Cyclic Fatigue Tests and Their Translational Implications for Survival of Reconstructions in Dentistry

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Abstract.

Introduction

Investigations on durability of dental reconstructions are crucial for clinical dentistry since mechanical failures in the form of fractures have financial consequences both for the patient and the dentist. Removal and repair of restorations may be arduous and have also biological costs. The testing and evaluation of the material characteristics and durability prior to clinical use is essential to avoid both financial and biological costs in clinical practice but when clinical outcomes are evaluated such tests often lack clinical translational meaning [1,2]. This lecture will review the studies on cyclic fatigue tests and discuss their translational implications.

Materials and Methods

Original scientific papers published in MEDLINE (PubMed) and Embase database in English on cyclic loading on implant abutments were included in this systematic review. Only the studies that reported, static fracture values before and after fatigue cycling of implant abutments, were included that allowed comparison of aging effect through cyclic loading. Data (N) were analyzed using a weighted linear regression analysis ($\alpha=0.05$).

Results

In all of the included studies, forces were applied on the abutments in a different testing machine with either a stainless steel or a cobalt chromium indenter. The loading forces varied between 10 N and 1995 N with a frequency of 2-15 Hz. While the specimens were loaded at 30 degrees in 6 studies, in one study the loading force was applied 45 degrees of axis. In three studies the temperature of the environment ranged between 5-55°C. The cyclic loading environment was specified in 4 studies as 0.9% saline, saliva substitute, lubricant film or water. The number of cyclic loading varied between 25’000 and 5’000’000. In three studies the number of cycles was below 1’000’000 and in four studies it was equal to or more than 1’000’000. The specimens were loaded at a crosshead speed ranging between 0.5 and 3 mm/min. In general, loading conditions of the fatigue tests revealed heterogeneity in the sample but a meta-analysis could be performed for the following parameters: a) abutment material, b) implant-abutment connection, and c) number of fatigue cycles. Mean fracture strength of titanium (508.9±334.6 N) and for zirconia abutments (698.6±452.6 N) did not show significant difference after cyclic loading ($p>0.05$). Internal implant-abutment connections demonstrated significantly higher fracture strength after cyclic loading compared to external ones (internal: 774.0±582.3N; external: 481.2±137.5N; $p=0.022$). The mean fracture strength of all abutment types decreased significantly when number of loading cycles exceeded 1’000’000 cycles ($<1\times10^{-6}$: 1047.0±751.3 N; $>1\times10^{-6}$: 556.7±317.6 N; $p=0.032$).

Conclusion

The abutment type, abutment material, loading conditions (jig dimensions, type, cross-head speed, indenter type, diameter), cyclic loading conditions (medium, temperature, loading magnitude, speed, number of cycles) should be defined precisely in the dental fatigue studies. Current studies regarding the fatigue strength of dental implant components should be evaluated cautiously considering the heterogeneity in testing conditions. Regardless of the

brand, increased number of cyclic loading (>$1x10^{-6}$) decreased the fracture strength of all implant components tested, compared to <$1x10^{-6}$.

References

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