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CLSM Analyzes and Ultramorphological Surface Pattern of Mucosal Titanium Implant Interfaces

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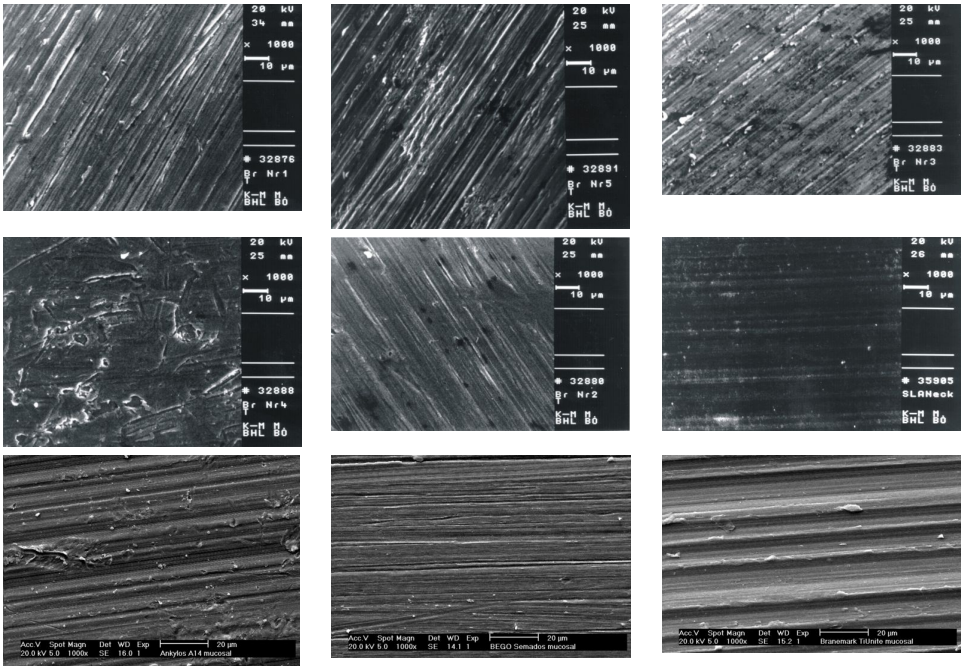
Introduction

There are several studies concerning the similarities and the differences between the oxide on different cp Ti-surfaces. However, their biological sequelae are not entirely known. Maintaining the integrity of mucosal/implant surfaces-compartment presents a unique problem to the supportive periodontal therapy for preventing periimplantitis. The aim of this study was to investigate the microstructure of cp titanium implants in their transmucosal area. Surface topography and chemical composition of mucosal-implant interfaces is thougt to be critical to their clinical success.

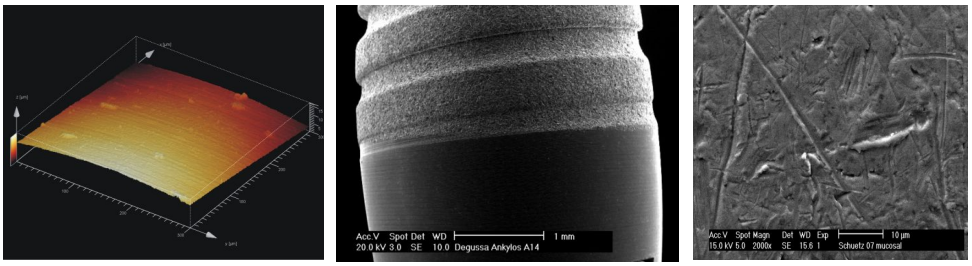
Objectives

The aim of our study was to investigate the topography and chemical composition of titanium mucosal-implant interfaces using surface analytical techniques (CLSM, MIES, SEM, SFM).

