Effect of Abutment Screw Design on the Seal Performance of an External Hex Implant System

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Topic: Material research

Seal integrity of the implant-abutment junction (IAJ) is a function of the design of the implant, the abutment, and the retaining screw, as well as the loading conditions to which the assembled dental implant system is subjected. The dental implant components should be engineered to resist microleakage at the IAJ interface. A robust seal can mitigate collateral transfer between the implant connection and surrounding tissues, thereby reducing the potential for inflammation and subsequent loss of these tissues. Preservation of the hard and soft tissue is critical to the performance of an implant system in terms of stability and aesthetics.

The design of the retaining screw can have a significant impact on IAJ seal integrity, as it is the element which generates the pre-load required to create and maintain a tight seal. The objective of this study was to characterize the seal robustness of an external hex implant system subjected to dynamic loading with titanium (Ti-Alloy) and Gold-Tite retaining screws.

Methods and Materials

A dynamic loading leakage test adapted from ISO14861, Dentistry - Implants - Dynamic Fatigue Test for Endoossous Dental Implant Bars was performed to compare the seal performance of the implant systems outlined in Table 1.

Table 1: Implant System Components Evaluated

<table>
<thead>
<tr>
<th>Implant System with Abutment Screws</th>
<th>Screw</th>
<th>Implant Item Number</th>
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<tbody>
<tr>
<td>Biomet GoldTite® Post (1,000 cycles)</td>
<td>GTP</td>
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Figure 1: Implant Abutment Item Number

The seal test setup is illustrated in Figure 1, and the protocol is described below. Five (n=5) systems were tested from each group.

1) A barb was machined at the apical tip of the implant to provide access to the internal aspect (Figure 2).
2) The implant was fixated in a phenolic-resin block, exposing 3.0mm of the coronal portion while allowing access to the apical barb.
3) Tubing was connected to the implant barb, and the abutment was loosely assembled to the implant.
4) Using a peristaltic pump, red dye was bled through the system to eliminate air bubbles and to confirm adequate flow.
5) Nm of torque was then applied to the abutment screw and the system was thoroughly rinsed.
6) The block was mounted in an electrodynamic test machine (Instron ElectroPuls E1000, Instron, Norwood, Massachusetts) at 20 degrees off-axis in a clear tank filled with fresh water (Figure 3).
7) The pump was turned on and the internal volume of the implant was pressurized to approximately 7psi. The IAJ was monitored with ultrasonic imaging and the leakage detection was performed immediately.
8) If no leakage was visually detected without a system load (per the prior step), the abutment was then cycled loaded at 100N for 100,000 cycles with the pump off to simulate system usage.
9) After the fatigue cycle, the seal was qualified by turning the pump on and monitoring the IAJ while loading at 100N at 2 Hz for 1,000 cycles.
10) If the test successfully completed the initial 100N dynamic load, steps 8 and 9 were repeated in load increments of 50N (Figure 4) until leakage was detected (Figure 5).

Results

The pre-load created by each screw design (n=5) at 35 Nm of torque was independently assessed aside from the seal test using a load cell and a digital force gauge.

Seal test results (Figure 6) indicate that the Gold-Tite screw improved the average seal strength over the systems utilizing the Ti-Alloy screw by more than 35% (650 ± 50 N vs 480 ± 91 N). An unpaired two-tailed t-test was used to compare the groups. A difference of P<0.05 was considered significant, and the statistical analysis showed that P=0.006.

Conclusions

The pre-load generated by a Gold-Tite abutment screw provides a statistically significant improvement over a Ti-Alloy abutment screw. As one could predict, this same trend was evidenced when testing external hex implant systems for seal robustness with Gold-Tite and Ti-Alloy abutment screws. Y-axis for both test groups, are clinically relevant in terms of maximum bite forces. Given the potential functional and aesthetic detriments associated with an inferior seal, a Gold-Tite abutment screw should always be selected to increase the probability of a positive and sustainable clinical outcome.

References

1. Al-Jadad A, Attin T, Pettemòlå K, Thilmerdin P. “The Seal is the Deal”: Gas-Enhanced Leakage Testing (GELT) for Implants. Poster Presentation (P4); The 11th International Symposium on Periodontics & Restorative Dentistry, June 2013, Boston, MA. Primary researcher’s PhD fellowship was supported by BIOMET 3i LLC. Aim of study was to develop a customized and standardized measurement device allowing repetitive non-destructive evaluation of implant leakage. Three implant systems were tested (n=10, four of each group which were negative controls). The research was funded by BIOMET 3i LLC.


† These clinicians have or have had financial relationships with BIOMET 3i resulting from speaking engagements, editorial engagements and other retained services.

‡ Dr. Porter, M, and M, Towse conducted this research while employed by BIOMET 3i.