A Protocol for Wear Testing Dental Abutments Subject to Surface Modification

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Introduction

Nowadays, the application of an anti-wear coating on selected parts of the implant assembly is considered one of the most reliable methods for promoting the long-term stability of a dental implant [1; 2]. Nevertheless, while there are multiple international standards for fatigue or corrosion testing of metallic implantable devices [3; 4], up to this day no standard that would provide the guidelines for wear testing of dental coatings has been introduced.

Materials and methods

How to estimate wear of a dental implant?
Simulate 1 year of *in vivo* use in the „worst case scenario" conditions (Fig. 1) on both non-coated (Fig. 2) and PVD-TiN coated abutments.

The wear test protocol

Tighten the abutment to the implant
Use a digital torque meter, 30 Ncm torque

Simulate 1 year of chewing
1M cycles
load changes between 13 and 135 N

Measure the resultant detorque
Untighten the abutment with a digital torque meter

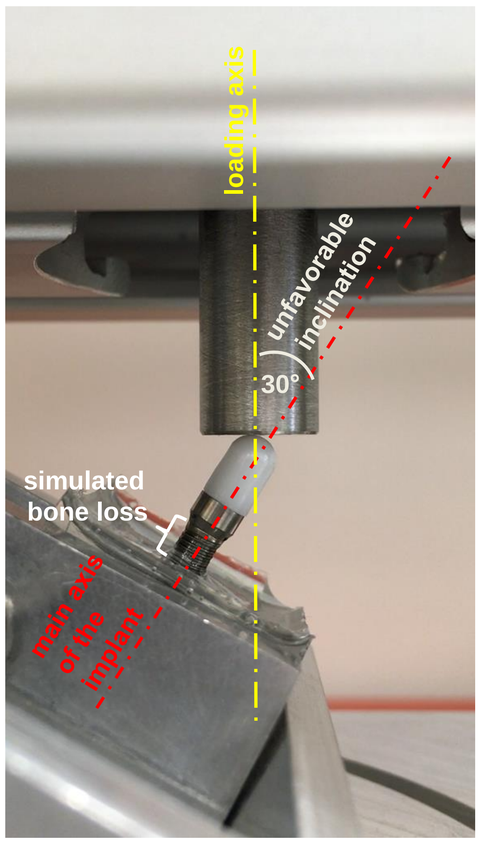


Fig. 1. Setup of the cyclic loading machine, fabricated according to ISO 14801 requirements [3]

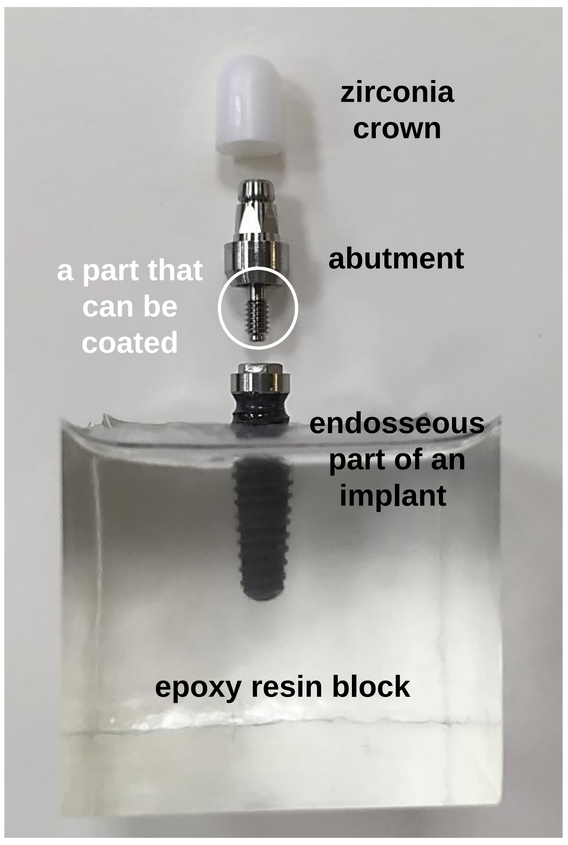


Fig. 2. The implant assembly

Results

*Comparison – the initial detorque vs. the detorque after the cyclic loading, **the non-coated samples** (mean ± SD), n = 5*

Detorque before loading [Ncm]	Detorque after loading [Ncm]
27.7 ± 1.5	20.6 ± 1.8

ca. 26% loss compared to the value of the initial detorque

Statistically significant difference in detorque according to the paired t-Student test [$\alpha = 0.05$, P_{wr} $(1-\beta) = 0.98$] shows that the abutment is loosened up due to simulated chewing process.

