322

Cell functions of human alveolar bone osteoblasts and gingiva fibroblasts on y- and ce-stabilized zirconia with different surface topographies

Brigitte Altmann[1], Thorsten Steinberg[2], Kerstin Rabel[2], Erik Adolfsson[3], Falk Bernsmann[4], Laura Montanaro[5], Tobias Fürderer[6], Jerome Chevalier[7], Ralf-Joachim Kohal [1]

[1]Department of Prosthodontic Dentistry, [2]Department of Oral Biotechnology, Center for Dental Medicine, University Medical Center Freiburg, Freiburg, Germany, [3]Swerea IVF AB, Mölndal, Sweden, [4]NTTF Coatings GmbH, Rheinbreitbach, Germany, [5]Politecnico di Torino, Torino, Italy, [6]DOCERAM Medical Ceramics GmbH, Dortmund, Germany, [7]University of Lyon, INSA-Lyon, Lyon, France

Background and Aim

In order to reduce the sensitivity of zirconia-based materials to low temperature degradation, a new ceria-stabilized zirconia was developed. Furthermore, different surface treatments were applied to the new zirconia biomaterial to improve soft tissue and osseointegration.

The present study aimed at investigating distinct cell functions of primary human alveolar bone osteoblasts (ABO) and gingiva fibroblasts (GF) on a new ceria-stabilized zirconia (Ce-TZP) with different surface topographies in comparison to conventional yttria-stabilized zirconia (Y-TZP).

Methods and Materials

Surfaces of the Ce- and Y-TZP-based biomaterials were analyzed by scanning electron microscopy (SEM) and interferometry (IFM). Cell culture evaluation was performed using fluorescence-based actin cytoskeleton staining for morphometry, alamarBlue metabolic assay and DNA quantification for estimation of cell proliferation.

Results

Surface characterization of zirconia-based materials

Ce- and Y-TZP disks displayed different surface topographies (Fig. 1), characterized by S_a values ranging from 0.33 to 0.68 µm for rough and 0.19 µm for smooth surfaces (Tab. 1).

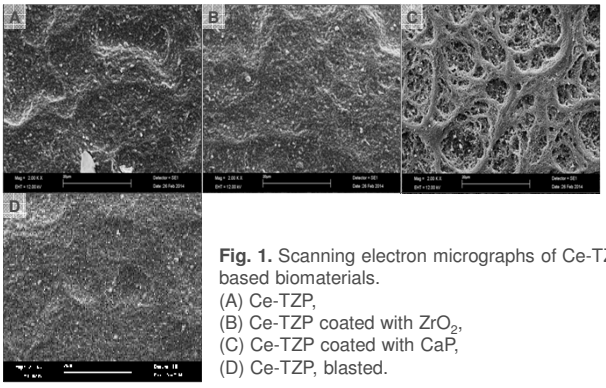

Fig. 1. Scanning electron micrographs of Ce-TZP-based biomaterials.
(A) Ce-TZP,
(B) Ce-TZP coated with ZrO_2,
(C) Ce-TZP coated with CaP,
(D) Ce-TZP, blasted.

Tab. 1. Surface evaluation of implant biomaterial surfaces by IFM. S_a (average surface height deviation amplitude), S_{ds}(number of peaks per area) and S_{dr} (surface enlargement compared to a totally flat reference area).

	S_a [µm] ± SD	S_{ds} (1/µm²) ± SD	S_{dr} (%) ± SD
Osteoblasts			
Y-/Ce-TZP	0.33 ± 0.02	0.15 ± 0.01	10.33 ± 4.79
Y-/Ce-TZP + ZrO_2	0.19 ± 0.07	0.14 ± 0.00	4.34 ± 1.45
Y-/Ce-TZP + CaP	0.32 ± 0.06	0.16 ± 0.01	12.07 ± 3.88
Y-/Ce-TZPb (blasted)	0.68 ± 0.21	0.13 ± 0.02	12.86 ± 5.84
Fibroblasts			
Ce-TZPr (rough)	0.32 ± 0.07	0.15 ± 0.01	12.67 ± 9.75
Ce-TZPs (smooth)	0.21 ± 0.09	0.10 ± 0.02	5.12 ± 2.99

Biological evaluation of zirconia-based materials

Initial cell attachment of ABO was affected by surface topography, yielding more elongated and spread cells on smooth surfaces when compared to rough Ce- and Y-TZP disks (Fig. 2).

