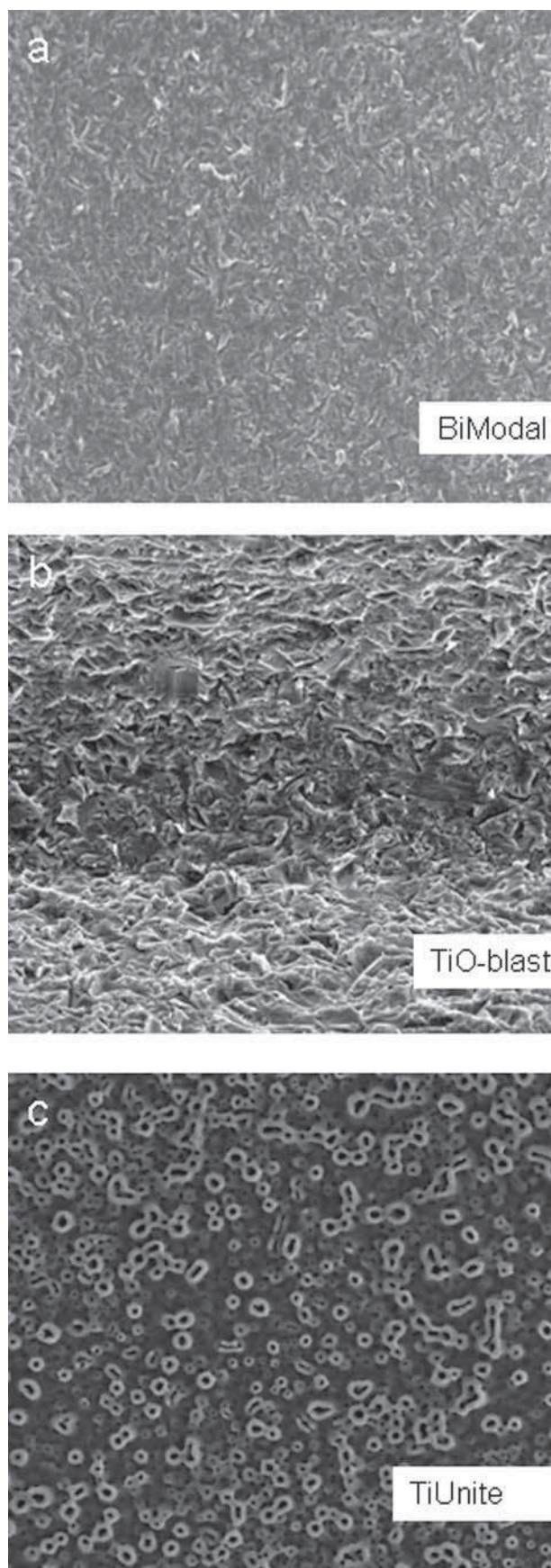


Figure 1: Scanning electron micrography (SEM) of the three surfaces evaluated; a/ Bimodal surface, b/ TiO-blasted surface, c/ Oxidized surface

were kept on intravenous infusion of saline during surgery, all of which was carried out under sterile conditions. After surgery the animals received intravenously vitamin compound (Potenay®, Brazil); an anti-inflammatory/analgesic (Banamine®, Brazil) and antibiotic (Pentabiótico®, Brazil). The antibiotic was administered in single doses immediately after surgery, and then 48 and 96 hours postoperatively. The study protocol had been approved by the University of Sao Paulo's Animal Research Ethics committee.

Experimental protocol

The mandibular premolars were extracted five months prior to commencement of the experiment. At the time of implant placement, crestal incisions were made and mucoperiosteal flaps were raised bilaterally. Two implant cavities were prepared on each site, in accordance with the manufacturers guidelines. Two NE implants were placed on one side and one each of AT and NB implants on the contra lateral side (Figs. 2a and b). Cover screws were placed and the flaps were closed and sutured.

