

# Influence of a zirconia sandblasting treated surface on peri-implant bone healing: An experimental study in sheep

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## Abstract

A sandblasting process with round zirconia ( $ZrO_2$ ) particles might be an alternative surface treatment to enhance the osseointegration of titanium dental implants. Our previous study on sheep compared smooth surface titanium implants (control) with implant surfaces sandblasted with two different granulations of  $ZrO_2$ . As the sandblasted surfaces proved superior, the present study further compared the  $ZrO_2$  surface implant with other surface treatments currently employed: machined titanium (control), titanium oxide plasma sprayed (TPS) and alumina sandblasted (Al-SL) at different times after insertion (2, 4 and 12 weeks). Twelve sheep were divided into three groups of four animals each and underwent implant insertion in tibia cortical bone under general anaesthesia. The implants with surrounding tissues were subjected to histology, histomorphometry, scanning electron microscopy and microhardness tests. The experimentation indicated that at 2 weeks Zr-SL implants had the highest significant bone ingrowth ( $p < 0.05$ ) compared to the other implant surfaces, and a microhardness of newly formed bone inside the threads significantly higher than that of Ti. The present work shows that the  $ZrO_2$  treatment produces better results in peri-implant newly formed bone than Ti and TPS processing, whereas its performance is similar to the Al-SL surface treatment.

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## 1. Introduction

Materials science has developed various materials and treatments to enhance implant osseointegration: geometric implant design, chemical composition, surface roughness, ion release, charge and specific energy of the implant are major factors positively influencing osseointegration [1–5]. Titanium is still the most commonly used material for dental implants on account of its good mechanical properties, lack of cellular toxicity and inflammatory response in the peri-implant tissues.

Several metal implant surface modifications have been developed: passivation, anodization, ion implantation, roughness, texture and glow discharge. Among them, texturing and roughness techniques, such as plasma spraying, sandblasting and acid etching, are used to increase the surface area of an implant up to five or sixfold, providing a greater potential for interlocking with bone [6–10].

The powders most commonly used for blasting rough-surface dental implants are those made of  $Al_2O_3$  with a granulometry ranging between 25 and 500  $\mu m$  [11–13]. The biological effect of surface contamination by residual blasting alumina particles is a matter of controversy. Some authors claim that the presence of the alumina may be responsible for the observed tissue breakdown and procedures avoiding

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alumina blasting are recommended as a precautionary measure [14]. By contrast, other experimental studies failed to support the hypothesis that residual blasting aluminum particles influence the osseointegration of titanium dental implants [15]. To overcome the potential risks of any contaminants and at the same time increase the surface area, blasting particles of different materials have been used, such as those of titanium dioxide ( $\text{TiO}_2$ ), fluorohydroxyapatite (HA), or blasting processes followed by HA coating or acid etching, or biphasic calcium phosphate ceramic grit-blasted (BCP-Ti) [16].

Although  $\text{Al}_2\text{O}_3$  is the most widely used material in the family of engineering ceramics,  $\text{ZrO}_2$  is suitable by virtue of its hardness and resistance to wear [17]. Guizzardi et al. [18] showed that even in the presence of processing residues  $\text{ZrO}_2$  sandblasting titanium surfaces better influenced *in vitro* human mandible osteoblast metabolic activity than other treatments as they induced a faster proliferation rate with a high phenotype differentiation. An *in vivo* study by the present authors showed that in the early period of healing (2 weeks),  $\text{ZrO}_2$  sandblasted titanium implants, versus Ti implants, seemed to influence both the increase in peri-implant osteogenesis and the rate of mineralization [19].

The purpose of the present study was to evaluate further *in vivo* the efficacy of  $\text{ZrO}_2$  sandblasting in comparison with other surface treatments currently used –  $\text{Al}_2\text{O}_3$  sand-

blasting and titanium plasma spraying – to improve the osseointegration of titanium endosseous dental implants at short- and medium-term experimental times.

