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 detrimental associations with an inferior seal: bacterial invasion and subsequent colonization of the internal aspect, microleakage, malodor, inflammation, peri-implantitis, and crestal bone loss.1,2,11 There are many causal factors that have been assigned to an inadequate IAJ seal: macroconnection design, initial micropits, 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 for coronal bone crestal bone access to the apical barb. Red dye was bled from the internal volume pressurized at 7 psi.

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: 1) 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.

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 Astras and Straumann implant assemblies, however, experienced component yielding and/or fractures that resulted in subsequent breach. 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 test samples. A Tukey’s HSD test (p<.0001) was performed to determine where the variations were. Astra (M=520) and Thommen (M= 230) 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.

CONCLUSIONS

A new test method has been developed to qualitatively assess the seal robustness of implant systems subjected to clinically relevant 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 and 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


Zach Suttin, Ross Towse, Joell Cruz
BIOMET 3i, Palm Beach Gardens, Florida, USA

Table 1 - Test System Component Catalog Dimensions

<table>
<thead>
<tr>
<th>System</th>
<th>Implant Shape</th>
<th>Implant Thread</th>
<th>Abutment Shape</th>
<th>Abutment Thread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thommen® Premier</td>
<td>4.0(L)x14(L)</td>
<td>4.0(L)x0.82(L)</td>
<td>4.0(L)x14(L)</td>
<td>4.0(L)x0.82(L)</td>
</tr>
<tr>
<td>Astra® Osseospacer™</td>
<td>4.0(L)x15(L)</td>
<td>4.0(L)x0.83(L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straumann® Level</td>
<td>4.1(L)x14(L)</td>
<td>4.1(L)x0.85(L)</td>
<td>4.1(L)x14(L)</td>
<td>4.1(L)x0.85(L)</td>
</tr>
<tr>
<td>BIOMET® Certain® Prevail®</td>
<td>4.1(L)x15(L)</td>
<td>3.4(L)x0.89(L)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

Figure 1 – Barbed implant (a), phenolic block with test samples (b), and peristaltic pump setup (c).

Figure 2 – Cycle seal test configuration.

Figure 3 – Video monitoring of the seal test.

Chart 1 - Cyclic Loading Test Data

<table>
<thead>
<tr>
<th>System</th>
<th>Failure Load (N)</th>
<th>Max Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thommen®</td>
<td>230</td>
<td>150</td>
</tr>
<tr>
<td>Astra®</td>
<td>520</td>
<td>400</td>
</tr>
<tr>
<td>Straumann®</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>BIOMET®</td>
<td>900</td>
<td>700</td>
</tr>
</tbody>
</table>

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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.

An ANOVA was conducted to compare the ramped cyclic loading test results, and a difference was established between at least 2 of the test samples. A Tukey’s HSD test (p<.0001) was performed to determine where the variations were. Astra (M=520) and Thommen (M=230) 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.

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