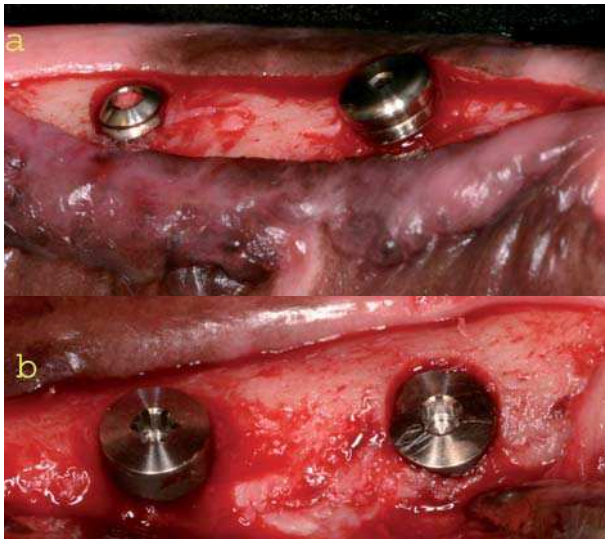
After 4 months of healing, the dogs were sacrificed and the implants with their surrounding tissues were harvested and fixed by immersion in buffered formaldehyde.

Histology

The fixed specimens were dehydrated in a graded series of ethanol and embedded in light curing methacrylate (Technovit® 7200 VCL, Kulzer, Friedrichsdorf, Germany). Ground sections approximately 10 µm thick were prepared using a sawing and grinding technique (Exakt Apparatebau®, Norderstedt, Germany) and stained with toluidine blue. One central section was taken from each implant site in the bucco-lingual direction.

The sections were examined under a Leitz microscope equipped with a Microvid system for morphometrical measurements. The degree of bone-implant contact (BIC) was measured from the first bone contact and expressed as a percentage mean total BIC. The bone area (BA) within the implant threads was measured and expressed as a mean total BA.

Figure 2. Clinical photographs showing
a/ TiO-blasted (left) and oxidized (right) implants.
b/ Bimodal surface implants.



RESULTS AND DISCUSSION

Healing was uneventful in all dogs. Some marginal bone resorption, especially on the buccal aspect, was seen for all implant types at the marginal portion which may be due to remodelling continuing after tooth extraction (Arajou et al. 2005).

Histology revealed close contact between mature bone and test implants (Figs 3). There were no apparent differences between test and control implants and new bone was observed to fill the threads of all three surfaces (Figs. 4a-c). In some areas, the presence of a thin layer of bone and an osteoblast seam facing the bone marrow indicated bone formation directly at the test implant surface (Fig. 5); as previously described for the control implant surfaces used in the study, i.e. blasted and oxidized surfaces (Ivanoff et al. 2001, Rocci et al. 2003). It has been speculated that such direct bone formation seen at surface modified implants is the result of an adherent blood clot through which mesenchymal cells can migrate and differentiate to form bone directly on the implant surface (Davies 2003).

The morphometric measurements showed no apparent differences with regard to BIC or BA as similar mean values were obtained (Fig. 5). However, few animals were used and statistics could not be applied.

