Accepted for publication in **"The Journal of Prosthetic Dentistry"**
February 02, 2021. DOI: https://doi.org/10.1016/j.prosdent.2020.11.015

Implants of distinct material and surface treatments all lead to similar osseointegration results

Physical Characterization of 3 Implant Systems Made of Distinct Materials with Distinct Surfaces

João Pimenta, DDS, DMD[1], Serge Szmukler-Moncler, DDS, PhD[2], Ariel Raigrodski, DMD, MS[3]

Abstract

Statement of problem: Dental implants undergo various surface treatments. Studies that have characterized their surface and subsurface by using the same methods are scarce.

Purpose: to physically characterize the surface and subsurface of implant systems made of commercially pure titanium grade 4 and Ti alloy grade 23 and to evaluate whether airborne-particle abrasion and acid etching is an appropriate surface treatment for Ti alloy gr 23.

Material and methods: Implant groups (n=3) were as follows: TG4AO, cp Ti gr 4, treated with anodic oxidation (3.5×8 mm) (NobelReplace Conical; Nobel Biocare); TG23AE, Ti gr 23 (TiAlV ELI) airborne-particle abraded-and-etched (3.9×8 mm) (V3; MIS); and TG4AE, cp Ti grade 4, airborne-particle abraded and etched (3.3×8 mm) (BL; Institut Straumann). Surface roughness, surface topography, and elemental and surface composition were investigated with optical profilometry, scanning electron microscopy, energy dispersive X-ray spectroscopy, and X-ray diffraction. The presence and size of Ti hydride (TiH) needles were determined on metallographic sections. Depth profiling was obtained by time-of-flight secondary ion mass spectrometry (ToF-SIMS) to determine possible enrichment of an alloying element at the implant surface.

Results: The mean arithmetic deviation roughness (S_a), of TG4AO was 0.80 µm. The S_a of TG4AO was 1.22 µm, and the S_a of TG4AO was 1.59 µm. The difference between the groups was significant (P<.001). TG23AE and TG4AE displayed a macrotexture and microtexture with pores; TG4AO showed a 3-to 12-µm canyon-like structure. The surface and subsurface compositions were as follows: for TG4AO, αTi and phosphorus-rich anatase; for TG23AE, α-Ti matrix with β-Ti grains; and for TG4AE, α-Ti and δ-TiH_{2-x}. TiH needles

were found only on TG4AE; the Ti oxide layer of TG4AO was rough, 3-to 16-µm thick, and porous. The time-of-flight secondary ion mass spectrometry (ToF SIMS) concentration profile of TG23AE did not show enrichment of any alloying element.

Conclusions: The roughness, topography, and composition of the surfaces were different for all implants tested. Airborne-particle abrasion and subsequent etching was an appropriate treatment for Ti gr 23 alloy implants.

