Implant Abutment Fracture Strength Comparison

In engineering, fatigue strength is considered an important mechanical property when evaluating a load-bearing component. This is true of implant components as well. The ultimate goal in measuring load-bearing capacity of implant materials is to determine whether they can clinically endure chewing forces. Coray et al from the University of Zürich, Switzerland, designed a systematic review to compare fracture strength of different types of implant abutments after cyclic loading.

The authors investigated:
- abutment materials
- abutment connection types
- number of fatigue cycles
- fracture strength

Only English language articles published between 1970 and 2014 that reported static fracture values before and after fatigue cycling of abutments were included in the authors’ search of PubMed and EMBASE databases and 10 specialized journals. This allowed for a comparison of aging effect through cyclic loading. Studies evaluating abutments in combination with the prosthesis were excluded. Data were analyzed using a weighted linear regression analysis.

Of the full-text articles selected for review, 7 in vitro studies published between 1999 and 2014 met the inclusion criteria; 3 studies examined fracture strength of abutment before cyclic loading. Fracture strength for these abutments (all made of Ceramic Abutment Survival

Rising patient demand for improved esthetics has led to the development of ceramic abutments. With the increased use of these abutments for single implant restorations, the question arises as to the long-term survival and complication rates of these components. This issue of Report on Prosthodontics reviews the current literature regarding the survival of ceramic abutments.

Inside this issue:
- One- and Two-piece Custom Zirconia Abutments in the Anterior Maxilla
- Predictability of Posterior Zirconia Abutments
- Clinical Outcomes Of Anterior Implant Abutments

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titanium) ranged from 430 ± 59 N to 1955 ± 18 N. Fracture strength after cyclic loading showed no significant difference between abutment materials (titanium abutments, 508.9 ± 334.6 N; zirconia abutments, 698.6 ± 452.6 N).

Internal implant–abutment connections demonstrated significantly higher fracture strength after cyclic loading than did external implant–abutment connections. The fracture strength of the internal connection was 774.0 ± 582.3 N compared with 481.2 ± 137.5 N for the external connection ($p = .022$). The mean fracture strength of all abutment types decreased significantly when the number of loading cycles exceeded 1 million cycles.

The authors noted that the testing conditions varied greatly across studies or were not reported. The authors cautioned against overinterpreting the results because of the varied testing conditions and recommended the need for more standardized testing. However, based on this study, the authors concluded that the abutment–connection type affected the fatigue strength more than did the abutment material.


**Table 1.** Biological parameters of 1- and 2-piece custom zirconia abutments at 48 months

<table>
<thead>
<tr>
<th></th>
<th>Plaque index</th>
<th>Bleeding index</th>
<th>Marginal bone loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-piece restoration</td>
<td>0.47 ± 0.50</td>
<td>0.47 ± 0.50</td>
<td>1.40 ± 0.99</td>
</tr>
<tr>
<td>2-piece restoration</td>
<td>0.48 ± 0.51</td>
<td>0.24 ± 0.44</td>
<td>1.17 ± 0.89</td>
</tr>
<tr>
<td>$p$ value</td>
<td>.893</td>
<td>.053</td>
<td>.342</td>
</tr>
</tbody>
</table>

1-piece zirconia abutment restorations were placed on 45 implants, while 2-piece zirconia abutment restorations with cement-retained crowns were placed on 29 implants.

During the observation period of up to 4 years,

- 3 (10.3%) all-ceramic restorations in the 2-piece restoration group fractured
- 2 (4.4%) 1-piece restorations fractured after 26 months

Implant survival was 100%. No patients suffered from pain or peri-implant infection, and none of the implants were mobile. There was no significant difference between the 2 groups with regard to the plaque index, bleeding index or bone loss. Only 2 implants had bone loss >1 thread (Table 1).

Although the data were very promising, any conclusions drawn from this study should be viewed with caution due to the limited number of implants examined and the short observation time. Additional studies with greater numbers of implants and longer follow-up should be performed.


**One- and Two-piece Custom Zirconia Abutments In the Anterior Maxilla**

The development of customized zirconia abutments for single implants accommodated implant use in less than ideal positions and improved esthetics, while supporting the soft tissues and the overlying crown. Custom zirconia abutments are either 1 piece (zirconia abutment with veneering ceramic) or 2 piece (zirconia abutment with cemented zirconia crown). Paolantoni, a private practitioner from Naples, Italy, et al conducted a randomized controlled study of 65 patients (74 missing anterior maxillary teeth) to compare the incidence of complication in 1-piece and 2-piece custom zirconia abutments over a 4-year period. Screw-retained

**Predictability of Posterior Zirconia Abutments**

Ceramic abutments have been used in both the anterior and posterior regions of the mouth as an alternative to improve mucogingival esthetics. Clinical outcomes of components in the anterior and posterior regions of the mouth may vary due to the differences in occlusal forces in the 2 areas of the mouth.

To evaluate the survival rates and the mechanical and biological complications of zirconia abutments compared
with titanium abutments in posterior regions, Vechiato-Filho et al from Universidade Estadual Paulista, Brazil, conducted a systematic review of articles published between 2004 and 2014. Included studies evaluated single-implant crowns in the posterior area with a mean observation period of ≥1 year. Simple or systematic reviews, studies examining implants in the anterior region of the mouth, implants restored with multi-unit prostheses, case reports or case series with <10 patients, and studies without clinical data such as surveys and questionnaires were excluded. A funnel plot was used for the meta-analysis.