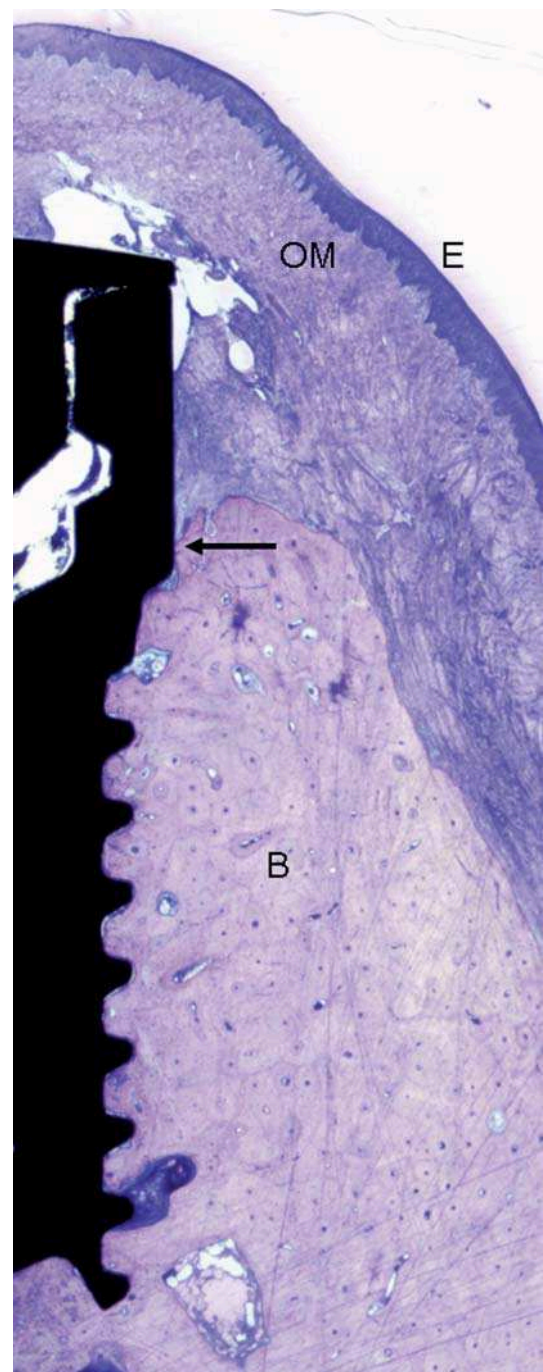


Figure 3. Light micrograph showing overview of a test implant (left) in contact with mature bone (B). The implant is covered by oral mucosa (OM) lined by an epithelium (E). The arrow points to the first bone contact.

CONCLUSION

The present pilot study revealed bone integration of the novel bimodal implant surface, with no apparent differences from TiO-blasted and oxidized control implants after four months of healing.

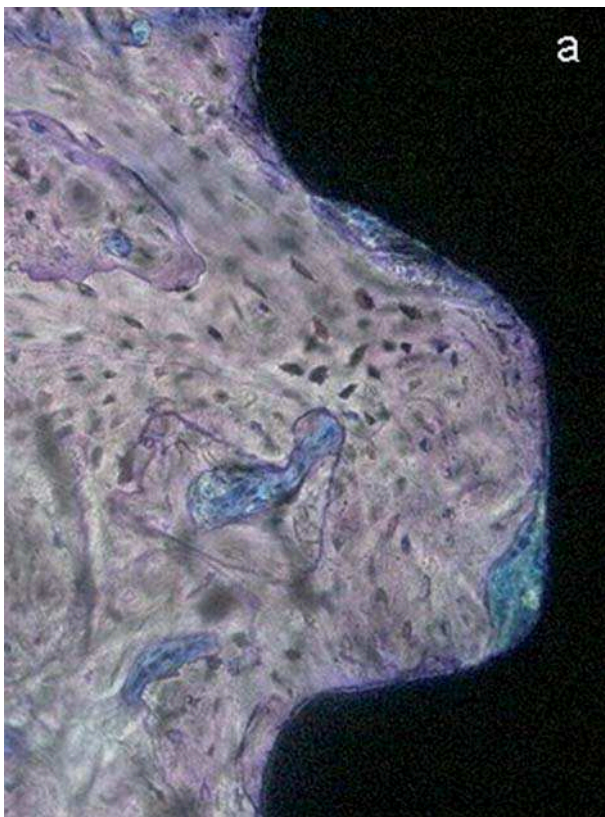


Figure 4. Light micrographs showing bone formation towards all three implant surfaces.:
a/ Bimodal surface, b/ TiO-blasted surface, c/ Oxidized surface

REFERENCES

Albrektsson T, Brånemark PI, Hansson H, Lindström J. Osseointegrated implants. Requirements for ensuring a long-lasting direct bone-to-implant anchorage in man. *Acta Orthop Scand* 1981;52:155-170

