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Bending moments of zirconia and titanium implant abutments supporting all-ceramic crowns after aging

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Abstract

Objectives: To test the fracture load and fracture patterns of zirconia abutments restored with all-ceramic crowns after fatigue loading, exhibiting internal and external implant–abutment connections as compared to restored and internally fixed titanium abutments.

Materials and methods: A master abutment was used for the customization of 5 groups of zirconia abutments to a similar shape (test). The groups differed according to their implant–abutment connections: one-piece internal connection (BL; Straumann Bonelevel), two-piece internal connection (RS; Nobel Biocare ReplaceSelect), external connection (B; Branemark MkIII), two-piece internal connection (SP, Straumann StandardPlus) and one-piece internal connection (A; Astra Tech AB OsseoSpeed). Titanium abutments with internal implant–abutment connection (T; Straumann Bonelevel) served as control group. In each group, 12 abutments were fabricated, mounted to the respective implants and restored with glass–ceramic crowns. All samples were embedded in acrylic holders (ISO-Norm 14801). After aging by means of thermocycling in a chewing simulator, static load was applied until failure (ISO-Norm 14801). Fracture load was analyzed by calculating the bending moments. Values of all groups were compared with one-way ANOVA followed by Scheffé post hoc test (P-value$<$0.05). Failure mode was analyzed descriptively.

Results: The mean bending moments were 464.9 $\pm$ 106.6 N cm (BL), 581.8 $\pm$ 172.8 N cm (RS), 556.7 $\pm$ 128.4 N cm (B), 605.4 $\pm$ 54.7 N cm (SP), 216.4 $\pm$ 90.0 N cm (A) and 1042.0 $\pm$ 86.8 N cm (T). No difference of mean bending moments was found between groups BL, RS, B and SP. Test group A exhibited significantly lower mean bending moment than the other test groups. Control group T had significantly higher bending moments than all test groups. Failure due to fracture of the abutment and/or crown occurred in the test groups. In groups BL and A, fractures were located in the internal part of the connection, whereas in groups RS and SP, a partial deformation of the implant components occurred and cracks and fractures of the zirconia abutment were detected.

Conclusion: The differently connected zirconia abutments exhibited similar bending moments with the exception of one group. Hence, the type of connection only had a minor effect on the stability of restored zirconia abutments. In general, restored titanium abutments exhibited the highest bending moments.

Replacing single missing teeth in esthetically demanding anterior regions using osseointegrated implants has become a predictable treatment modality with high survival rates (Jung et al. 2008b; Jung et al. 2012). Clinical success is not only dependent on successful osseointegration, but also on the performance of the respective suprastructure. Different materials and components were proposed for implant-supported single crowns.

As an abutment material, traditionally titanium is selected because of its mechanical properties (Andersson et al. 1995). Yet, the color of underlying titanium abutments negatively affected the appearance of peri-implant mucosa (Park et al. 2007; Jung et al. 2008a; van Brakel et al. 2011). To provide more predictable results regarding esthetic aspects, all-ceramic abutments made out of alumina and zirconia were introduced (Liu et al. 2012).

Among all-ceramic abutments, *in vitro* studies demonstrated superior fracture resistance of zirconia abutments ranging from 444 N to 738 N as compared to alumina

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