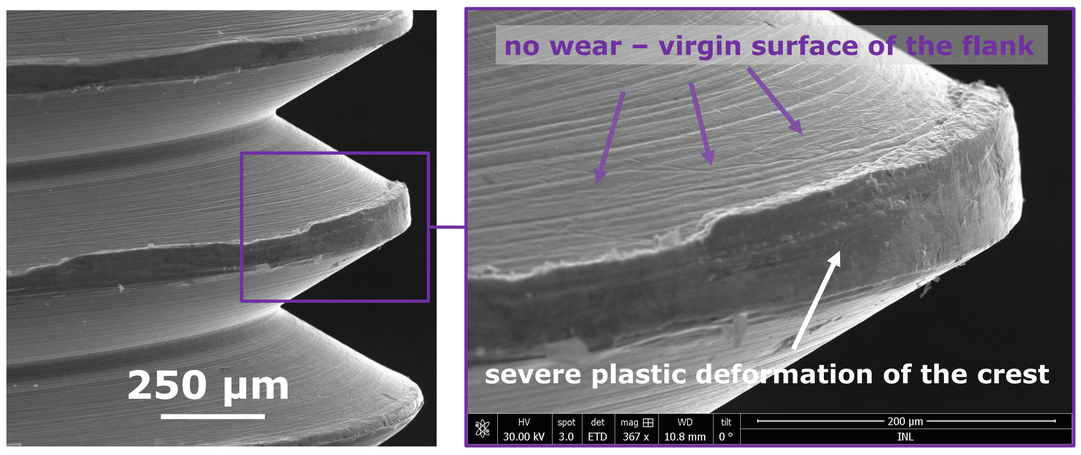
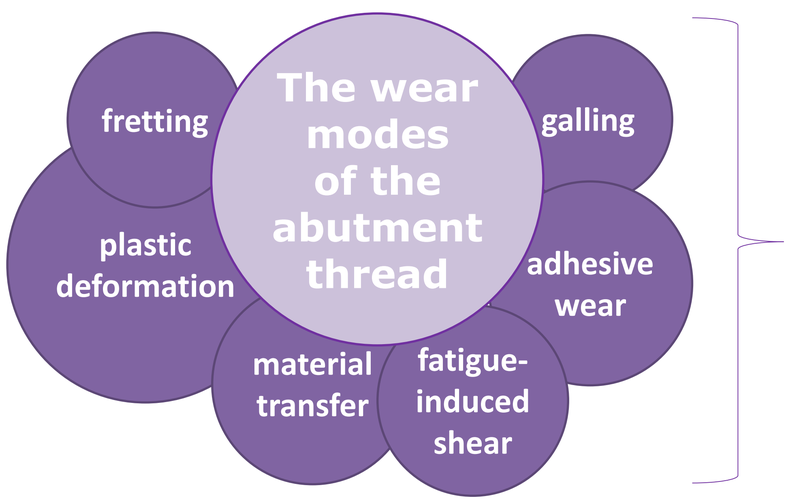


Fig. 3. Loosening of the abutment is caused i.a. by the severe wear of the abutment thread



Solution?
Search for a suitable anti-wear coating

Example: Ti + TiN film

Before 1st tightening | After 1st tightening

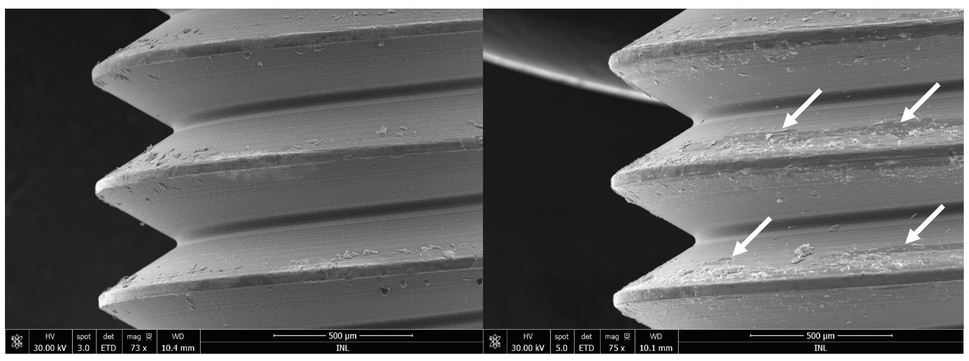


Fig. 4. The designed wear test protocol revealed adhesion problems of the TiN film (arrows). The coating optimization process is stil ongoing.

Conclusion

According to the results, the post-loading surface condition as well as the loosening torque can be used to select the promising anti-wear coatings. The developed method provides comparison between bare and surface modified implant parts, while the collected data can be tested for statistical significance. Moreover, the wear patterns observed for the non-coated samples (Fig. 3) correspond to the literature data on the implant abutments used in vivo [5; 6].

References

[1] Hurson, S. M. "Titanium Surface Treated Dental Screw for Attaching a Prosthetic Component to an Implant" United States Patent no. 5833463 (1998).
[2] Kumar, A. "Diamond-like Carbon Coated Dental Retaining Screws" United States Patent no. 6447295 (2000).
[3] International Standard Organization, "ISO 14801:2016 Dentristry - Implants - Dynamic loading test for endoessous dental implants" (2016).
[4] "European and International Standards on Medical Devices in Dentistry", Deliversky J., et al., Journal of IMAB, Vol. 21, pp. 713–717 (2015).
[5] "The morphology of collected dental implant prosthesis screws surface after six months to twenty years in chewing", Secatto, F. S. B., et al., Dent Oral Craniofac Res, Vol. 3, pp. 1-7 (2017).
[6] "Mechanical Behavior and Failure Analysis of Prosthetic Retaining Screws after Long-term Use In Vivo. Part 1: Characterization of Adhesive Wear and Structure of Retaining Screws", Fournelle, R., et al., J Prosthodont, Vol. 17, pp. 168–180 (2008).

Acknowledgments

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