SEM analyzes



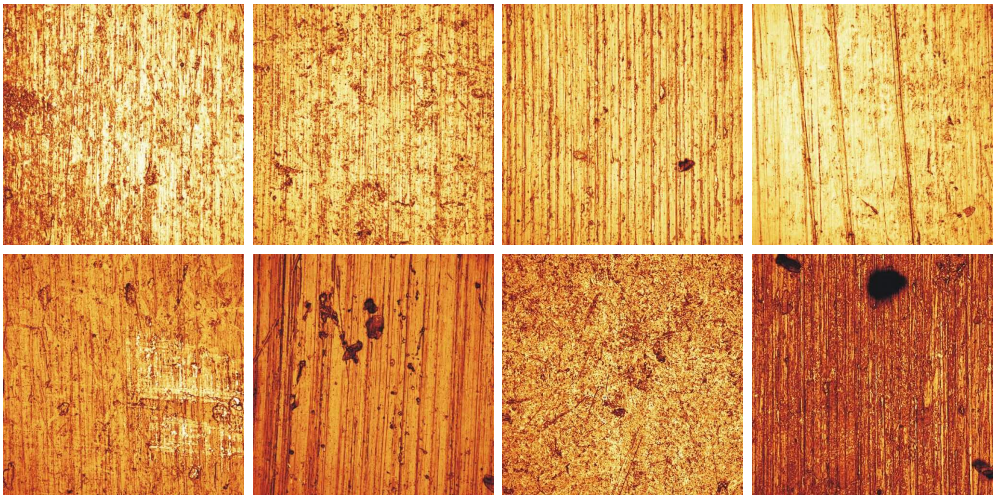
Samples of investigated mucosal titanium implant surfaces as CLSM- and SEM-images



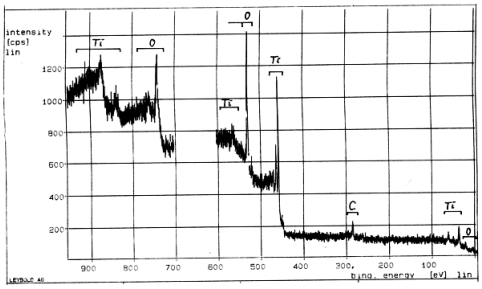
Material and Methods

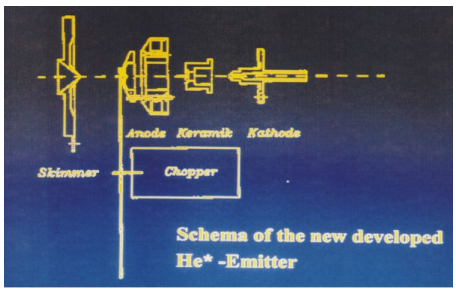
The mucosal surface compartments of 10 different implant systems were utilized as a test area. The ultramorphological analyzes was carried out using Confocal Laser Scanning Microscopy (CLSM), Metastable Induced Electron Spectroscopy (MIES), Scanning Electron Microscopy (SEM) and Scanning Force Microscopy (SFM).

Confocal Laser Scanning Microscopy (CLSM)

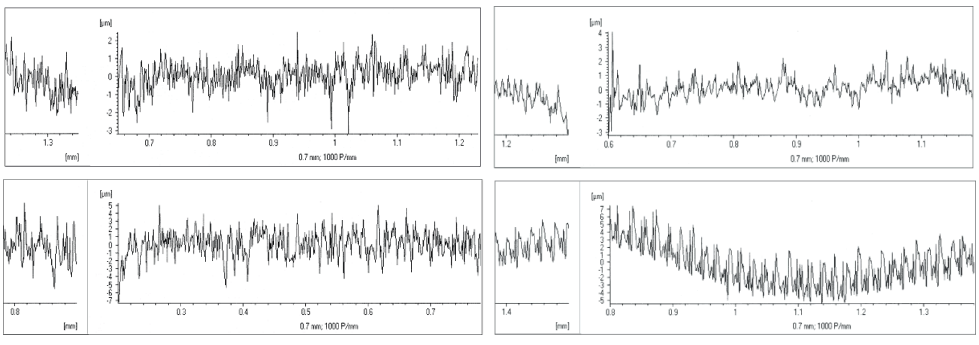


Metastable Induced Electron Spectroscopy (MIES):
The analysis was carried out with the AN 10/25S Link Analytical (Oxford) and the Leybold instrument MAX 100 equipped with especially developed He*-source.

