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SURFACE CHARACTERISTICS AND *IN VITRO* BIO-ACCEPTABILITY OF MACHINED AND CAST PURE TITANIUM AND TITANIUM ALLOY

BY

LORNA CELIA CARNEIRO

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Promotor

Prof Dr SJ Botha
Centre of Stomatological Research
School of Dentistry, University of Pretoria.

Co-Promotor

Prof Dr PL Kemp
Department of Prosthetics
School of Dentistry, University of Pretoria

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DECLARATION

I, Lorna Celia Carneiro, declare that this thesis entitled:

"Surface Characteristics and *In Vitro* Bio-acceptability of Machined and Cast Pure Titanium and Titanium Alloy"

which I herewith submit to the University of Pretoria for the Degree of Philosophiae Doctor in Dentistry, is my own original work, and has never been submitted for any academic award to any other tertiary institution for any degree.

2003
Date

Lorna Celia Carneiro

Die verklaarder erken dat hy/sy ten volle op hoogte is van die inhoud van hierdie verklaring en dit begryp. Hierdie verklaring was beë-dig/bevestig voor my.	The deponent has acknowledged that he/she knows and understands the contents of this affidavit which was sworn to/affirmed before me.
Landdrosdistrik/Magisterial District Kom. van Ede/Com. of Oaths PRETORIA	DANIEL PIETER BOTHA Asst. Registrateur/Registrar Univ. van/of Pretoria Datum 28/01/03 Date

DEDICATION

My late brother-in-law

Agnelo

My parents

My husband

Primo

Our children

Ryan, Elton and Michael

Commit to the LORD *whatever you do, and your plans will succeed*

Proverbs 16:3

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SUMMARY

Properties making Ti and its alloys popular implant materials are determined by manufacturing conditions. With introduction of cast Ti into the dental fraternity, alternative methods of implant fabrication are possible. This study determined and compared differences in bio-acceptability between surface characteristics of machined and cast Ti and Ti-alloy in relation to materials used, fabrication procedure employed, surface enhancements and Radio Frequency Glow Discharge Treatment (RFGDT). Discs of 6.35mm diameter, 2mm thick, were prepared using cpTi and Ti6Al4V by machining and casting, and specific topographies were introduced. The first group of surfaces was from machining and casting procedures (controls). The second group was surfaces enhanced according to proprietary specifications of Southern Implants (SI). The third group was experimentally enhanced surfaces (ES). Enhancement included grit blasting and acid etching. From each group 21 of 24 samples were RFGDT. Electron Spectroscopy and Profilometric analysis of the Ti surfaces determined chemical composition, oxide thickness and surface roughness. Growth of human gingival fibroblasts and osteoblast-like cells, and scanning electron microscopy (SEM) determined *in vitro* bio-acceptability of different samples. Surface chemical composition was the same for cpTi and Ti6Al4V samples. Cast and enhanced samples were different from machined samples with higher % concentration of Sodium and Aluminium ($p<0.05$). RFGDT reduced Carbon and other surface contaminants and enhanced the Oxygen and Titanium atomic % concentration ($p<0.05$). The Sodium and Aluminium atomic % concentration was not affected. The major surface peak was TiO_2 for Ti and oxygen peaks varied considerably between machined and cast samples. Surface topography of cast samples had higher surface analysis values compared to machined samples ($p<0.05$). RFGDT increased surface area and Rp values ($p<0.05$). No significant differences in oxide thickness were observed between materials employed, but it was significantly higher for cast and enhanced samples. RFGDT significantly increased oxide thickness of samples. Fibroblasts showed significant increases in % attachment efficiency and proliferation (%AEP) with time while osteoblast-like cells showed a significant decrease with time. The %AEP of fibroblasts and osteoblast-like cells on different samples was not significantly different. Cast Ti6Al4V control and machined Ti6Al4V SI samples had relatively higher %AEP for osteoblast-like cells than the control or other samples. SEM revealed that fibroblasts and osteoblast-like cells displayed similar attachment behaviour. On machined surfaces cells spread, displaying the underlying topography while on cast and enhanced surfaces cells attached to the available peaks and used these attachments to suspend themselves over the surface. Filopodia were responsible for the attachment of cells. Significant differences in chemical composition were introduced by casting and surface enhancement procedures. RFGDT significantly reduced the concentration of Carbon and other contaminants on the surface exposing the surface Titanium oxide. Cast samples had rougher surface topography than machined samples. RFGDT significantly increased surface area and peak height. Casting, surface enhancement and RFGDT significantly increased oxide thickness. With time fibroblasts showed significant increases in %AEP while osteoblast-like cells significant decreases. Fibroblasts tended to proliferate on relatively smooth surfaces whereas osteoblast-like cells favored rougher surface topography produced by casting and surface enhancement.

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