6th International CAMLOG Congress, June 9–11, 2016 in Krakow, Poland

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Funded by:
Bundesministerium für Wirtschaft und Technologie

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White ceramized implants and abutments to optimize the aesthetic outcome and improvement of hard and soft tissue management: an *in vitro*-study

Introduction

Dental implant restoration has become a routine procedure with high success rates. The dental prosthesis consists of three parts: implant, abutment and crown. The transition zone of the implant and the abutment as a connecting element from the gingiva to the crown may be visible when replacing incisors or cuspid teeth. This may display an aesthetic disadvantage. Ceramization through a novel plasma electrolytic oxidation (PEO) technique of the transition zone which then mimics natural tooth color may be a solution for this problem. This study describes the production of the novel surface as well as its cytocompatibility and cellular attachment *in vitro*. Fig. 1 and fig. 2 depict the concept and the novel surface.

Fig. 1: SEM image of an abutment

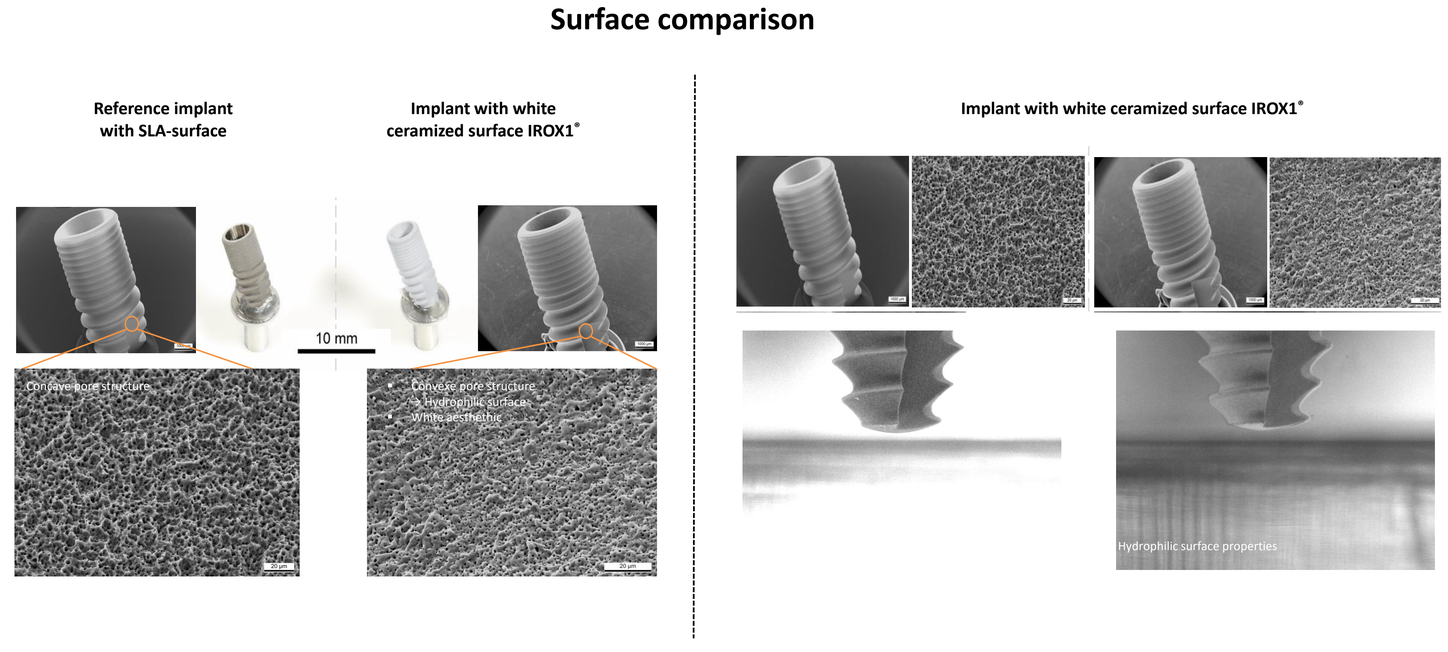

Fig. 2: Comparison of the implants and abutments that were tested in this study. Left: untreated reference. Right: ceramized surface.