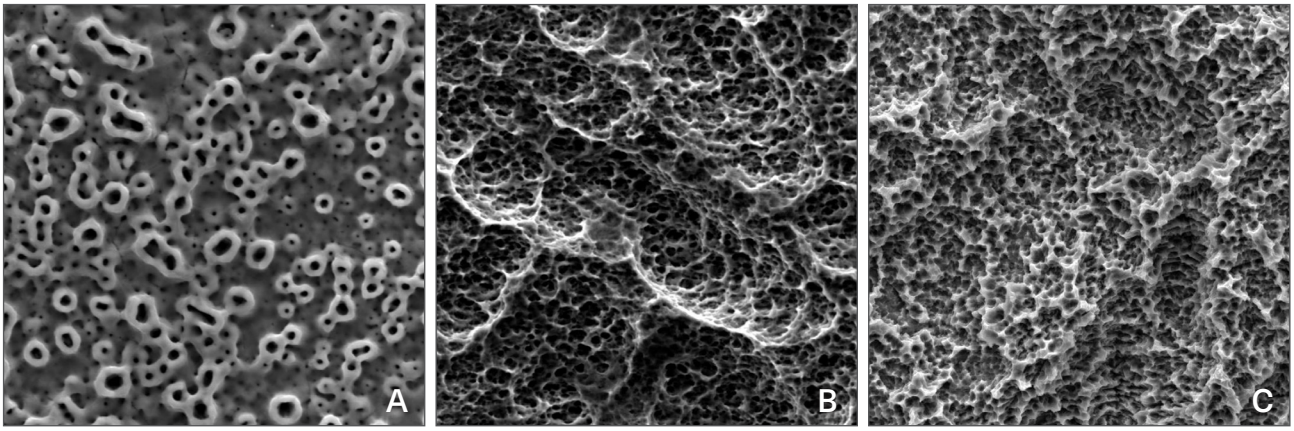

Figure 1. Surface characteristics of implant of each of groups tested. A, Close view of TG4AO. Note random distribution of canyon-like structure with craters and cracks running over the oxide layer (original magnification ×2000, bar=50 µm). B, Close view of TG23AE. Micropores carved by acid on top of macrostructure produced by airborne-particle abrasion (original magnification ×2000, bar=50 µm). C, Close view of TG4AE. Superimposed micropores on top of macrotextured surface appear numerous and sharp.

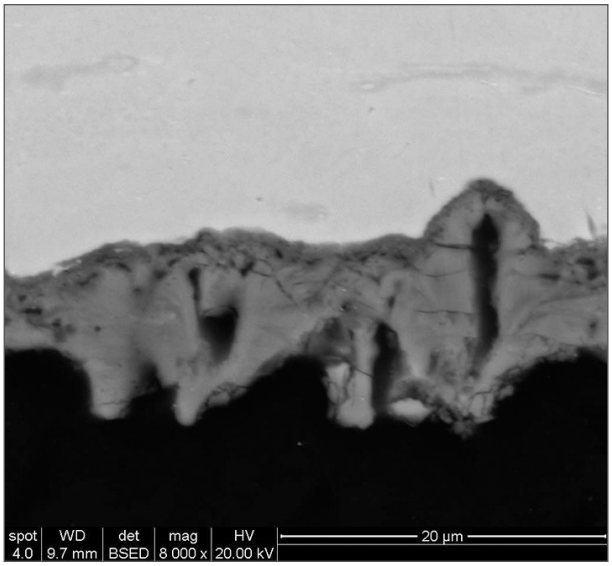

Figure 2. Backscattered scanning electron micrographs of metallographic sections of TG4AO. Original magnification ×8000. Oxide layer darker than Ti bulk material, indicating that atomic weight (or Z-contrast information) of oxide is below that of Ti bulk material. Darker image indicates lighter material providing signal. Thickness of oxide layer uneven, from approximately 3 to 12 mm. Canyon-like structure delimits craters for possible bone ingrowth. Oxide porous and cracks running in grown anatase.

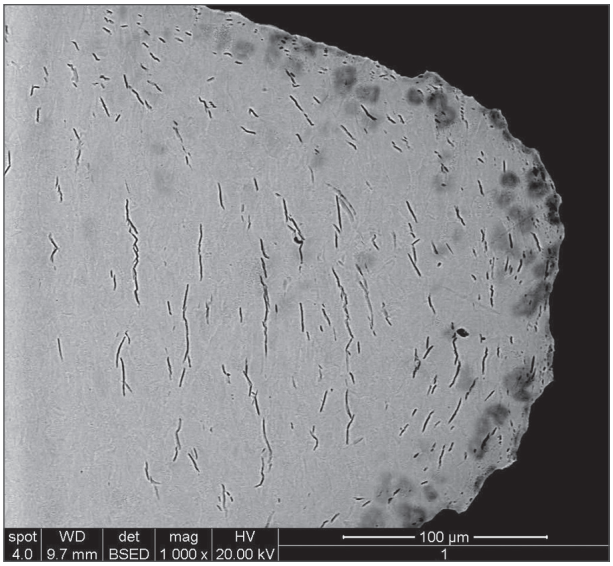

Figure 3. Backscattered scanning electron micrographs of metallographic sections of TG4AE after etching. Original magnification ×1000. Various sizes of TiH needles, shorter when closer to implant surface.