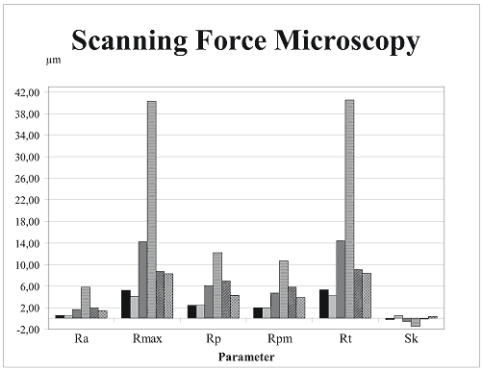




XPS clearly showed the presence of Ti, O and C. Considerable surface contaminations were detected. In particular, high levels of carbon (C) contaminants were detected.
The top surface of organic adlayer is composed of hydrocarbons, exclusively. A XPS derived concentration depth profile reveals the carbon concentration to be constant within a depth range of about 9Å. Beyond the depth of 9Å the carbon concentration decreases. Simultaneously, Ti emerges accompanied by a strong rise of O concentration, obviously not only referring to the TixO, but predominantly to the O containing moieties (COO-,SO_4-,OH). After removal of the organic adlayer using soft sputtering with He+ ions O is only present in the oxidic state, forming TiO_2. The greater thickness of CH_2-layers and the relatively high content of O_2 in between of CH_2-layer and TiO_x-layers of Ti Grade 4 may explain the observed differences in bacterial adhesion studies between different conditioned Ti surfaces under in vivo conditions .



Scanning Force Microscopy
(Microfocus UBM):
- 3-5 mW
- wave length 780nm LED, light emiting diode
- working distance ca. 2mm
- scanning speed ca. 1,2 kHz
- 6 different kinds of micro-roughness: Ra, Rt, Rmax, Rp, Rpm, Sk.



Results

(1) The SEM analyzes of the surfaces showed different fracturing of metal chips and pitting attack.
(2) It is suggested that the light particles that were formed during turning and are loosely bonded to the surface.
(3) From the CLSM and Scanning Force Microscopy analyzes it appears that the diameter of the pits varied in the range of approximately 0,1 to 10 µm.
(4) The results of the MIES analyzes suggest that the inner layer has a structure close to TiO_2, while the outerlayer is dominated by CH_2-groups with a few -C=O groups inside the hydrocarbon overlayer.
(5) Our spectra give clear evidence that only titanium in the oxidic, not in the metallic state is found within the observation depth of 10 Ångstroms.
(6) The detailed analyzes of the spectra assign the dominant part of the carbon signal to -CH_2- groups (polyethylen) whereas a small fraction of the signal is due to carbon atoms near either oxygen or other oxidizing species like halogens. As no traces of halogen were found we conclude that this feature is caused by oxygen forming, C=O groups.

Conclusions

The results suggest a two-layer structure for the passive film to be formed on titanium after exposition to the sulcus crevicular fluid.
The oxide layer on the surface of titanium implants is thougt to be critical to their clinical success.
The granular structure observed on mucosal-implant surfaces seems to indicate that the dissolution occurs at localized defects in the passive film influencing the barrier function of implanto-gingival tissues.
The mucosal/implant surfaces-compartment should form a seal at the soft tissue interface to ensure the integrity of the integument.

Acknowledgment:
The authors thank the following individuals for their input and expert technical assistance in SEM, MIES and CLSM analysis: Prof. Dr. Duschner and Dipl.-Phys. Götz, Applied Structure- and Microanalysis, University of Mainz, OÄ Dr Schmitz, Pathology, Bochum University, Dr. Heinz, Institute of Experimental Physics, University of Witten/Herdecke, Germany

Abbreviations

CLSM = Confocal Laser Scanning Microscopy
MIES = Metastable Induced Electron Spectroscopy
SEM = Scanning Electron Microscopy
SFM = and Scanning Force Microscopy

This Poster was submitted by Univ.-Prof. Dr. med. dent. habil. Wolf-Dieter Grimm.

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Poster Faksimile:

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[1]University of Witten/Herdecke, [2]Leipzig University, Germany,

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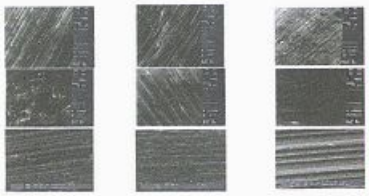

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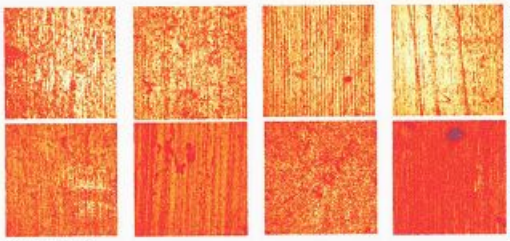

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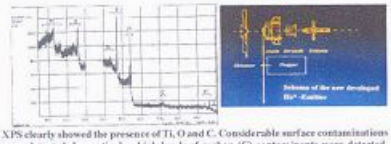

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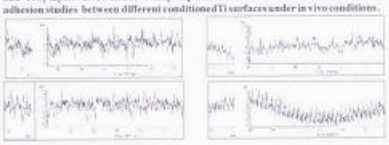

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