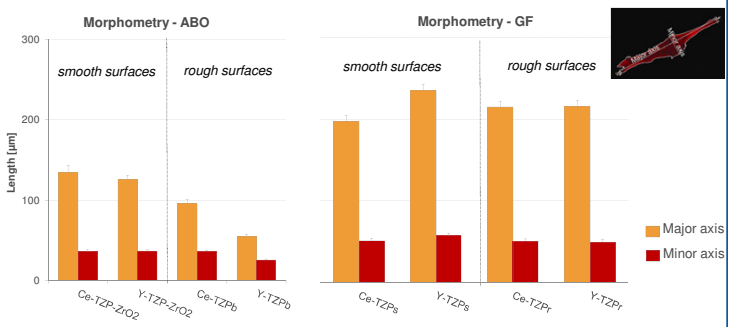

Fig. 2. Quantitative morphometric analysis of ABO and GF morphology on representative smooth an rough surfaces after 24 h culture.

alamarBlue assay and DNA quantification (Fig.3) showed that at early culture periods proliferation of ABO and GF was comparable on all differently structured surfaces. During continuous cultivation, ABO proliferation seemed then to be modulated by the surface properties, while GF cells remained unaffected.

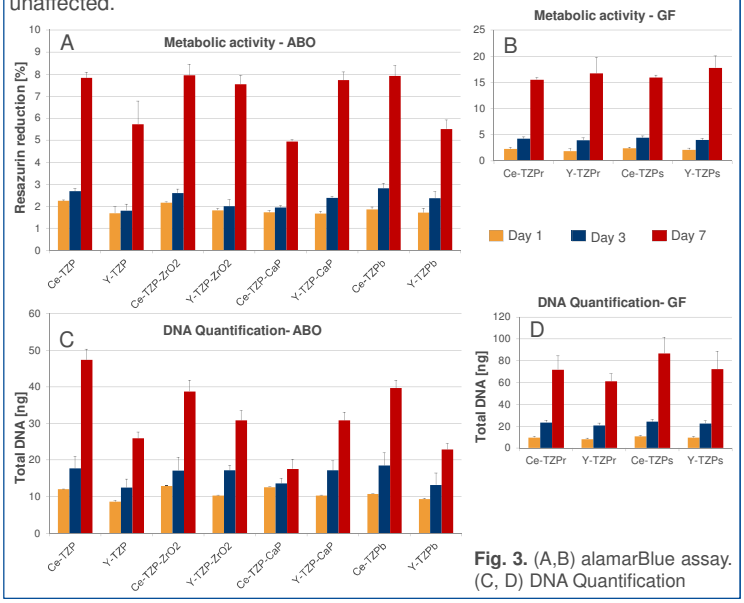

Fig. 3. (A,B) alamarBlue assay. (C, D) DNA Quantification

Conclusions

The results revealed that the new Ce-TZP composite is non-toxic for cells derived from periodontal tissues, and thus represents a promising material for prospective dental implants. In addition, our data show that cell function modulation by surface topography is not only a function of culture time, but also depends on cell type, namely alveolar bone osteoblasts or soft tissue gingiva fibroblasts.

This study was supported by the European Commission (FP7-280741-LONGLIFE Collaborative project).

Presented at the 23rd Annual Scientific Meeting of the European Association for Osseointegration 25-27 September 2014, Rome, Italy