## 2. Materials and methods

### 2.1. Implant design and surface characterization

Conical screw-shaped self-tapping endosseous implants, made of commercially pure titanium (grade II – ISO 5832-2, CpTi) (Or-Vit, Castelmaggiore, Bologna, Italy) with an intraosseous portion 8.0 mm in length and 4.0 mm in outer diameter were used. One hundred and sixty fixtures were configured with 4 different surface designs. Forty implants with a turned surface (Ti) (figure not shown) were used as controls, while the other 120 fixtures were used as substrates for different surface treatments. Forty Ti implants were plasma-spray coated in vacuum (TPS) (figure not shown) with CpTi obtaining a macro-roughened surface. At 2.5 atm for 1 min, 40 Ti implants were sandblasted (Al-SL) with sharp  $\text{Al}_2\text{O}_3$  grit (250–500  $\mu\text{m}$ ) (Fig. 1a) and the other 40 (Zr-SL) with  $\text{ZrO}_2$  beads (60–200  $\mu\text{m}$ ) (Fig. 1b), thus forming micro-roughened surfaces (Fig. 1c and d). All the implants were cleaned and degreased by a detergent solution in an ultrasound bath (30 °C for 30 min), rinsed in distilled water (30 °C for 30 min), air-dried at 50 °C for 30 min and then at 180 °C for 60 min. Finally all the implants were

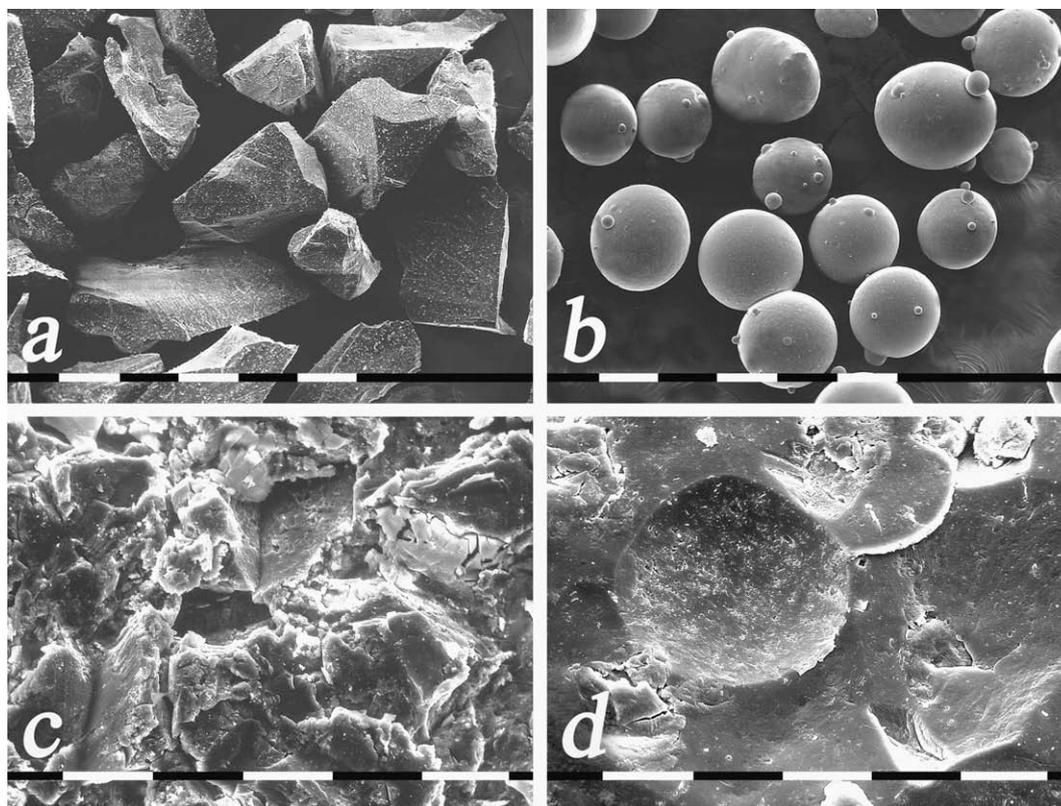


Fig. 1. SEM micrographs. (a)  $\text{Al}_2\text{O}_3$  prismatic sharp particles and (b)  $\text{ZrO}_2$  round particles: bar = 100  $\mu\text{m}$ . Microroughness of the sandblasted surface of the Al-SL (c) and of the Zr-SL (d) implants: bar = 10  $\mu\text{m}$ .

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