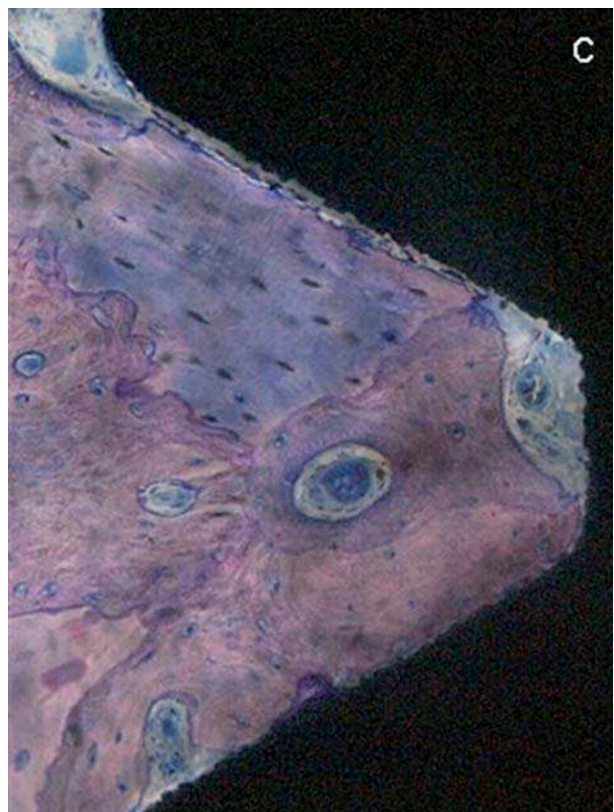
Albrektsson T, Wennerberg A. Oral implant surfaces: Part 1--review focusing on topographic and chemical properties of different surfaces and in vivo responses to them. *Int J Prosthodont*. 2004;17:536-43.

Araujo MG, Sukekava F, Wennstrom JL, Lindhe J. Ridge alterations following implant placement in fresh extraction sockets: an experimental study in the dog. *J Clin Periodontol*. 2005;32:645-52.

Branemark PI, Adell R, Breine U, Hansson BO, Lindstrom J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. *Scand J Plast Reconstr Surg*. 1969;3(2):81-100.

Davies JE, Hosseini MM. Histodynamics of endosseous wound healing. In Davies, JE (ed) *Bone engineering*. Em squared incorporated, Toronto 2000, pp1-14

Davies JE. Understanding peri-implant endosseous healing. *J Dent Educ* 2003;67:932-949



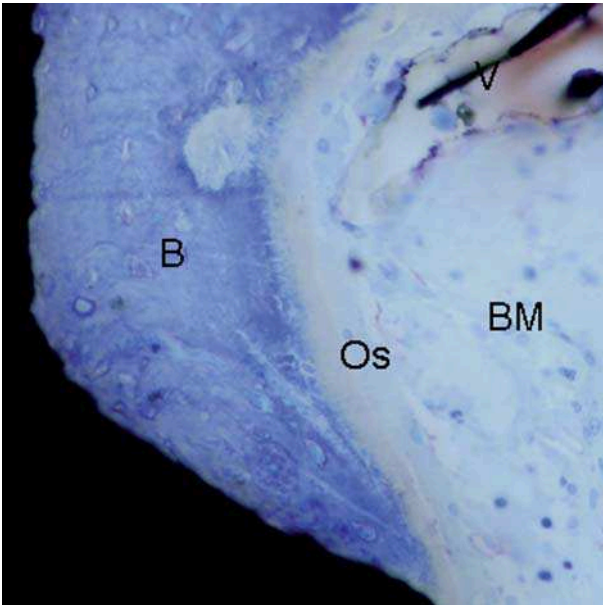


Figure 5. Light micrograph of a bimodal implant surface (I). Bone (B) is formed from the surface and towards the bone marrow (BM). Os = osteoid, V= vessel

Ivanoff CJ, Hallgren C, Widmark G, Sennerby L, Wennerberg A. Histologic evaluation of the bone integration of TiO(2) blasted and turned titanium microimplants in humans. Clin Oral Implants Res. 2001;12:128-34.

Johansson C, Albrektsson T. Integration of screw implants in the rabbit: a 1-year follow-up of removal torque of titanium implants. Int J Oral Maxillofac Implants. 1987;2:69-75.

Rocci A, Martignoni M, Burgos PM, Gottlow J, Sennerby L. Histology of retrieved immediately and early loaded oxidized implants: light microscopic observations after 5 to 9 months of loading in the posterior mandible. Clin Implant Dent Relat Res. 2003;5 Suppl 1:88-98.

Schroeder A, Pohler O, Sutter F. [Tissue reaction to an implant of a titanium hollow cylinder with a titanium surface spray layer] SSO Schweiz Monatsschr Zahnheilkd. 1976;86:713-27.

Sennerby, L., Thomsen, P. and Ericson, L.E. Early bone tissue response to titanium implants inserted in rabbit cortical bone. I. Light microscopic observations. J Mat Sci: Mat Med 1993; 4:240-250

Figure 6. Results from morphometrical measurements of BIC and BA.