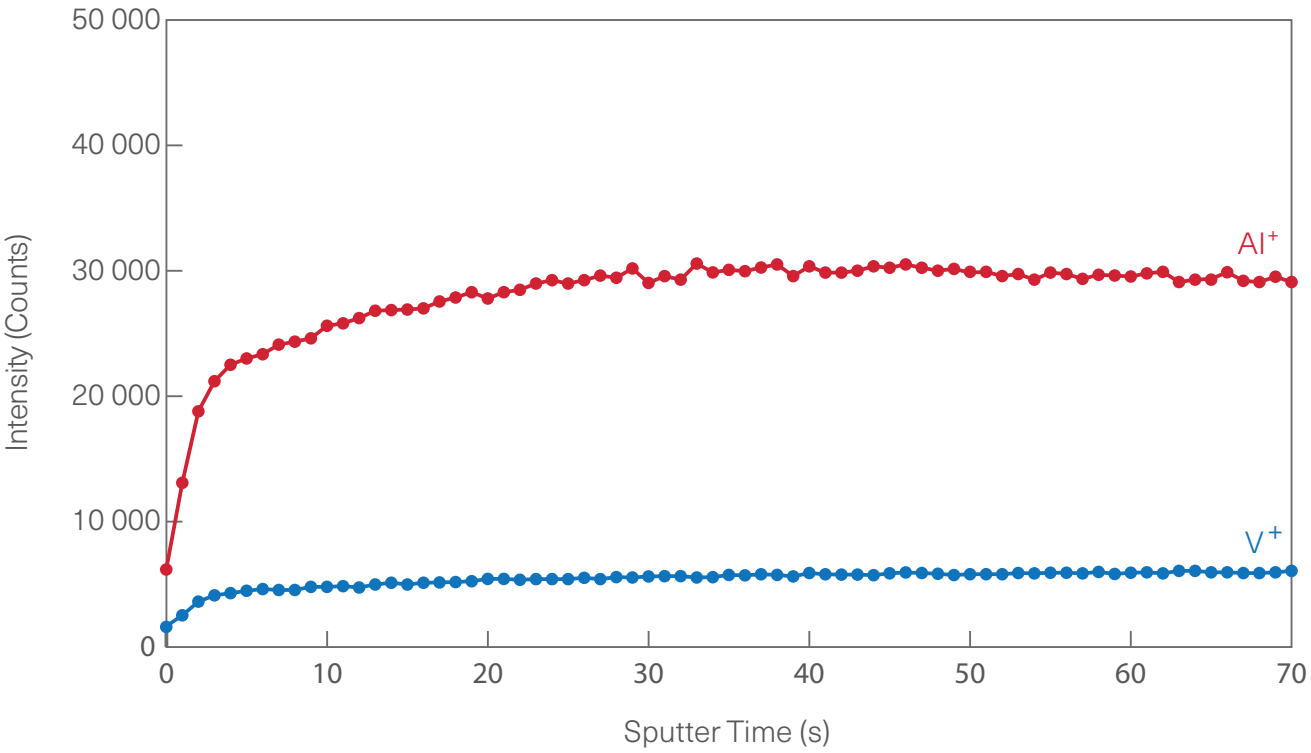

Figure 4. Time-of-flight secondary ion mass spectrometry depth profiling of Al and V. Note concentration reduction of Al+ and V+ from bulk toward surface. No Al or V signal augmentation close to surface or within oxide layer.

Authors' affiliations

[1]Private practice, Barcelos, Portugal.

[2]Director of Research, MIS Implants Technologies, Bar Lev Industrial Park, Misgav, Israel.

[3]Professor, Department of Restorative Dentistry, University of Washington School of Dentistry, Seattle, Wash.