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Influence of UV-light and non-thermal plasma on rough titanium surfaces *in vitro*

Introduction and Purpose

Various studies described positive effects of **ultraviolet (UV) irradiation** or **non-thermal plasma (NTP) treatment** on **titanium and zirconia surfaces**. The aim of this study was to determine and compare the effects of UV-light and non-thermal plasma treatment on rough titanium surfaces regarding the changes in wettability, surface chemistry as well as cell attachment and proliferation of murine osteoblast-like cells *in vitro*.

Methods

- **Sandblasted and acid-etched titanium disks** (grade 4, Fig. 1) were divided into a non-treated control group and two experimental groups either treated by UV-light (0.05 mW/cm² at $\lambda = 360$ nm and 2 mW/cm² at $\lambda = 250$ nm) or by NTP of argon (24W; -0.5 mbar) for 12 minutes each
- Wettability was assessed using **dynamic contact angle measurement** (Surtens Universal, OEG, Germany)
- **X-ray photoelectron spectroscopy (XPS)** analysis was performed (Kratos Axis Nova, Kratos Analytical, UK)
- Murine osteoblast-like cells (MC3T3-E1, Sigma Aldrich, Germany) were used for *in vitro* experiments
- Cell attachment was assessed using **fluorescein diacetate / propidium iodide staining** (live-dead-staining) after 2, 24 and 72 hours and cytotoxicity assay (**LDH**)
- Proliferation was determined using an **XTT assay**

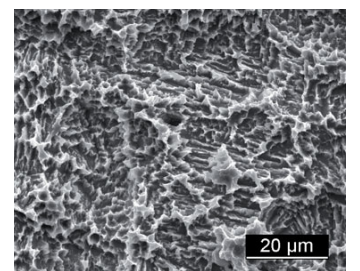


Fig. 1: Electron micrograph of a non-treated titanium disk

Results

- UV-light and NTP treatment **did not alter** the **surface structure or roughness** parameters
- UV light and NTP **significantly increased wettability** on the titanium surfaces ($P < 0.001$, Fig. 2)
- UV-light and NTP **significantly decreased carbon remnants** ($P < 0.002$, Fig. 3)
- NTP was even **more effective** in carbon removal than UV light ($P = 0.03$, Fig. 3)
- UV light and NTP **significantly increased cell attachment** compared to the non-treated disks ($P < 0.001$, Fig. 4)
- NTP **significantly increased cell proliferation** ($P = 0.002$, Fig. 5) compared to the non-treated as well as to the UV-treated disks
- Neither NTP nor UV-light treatment resulted in cytotoxic effects

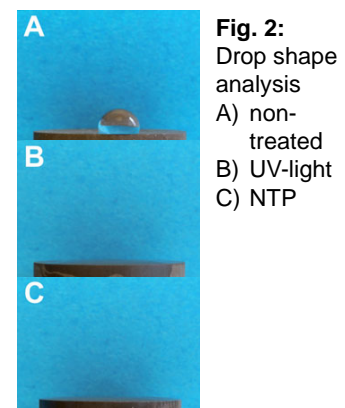


Fig. 2: Drop shape analysis
A) non-treated
B) UV-light
C) NTP

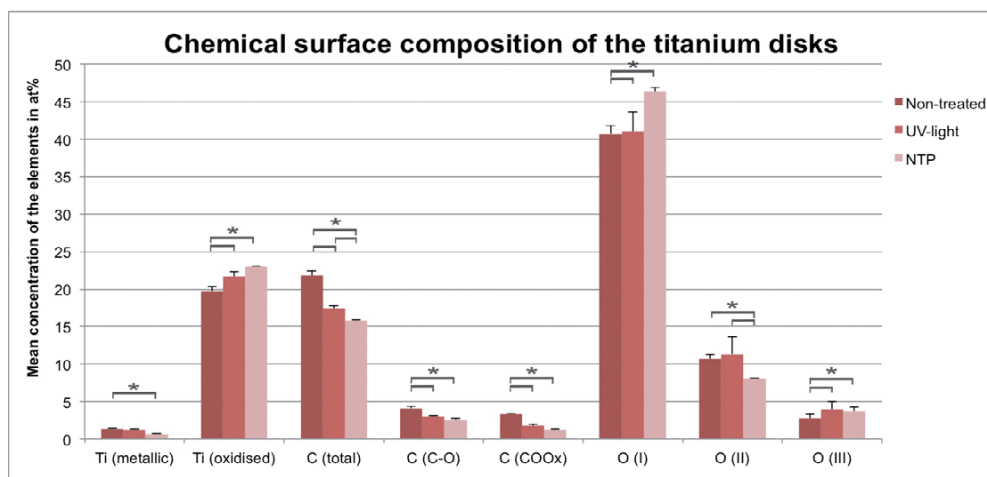


Fig. 3: Surface composition of the disks. Mean concentration of the elements in at% and standard deviation. Ti: titanium; C: carbon; C_{C-O}: carbon bound to oxygen; C_{COOx}: ester, carboxylic or carbonate groups; O_I: oxides; O_{II}: OH-groups; O_{III}: adsorbed water. * statistically significant differences

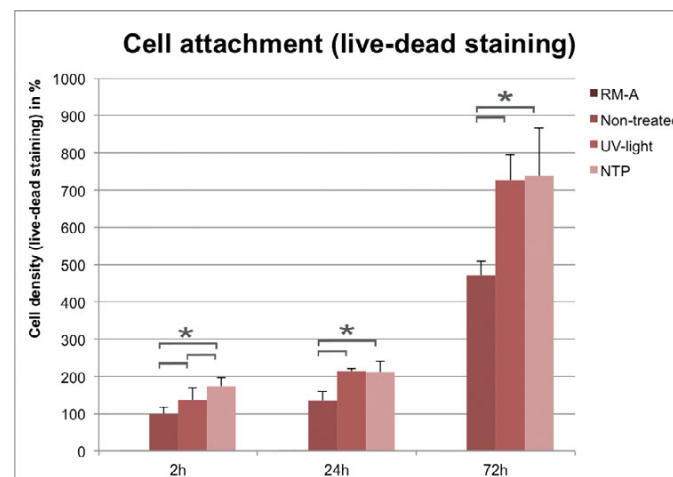


Fig. 4: Cell attachment of MC3T3-E1 cells after 2, 24 and 72 hours of incubation. * statistically significant differences

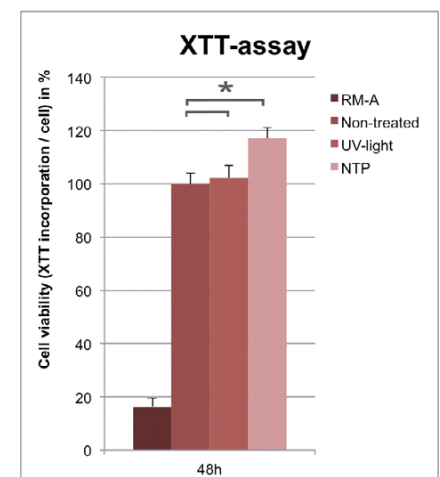


Fig. 5: Proliferation assay (XTT) after 48 hours of incubation. * statistically significant differences

Conclusions

Surface treatment by UV-light or NTP led to a **significant reduction of carbon remnants** and a **significant increase in wettability on rough titanium surfaces**. Both methods are able to **increase the bioactive capacity of titanium surfaces *in vitro*** with slight advantages for NTP in carbon removal and cell proliferation compared to UV-light. However, further studies are needed to confirm the identified effects as well as the determined advantage of NTP *in vitro* and *in vivo*.

Literature

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Disclosure

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