Material and Methods

After abutment manufacture, a whitish transition zone was created by PEO. SEM/EDX and profilometry analysis were performed and the surface cytocompatibility was assessed according to DIN ISO 10993-5/-12. Fibroblast adhesion was determined using a live/dead staining assay. Indentation and scratch tests were performed to determine the surface hardness. Fig. 3 outlines the procedures used for cytocompatibility assessment.

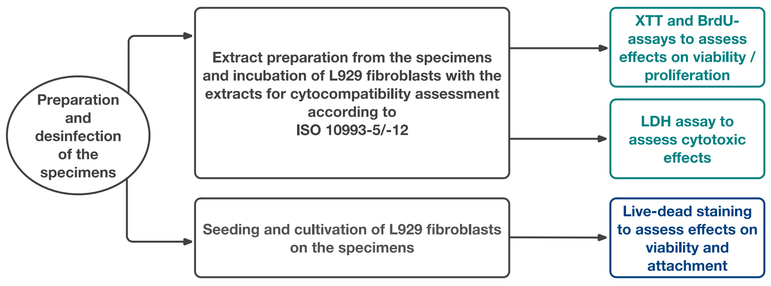

Fig. 3: Schematic outline of the procedures used for cytocompatibility assessment and determination of cellular attachment of cells cultured directly on the material surfaces.

Results

The visible abutment transition zone was successfully ceramized. The ceramic layer presented as a porous-rough whitish surface under the microscope which did not stain after repeated immersion tests in heparinized blood. Cytocompatibility and fibroblast adhesion were excellent (equivalent to the negative control, see fig. 4 and fig. 5). Mechanical analysis revealed satisfying parameters regarding hardness and resistance of the surface.

