A Novel Method for Assessing Implant-Abutment Connection Seal Robustness

Zach Suttin, Ross Towse, Joell Cruz

BIOMET 3i, Palm Beach Gardens, Florida, USA

OBJECTIVE

The aim of this study was to develop a method for characterizing the implant-abutment seal capability of dental implant systems subjected to dynamic loading conditions.

BACKGROUND

The seal integrity of the implant-abutment-junction (IAJ) is of significant interest due to the potential detriments associated with an inferior seal: bacterial invasion and subsequent colonization of the internal aspect, microleakage, malodor, inflammation, peri-implantitis, and crestal bone loss[1,2,3]. There are many causal factors that have been assigned to an inadequate IAJ seal: macro connection design, initial microgaps, abutment micromotion, screw loosening, and user error. The ability to assess seal robustness under dynamic loading conditions is ideal, as it is more representative of the clinical situation.

MATERIALS AND METHODS

Four (4) industry recognized implant systems were selected as described in Table 1. Five (5) systems from each manufacturer were tested. The apex of each test implant was modified to have a barb-type fitting and a thru hole to reach the internal aspect (figure 1a). The implants were potted in phenolic resin to simulate 3mm of coronal bone resorption, and to allow for access to the apical barb (figure 1b). Prior to testing, each system was loosely assembled and tubing was connected to the implant barb. Red dye was bled through the system using a peristaltic pump to confirm flow (figure 1c).

Table 1- Test System Component Catalog Dimensions

Implant Systems	Implant Sizes (mm)	Titanium Abutments (mm)
Thommen SPI®Element	4.0(D) x 14(L)	4.0(D) x 8(L)
AstraTech Osseospeed™	4.0(D) x 15(L)	4.0(D) x 9(L)
Straumann® Bone Level	4.1(D) x 14(L)	4.1(D) x 8.5(L)
BIOMET *3i* Certain® Prevail®	4.1/3.4(D) x 15(L)	3.4(D) x 9(L)

The manufacturer's recommended torque was applied to the abutment screw using a digital torque meter, and the system was thoroughly rinsed to remove any red dye from the external surfaces.

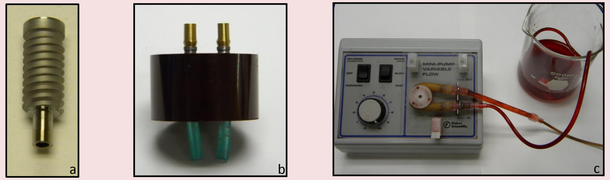


Figure1 – Barbed implant (a), phenolic block with test samples (b), and peristaltic pump setup (c).

The phenolic block was mounted at 20 degrees off-axis in a clear tank filled with water (figure 2). The pump was turned on and a high resolution video camera was focused on the implant-abutment junction (IAJ) to qualify the static seal (i.e., lack of red dye leaking from the internal volume pressurized at 7 psi).

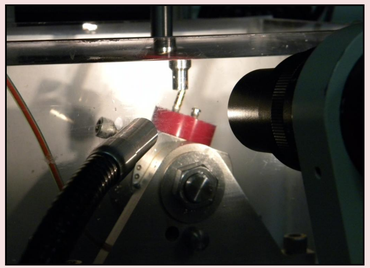


Figure 2 – Cyclic seal test configuration.

Following verification of the initial seal, the abutments were cyclically loaded on an Instron materials testing system using a ramped testing regimen in two phases:

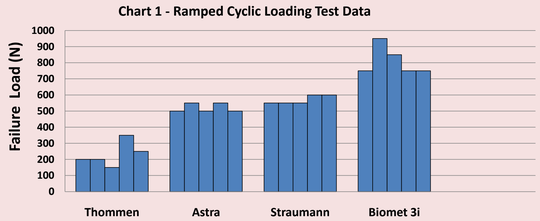
- A 100N load at 30Hz was applied for 100k cycles with the pump off to accumulate system wear.
- After the wear cycle, the seal was assessed by activating the pump and visually monitoring the IAJ at 50x magnification (figure 3) under the current load (100N) for 1k cycles at 2Hz.

Upon completion of this two-step cycle without a breach, the load was increased by 50N and the wear and assessment cycles were repeated. The test samples continued to be incremented by 50N until a breach was detected and/or a fracture occurred.

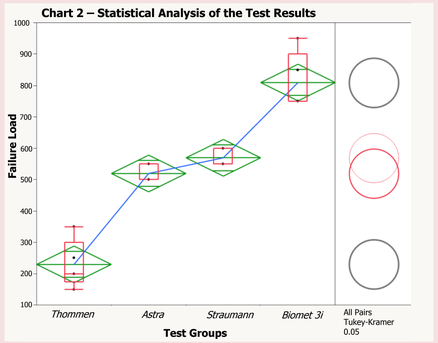
Figure 3 – Video monitoring of the seal test.

RESULTS AND DISCUSSION

The Thommen and BIOMET *3i* test samples failed due to a "pure breach" at the IAJ, meaning that none of the components in the implant assembly fractured prior to detecting the red dye. The Astra and Straumann implant assemblies, however, experienced component yielding and/or fractures that resulted in subsequent breaching. The failure loads (Chart 1) at which breaches occurred ranged from 150N to 950N, representing an accumulation of 200k to 1.8M cycles, respectively.



An ANOVA was conducted to compare the ramped cyclic loading test results, and a difference was established between at least 2 of the populations. A Tukey's HSD test ($p<.0001$) was performed to determine where the variations were. Astra (M=520) and Straumann (M=570) did not significantly differ from each other, but both were significantly greater than Thommen (M=230). Biomet 3i (M=810) was significantly greater than all other systems. Chart 2 shows the comparative results from the statistical analysis.



CONCLUSIONS

A new test method has been developed to qualitatively assess the seal robustness of implant systems subjected to clinically relevant cyclic loading conditions. Because the failure modes vary, an absolute assessment of the "pure breach" failure mode could not be conducted. Amongst the implant systems tested, the BIOMET *3i* Certain Prevail exhibited a robust seal without breach or failure at loads significantly higher than the other implant systems. This can be attributed to the interface design and screw pre-load.

REFERENCES

1. *Coelho P.G. et al. "In vitro evaluation of the implant abutment connection sealing capability of different implant systems." Journal of Oral Rehabilitation. 2008 35; 917-924*
2. *Lorenzoni F.C. et al. "Sealing Capability and SEM Observation of the Implant-Abutment Interface." International Journal of Dentistry. Volume 2011*
3. *Dilbart S. et al. "In Vitro Evaluation of the Implant-Abutment Bacterial Seal: The Locking Taper System." The International Journal of Oral & Maxillofacial Implants, Vol. 20, No. 5, p. 732-737, September 2005*

For Information contact:
Zachary Suttin
zachary.suttin@biomet.com