Use of Ceramic Abutments

Implant restoration in the esthetic zone can present many challenges for the clinician. Patient and clinician demands for implant restorations with better esthetics have led to the introduction of ceramic abutments. With this introduction, questions have arisen regarding the properties of ceramic materials and their use in the fabrication of implant abutments. This issue of Report on Prosthodontics discusses the use of ceramic abutments.

Precautions for Use of Zirconia Implant Abutments

Zirconia was introduced as a ceramic material for implant abutments because of its superior mechanical properties. When combined with computer-aided design/computer-assisted manufacturing (CAD/CAM) systems, zirconia abutments and frameworks provide an excellent esthetic result. Because zirconia has physical and mechanical properties different from the titanium of the implant on which it will be placed, careful attention must be paid to the abutment design due to its brittleness.

Aboushelib and Salameh from Alexandria University, Egypt, and King Saud University, Saudi Arabia, examined 5 clinically broken zirconia implant abutments retrieved from patients' fractography to determine the crack's origin. The stress at failure was identified using fracture marks observed on the broken surface under a scanning electronic microscope (SEM). Signs of damage, such as:

- friction marks
- microcracks
- grain pull-out

were also used to determine the failure mechanism.

In 3 of the 5 specimens, the critical crack location was identified on the internal surface of the zirconia abutment where it made contact with the metallic screw head. SEM examination revealed...
the presence of friction and abrasion marks on the internal surface of the abutment and on the head of the abutment screw. The other 2 abutments fractured due to overreduction of the lateral wall, which resulted in a thin cross section at the site of fracture. Patient records indicated minor movement of the implant crowns requiring crown removal and tightening of the abutment screw. The clinicians reported difficulty related to the reinsertions of the metallic screw into the fitting surface of the zirconia abutments. Although zirconia in the laboratory has proven to be a very strong material because of its high surface hardness and brittleness, high stress may be generated at contact points between the ceramic and the titanium components. Rotational freedom (movement) of the abutment may give rise to high stresses, frictional surface changes, fatigue or screw loosening. The authors made 3 important points in their discussion of the results.

1 Carefully seat the abutment using torque control instrumentation to prevent destructive forces.
2 Use radiographic verification of proper seating prior to final tightening to ensure proper orientation of the assembly.
3 Avoid overreduction of the axial walls of the abutment; the minimal thickness should be .05–.07 mm.

A prosthodontist is best able to make decisions about when it is appropriate to use these types of abutments and has the technical skills to take the appropriate precautions.


Bending Resistance of Implant-supported Alumina and Machined Zirconia Abutments

As ceramic abutments have developed, several different ceramics have been used for their fabrication. Some abutments are prefabricated, some are slip-cast or dry-pressed, while others use computer-aided design/computer-assisted manufacturing (CAD/CAM) technology. Because ceramics are brittle, one of the concerns about their use is fracture resistance. Therefore, Sundh and Sjögren from Umeå University, Sweden, undertook a study to evaluate the bending resistance of zirconia implant-supported CAD/CAM abutments and manually shaped reinforced alumina abutments.

The study examined zirconia and titanium abutments in combination with titanium implants and stainless steel analogues (10 groups with 5 specimens per group). Stainless steel analogues were used because the modulus of elasticity is higher than that of titanium and should, therefore, resist bending forces better, thereby providing more information regarding the ceramic material. Titanium abutments attached to titanium screw-type implants were used as the control.

Table 1 lists the various products tested. The In-Ceram system (zirconia-reinforced alumina) was manually shaped by one dental technician. The Denzir M and Denzir were created using CAD/CAM from prefabricated ceramic blocks. Abutments were placed on titanium implants or stainless steel analogues and torqued to 35 Ncm; ceramic copies were cemented onto the abutments using RelyX Unicem. To create the worst-case scenario, the specimens were then subjected to compressive loading using a universal testing machine with loads applied perpendicular to the long axis.

The Denzir abutments delivered and cemented to heat-treated Denzir copies attached to stainless steel analogues had significantly higher bending resistance than the control group. The Denzir copies cemented to heat-treated Denzir M abutments attached to implant fixtures and the In-Ceram specimens attached to stainless steel analogues showed significantly lower bending resistance than the heat-treated Denzir copies bonded to Denzir abutments as delivered and attached to stainless steel analogues. No statistically significant differences were seen among the other groups.

Twenty-nine titanium abutment screws were deformed, and 6 fractured. All titanium implants bent. After testing, all ceramic copies were still bonded to the abutments, with the exception of 3 specimens. When the abutments were unscrewed, fractures were detected in all but 3 ceramic abutments. The fractures were detected at the abutment-implant (analogue) interface. Clearly, this is an area of high stress concentration.

All combinations of ceramic abutments and copies survived forces in excess of 300 N, the physiological maximum incisal
Table 1. Materials tested

<table>
<thead>
<tr>
<th>Abutment</th>
<th>Type of material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straumann solid screw implant (Institut Straumann AG)</td>
<td>Titanium</td>
</tr>
<tr>
<td>Straumann RN synOcta abutment for cement-retained crowns/bridges, 5.5 mm height (Institut Straumann AG)</td>
<td>Titanium</td>
</tr>
<tr>
<td>Straumann RN synOcta abutment, 2.5 mm height (Institut Straumann AG)</td>
<td>Titanium</td>
</tr>
<tr>
<td>Denzir M (Cad Esthetics AB)</td>
<td>Prefabricated densely sintered magnesia partially stabilized zirconia</td>
</tr>
<tr>
<td>Denzir (Cad Esthetics AB)</td>
<td>Prefabricated hot isostatic-pressed yttrium oxide partially stabilized zirconia</td>
</tr>
<tr>
<td>RN synOcta-In-Ceram (Vita Zahnfabrik)</td>
<td>Partially sintered, porous alumina structure reinforced with partially stabilized zirconia and infiltrated with molten lanthanum glass</td>
</tr>
</tbody>
</table>

Kirn et al from Yonsei University School of Dental Medicine, South Korea, compared a pressable metal-ceramic custom implant abutment with a CAD/CAM zirconia abutment to determine the efficacy of fabricating the metal-ceramic abutment and evaluate the fracture resistance of the 2 types of abutments.