The search yielded 11 studies, of which 6 could be used for the meta-analysis. A total of 298 zirconia abutments and 136 titanium abutments placed in 382 patients were evaluated. The weighted mean follow-up period was 5.88 years. The 5-year success rate for zirconia abutments was 99.30% compared with 99.57% for titanium abutments. There were 25 complications with zirconia abutments (8.39%) compared with 13 complications with titanium abutments (9.56%).

No difference in the mechanical complications was observed between zirconia and titanium abutments. Minor veneer porcelain fracture and screw loosening were the most common complications (Table 2). The meta-analysis showed that zirconia abutments were approximately 0.52× more susceptible to veneer failure in posterior areas than were titanium abutments; however, there was no significant effect of the abutment type (zirconia or titanium) on the incidence of veneer failure.

Mean bone loss was 0.38 ± 0.87 mm for zirconia abutments and 0.20 ± 0.13 mm for titanium abutments. Bleeding on probing values were similar for the 2 types of abutments. There was no significant difference between zirconia and titanium abutments regarding biological complications.

The review data suggested that the use of zirconia abutments in the posterior for single implant crowns will yield clinical outcomes similar to those of titanium abutments. This conclusion is based on an average of 5-year data. Longer-term clinical outcome evidence should be collected.


### Table 2. Incidence of mechanical complications in posterior regions in the selected studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Torque of prosthesis (Ncm)</th>
<th>Screw loosening (n)</th>
<th>Fracture on screws (n)</th>
<th>Abutment fracture (n)</th>
<th>Veneer failure (n)</th>
<th>Prosthesis survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cionca et al 2014</td>
<td>CA</td>
<td>—</td>
<td>—</td>
<td>ZrA: 2</td>
<td>—</td>
<td>96</td>
</tr>
<tr>
<td>Nothdurft et al 2014</td>
<td>NR</td>
<td>ZrA: 3</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 8</td>
<td>NR</td>
</tr>
<tr>
<td>Zembic et al 2013</td>
<td>32</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>100</td>
</tr>
<tr>
<td>Lops et al 2013</td>
<td>25</td>
<td>ZrA: 2</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 4</td>
<td>100</td>
</tr>
<tr>
<td>Hosseini et al 2013</td>
<td>25</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 1</td>
<td>97</td>
</tr>
<tr>
<td>Hosseini et al 2011</td>
<td>25</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 100</td>
</tr>
<tr>
<td>Notthdurft and Pospiech 2010</td>
<td>NR</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 4</td>
<td>100</td>
</tr>
<tr>
<td>Sailer et al 2009</td>
<td>32</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>100</td>
</tr>
<tr>
<td>Zembic et al 2009</td>
<td>32</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>ZrA: 0</td>
<td>100</td>
</tr>
<tr>
<td>Canullo 2007</td>
<td>32</td>
<td>0</td>
<td>NR</td>
<td>ZrA: 1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Glauser et al 2004</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

CA, cemented abutments (no screw was used); NR, not reported; ZrA, zirconia abutment; TiA, titanium abutment.
Clinical Outcomes of Anterior Implant Abutments

Given the high esthetic demands for anterior implant restorations, the use of zirconia abutments in this area has increased. This is due to the perceived concern regarding soft tissue discoloration at the gingival margin caused by titanium abutments.

Bidra and Rungruanganunt from the University of Connecticut Health Center performed a systematic review to examine the clinical outcomes of anterior implant abutments. Specifically, the authors examined the survival and mechanical, biological and esthetic outcomes of zirconia implants compared with titanium abutments.


Inclusion criteria for the electronic search comprised

- English language peer-reviewed journals
- Human clinical studies
- Partially edentulous patients
- Missing teeth in the canine-to-canine region

Implant abutment designs can be characterized by the method of connection (1-piece screw-retained, 2-piece cemented, 2-piece screw-retained); the abutment material; the method of fabrication (prefabricated, customized cast, customized copy-milled, customized computer-aided design/computer-aided manufacturing [CAD/CAM]); and color. In the studies examined, the majority of the restorations were cement-retained crowns. Survival was defined as the presence of a functioning implant abutment. Failure was the absence or complete loss of the abutment requiring abutment replacement.

From the 27 studies, there were a total of 951 anterior abutments. The mean failure of the abutments (external hex implants only) was 1.15%. The heterogeneity between locations, abutment type, abutment material and restoration retention made a cumulative survival rate impossible to calculate. The minimal number of anterior abutment fractures were restricted to the ceramic abutments (8 alumina; 3 zirconia).

Complications were classified as either mechanical or biological in nature. Mechanical complications included abutment screw loosening, found primarily in external hex abutments.

Common crown complications included
- Minor fracture/chipping of porcelain
- Loss of crown retention

Biological complications included fistulas and mucosal recession. Mucosal recession was most commonly seen with prefabricated titanium abutments.

Change in the color of the peri-implant soft tissue was the most commonly studied esthetic outcome. Spectrophotometric analysis revealed less peri-implant discoloration associated with zirconia abutments than with metal abutments. However, studies using subjective/objective scoring criteria of patient esthetic satisfaction revealed no difference between the 2 types of abutments.

The authors concluded that their findings’ clinical significance suggested that the selection of an implant with an internal connection and a customized metal abutment may have the fewest mechanical complications. Although clinical data regarding peri-implant mucosal discoloration were limited, the authors indicated that in patients with thinner mucosal tissues or those with a high smile, zirconia abutments may be preferable.


In the Next Issue:

- Immediate vs early nonocclusal loading of dental implants placed flapless
- Efficacy of flapless vs open flap implant placement in partially edentulous patients
- Implant outcomes of flapless procedures
- Partial edentulism rehabilitation after 3 years

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