Influence of Abutment Angulation on Screw Fracture-Strength and Removal Torque

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Introduction / Objective

A screw retained implant supported restoration has many advantages ranging from maintenance to eliminating the possibility of excess cement that has proven to cause biological problems. The objectives of this in vitro study are to compare a screw system that allows deviation from the axis of an implant at 3 different angulations before, during and after cyclic loading. Then the fracture strength of the screws at the 3 angulations after cyclic loading.

Methods

28 Dynamic Abutments that allow deviation from the long axis of the implant (Talladium International Implantology, Lleida, Spain) with screws and specific screw driver and 28 titanium external hexagon implants (3i T3, Zimmer Biomet, Palm Beach Gardens, FL, USA) were used. The implants were embedded into auto polymerizing methyl methacrylate (Technovit 4000, Heraeus-Kulzer, Wehrheim, Germany). The Dynamic Abutments were separated into 4 categories based on labial palatal angulation and screw; Group 1: 0° attached to the implant using 3i Biomet gold square screw (control group); Group 2: 0°; Group 3: 20°; Group 4: 28° angle deviation. Groups 2 ,3 ,and 4 used Talladium screws. Each abutment was waxed to a full contour #9 crown and casted in Talladium Tilite Medical Ceramic Alloy (Talladium International Implantology).

Initial removal torque values were measured after each sample was subjected to 3 repeated torque and removal with a digital implant torque driver (Tohnichi Torque Gauge, Buffalo Grove, IL, USA) to the manufacturer's recommended values. All screws were torqued to recommended values prior to loading into a dual-axis chewing simulator (CS4-8, SD Mechatronik, Feldkirchen-Westerham, Germany) with an antagonistic stainless steel ball under an axial load of 40N for 1,200,000 cycles.

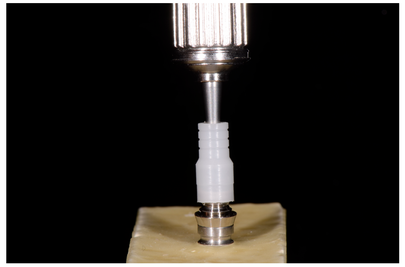

Fig. 1. 0° Dynamic abutment

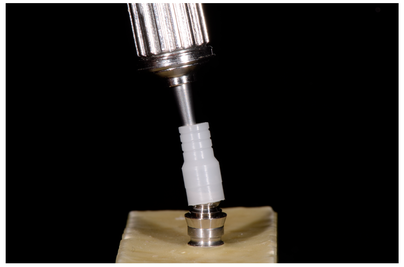

Fig. 2. 20° Dynamic abutment

Fig. 3. 28° Dynamic abutment

All samples were re-torqued at 9205 cycles to compensate for loss of initial preload due to settling effects[1]. Baseline and final (after cyclic fatiguing in a dual-axis chewing–simulator for 1,200,000 cycles) screw removal torque values were recorded with a digital implant torque driver.

A universal mechanical testing machine (Model 5965, Instron, Norwood, MA, USA) was utilized to test the fracture strength (FS) for each specimen. A rigid clamp system was used to hold the implants in at a 30° angle while the specimens were loaded under compression at a crosshead speed of 1mm/min until failure or obvious deformation. Peak loads are recorded in N. The testing protocol is based on the ISO recommendations (ISO 14801).

Average baseline removal and final removal values were calculated. Difference between baseline and removal torque (ΔRT) was calculated in order to compare the Dynamic Abutment Screw (DAS) to the conventional gold coated screw. Statistical analysis was performed using one-way ANOVA for ΔRT and FS separately with Bonferroni post-hoc test at α=0.05.

Results

	0° 3i Gold	0° DAS	20° DAS	28° DAS
ΔRT (Ncm)	-1.04	1.09	-0.51	-2.57
FS (N)	989.01	869.59	715.88	789.84

Table 1. Means values for ΔRT (Ncm) and fracture-strength (N)

The statistical significance between the groups when comparing the mean values was α=0.002, which was not statistically significant.

The screw broke in 5 out of 28 (17.8%) samples. Remaining samples failed by damaging the implant platform while the screw bent or loosened. All crowns stayed intact while the implant platform was severely bent or fractured.

Discussion

One of the concerns with using an angled abutment is the non axial load causing tensile forces to the retaining screw resulting in screw loosening especially in single-implant restorations. This in vitro test was designed to simulate 5 years of use (1,200,000 cycles of cyclic loading) and to determine the force necessary to fracture the screw[2].

The maxillary single tooth restoration was chosen as the subject since it is vulnerable to loosening of the retaining screw due to the non axial loading that leads to severe bending forces to the screw[3]. The removal torque of the sample group with 28° deviation from the implant axis was -2.57Ncm, indicating that the removal torque of the samples was the lowest. This comports with increased tensile forces to the screw with more severe non axial loading. Fracture strength of the gold screw was the highest and decreased for the DAS, however the change was not statistically significant. This indicates that the DAS in differing angulations has the potential of withstanding forces after cyclic loading that may be clinically sufficient, further in only 5 samples were any screws broken before the implant mechanically failed.

Conclusions

The removal torque and fracture strength of the DAS is comparable to the 3i Biomet gold screw. Within the parameters of this study deviation of the restoration from the implant axis did not have any significant influence on the screw removal torque values and fracture resistance after 5 years of simulated loading. Though the torque values were lower with increased angulation, screw retention allows easier remedy to loosened abutments than cemented.

References

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Acknowledgement / Contact

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