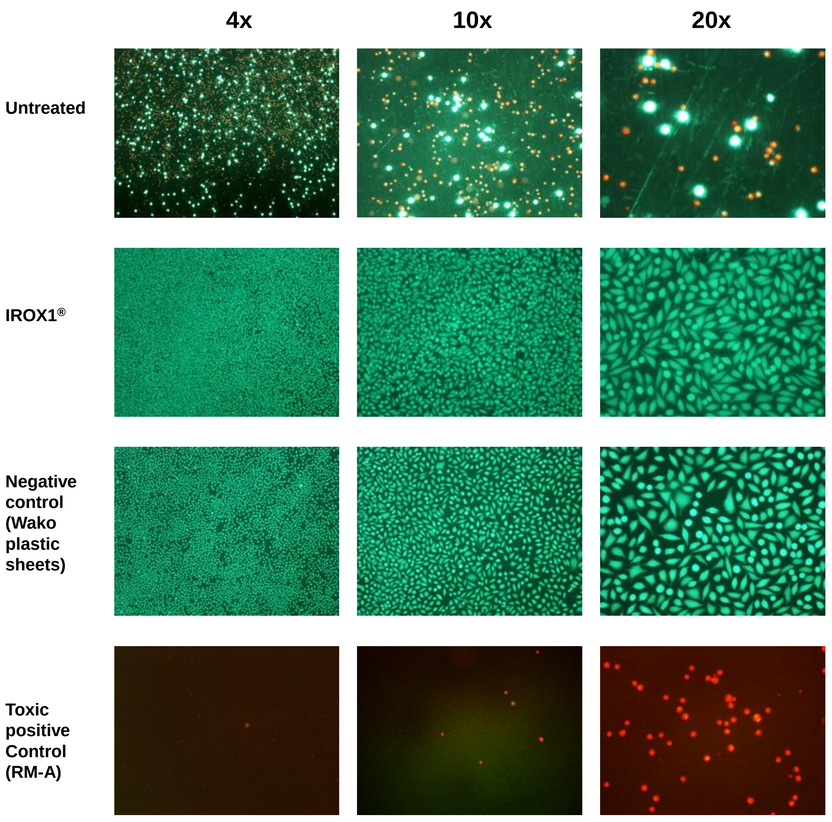

Fig. 4: Results of the live-dead staining assay. Double staining with fluoresceindiacetate (FDA) and propidium iodide (PI) was performed on L929 cells that were directly seeded and cultured for 24 h on the material specimens. The green dye FDA exclusively stains viable cells, dead cells with compromised plasma membrane integrity are stained by the red dye PI. L929 cells cultured on the ceramized surface IROX1® are viable and show a typical spindle-shaped fibroblast morphology indicating firm attachment. IROX1® is equivalent to the negative control in this assay. The untreated surface showed moderate cytotoxic effects in this assay probably due to contaminations from processing.

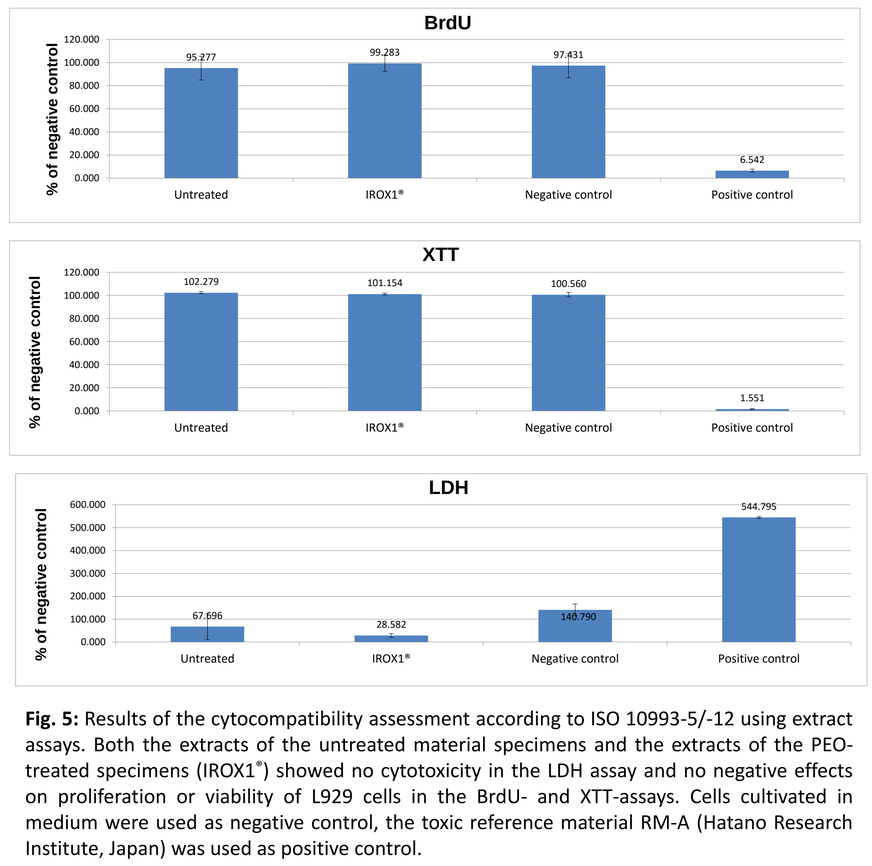

Fig. 5: Results of the cytocompatibility assessment according to ISO 10993-5/-12 using extract assays. Both the extracts of the untreated material specimens and the extracts of the PEO-treated specimens (IROX1®) showed no cytotoxicity in the LDH assay and no negative effects on proliferation or viability of L929 cells in the BrdU- and XTT-assays. Cells cultivated in medium were used as negative control, the toxic reference material RM-A (Hatano Research Institute, Japan) was used as positive control.

Conclusion

The white ceramic layer improves the aesthetic appearance of abutments in the anterior teeth region. *In vitro*, the ceramic layer shows no discoloration and excellent cytocompatibility and fibroblast adhesion.

Funding

This study was funded by the Bundesministerium für Wirtschaft und Energie.

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