Ten abutments were fabricated for each group. One group consisted of Procera Zirconia abutments (Nobel Biocare AB); the other group consisted of prepared metal abutments covered by lithium disilicate pressable ceramic abutment (IPS e.max Press; Ivoclar Vivadent). Twenty all-ceramic crowns were fabricated and bonded to the abutments using a resin luting agent. The crown-abutment specimens were then tested using a universal testing machine with a 5 N load at a 30° angle until failure.

The mean fracture load for the metal-pressable ceramic abutments was 901.67 ± 102.05 N. Five failures occurred as fractures around the lingual cervical areas resulting from deformation of the abutment screw. Failure from debonding between the metal and the pressable ceramic did not occur. The mean fracture load for the Procera abutment was 480.01 ± 174.46 N. Eight of these abutments failed in the cervical area of the abutment at the level of the screw head. Two abutments failed from abutment screw deformation in combination with ceramic fracture.

The fracture load in both groups exceeded that of normal occlusal loads in the anterior region of the mouth. The authors suggested that the higher fracture resistance might make pressable metal-ceramic custom implant abutments more suitable for patients with parafunctional habits. However, since static load testing is not relevant to the clinical performance of abutments, this recommendation should be questioned. A clinician’s expertise and judgment, combined with available scientific information, must guide treatment decisions.

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Comparison of Pressable Metal Ceramic Custom Abutments with CAD/CAM Zirconia Abutments

The strength of zirconia abutments under occlusal loads has been called into question. Although computer-aided design/computer-assisted manufacturing (CAD/CAM) zirconia has shown good mechanical properties in the laboratory, reports have suggested that microcracks induced by grinding may lower the strength of the material. These concerns have led to the alternative technique of casting the abutment in metal and then using a pressable ceramic to mask the metal.

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A Systematic Review of Ceramic and Metal Implant Abutment Performance

Fixed implant-supported crowns and fixed partial dentures are acceptable treatment options that now must include esthetic criteria as one of their outcome evaluations. A major esthetic limitation of metal abutments, particularly in the patient with a thin biotype gingiva, is the gray appearance of the peri-implant tissue. Recent advances in implant prosthodontics have involved the fabrication of ceramic abutments. However, concerns about fracture resistance and abutment survival rates have prompted further investigation into the use of this type of abutment.

Sailer et al from the University of Zurich, Switzerland, conducted a systematic review of studies relating to the performance of ceramic and metal implant abutments. Twenty-nine clinical studies met the criteria for inclusion in the analysis: 3 randomized clinical trials (RCTs) comparing ceramic and metal abutments; 1 RCT comparing titanium and gold abutments; 16 prospective studies; and 9 retrospective studies. The oldest of the studies was published in 1996. The studies included 5849 abutments (166 ceramic, 5683 metal) using 8 commercially available implant systems. Patients ranged in age from 14–88 years. The ceramic abutments had a mean follow-up time of 3.7 years; the metal abutments, 4.8 years.

The estimated 5-year survival rates for the ceramic and metal abutments were 99.1% and 97.4%, respectively. The estimated cumulative incidences of technical complications after 5 years were 15.9% for metal abutments and 6.9% for ceramic abutments. Abutment screw loosening was the most frequent technical problem. Annual fracture rates of all-ceramic crowns supported by ceramic abutments were similar to those of metal-ceramic crowns supported by metal abutments. Esthetic complications were more frequently observed with metal abutments. The cumulative biological complications after 5 years were estimated at 7.7% for metal abutments and 5.2% for ceramic abutments (Table 2).

This systematic review found no significant statistical differences in the clinical performance of ceramic and metal implant abutments. This may be a function of the small number of ceramic abutments included in these studies. However, although not statistically significant, there were fewer technical and esthetic complications with ceramic abutments, making the ceramic implant abutment a viable alternative to the metal implant abutment. These choices are best made by the prosthodontist, who will take into account all diagnostic information to determine the best treatment for the patient.


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### Table 2. 5-year summary estimates of metal and ceramic abutments

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Metal abutment n</th>
<th>5-year summary estimate (95% CI)</th>
<th>Ceramic abutment n</th>
<th>5-year summary estimate (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abutment loss</td>
<td>4807</td>
<td>2.6 (1.7-4.0)</td>
<td>166</td>
<td>0.9 (0.1-6.2)</td>
<td>.309</td>
</tr>
<tr>
<td>Abutment fractures</td>
<td>4025</td>
<td>0.07 (0.01-0.5)</td>
<td></td>
<td></td>
<td>.166</td>
</tr>
<tr>
<td>Abutment screw fractures</td>
<td>5083</td>
<td>0.8 (0.4-1.7)</td>
<td>112</td>
<td>0 (0-4.4)</td>
<td>&gt;.5</td>
</tr>
<tr>
<td>Technical complications</td>
<td>5483</td>
<td>15.9 (11.6-21.5)</td>
<td>166</td>
<td>6.9 (3.5-13.4)</td>
<td>.093</td>
</tr>
<tr>
<td>Biological complications</td>
<td>1876</td>
<td>7.7 (4.7-12.5)</td>
<td>166</td>
<td>5.2 (0.4-52)</td>
<td>.771</td>
</tr>
</tbody>
</table>

CI, confidence interval.