

# Prosthodontics

## NEWSLETTER

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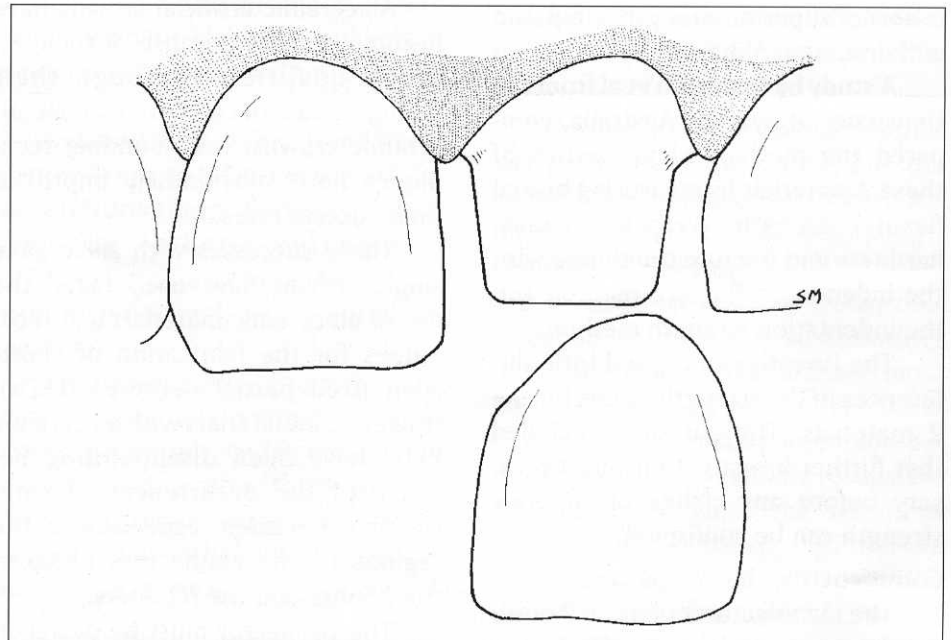
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The physical and mechanical properties of dental ceramics have steadily improved over the last 2 decades. This issue of *Prosthodontics Newsletter* reviews recent research on new ceramic materials and applications.

## New Developments in Dental Ceramic Technology

The physical and mechanical properties of ceramic restorative materials continue to improve, as does our knowledge of the expected clinical behavior of these materials. In the foreseeable future, ceramic materials and techniques may become attractive substitutes for many of our current restorative methods that incorporate metal in their design. This issue of *Prosthodontics Newsletter* reviews several recent research reports on prosthodontic applications of dental-ceramic technology.

### *In This Issue:*

- Mechanical Properties Of In-Ceram Alumina And In-Ceram Zirconia
- Connector Design of All-ceramic Fixed Partial Dentures
- Shading of Milled All-ceramic Crowns
- Resin Bond to Densely Sintered Alumina Ceramic
- Stresses in Single All-ceramic Premolar Crowns

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## Mechanical Properties Of In-Ceram Alumina And In-Ceram Zirconia

In-Ceram Alumina (Vita) is a glass-infiltrated ceramic material that has been used as a core material for all-ceramic restorations. A new material by the same manufacturer, In-Ceram Zirconia, has been introduced with claims of superior strength compared with In-Ceram Alumina.

A study by Guazzato et al from the University of Sydney, Australia, compared the mechanical properties of these 2 materials by measuring biaxial flexural strength, Weibull modulus, hardness and fracture toughness with the indentation fracture method and the indentation strength method.

The investigators found little differences in the strength values for the 2 materials. The authors concluded that further investigations are necessary before any claims of superior strength can be confirmed.

### Comment

The manufacturer of these 2 products has suggested the use of In-Ceram Alumina for anterior restorations only, but In-Ceram Zirconia was developed to potentially serve as a core material for posterior single crowns and 3-unit fixed partial dentures (FPDs). Results of this study suggest that this new material is unlikely to perform better than the alumina product.

Little is known about the clinical longevity of posterior FPDs made from all-ceramic restorative materials. Dentists should be very cautious when evaluating a manufacturer's claims concerning the indications for new ceramic restorative systems in the posterior regions of the mouth, especially suggestions for their use to fabricate posterior FPDs.

Guazzato M, Albakry M, Swain MV, Ironside J. Mechanical properties of In-Ceram Alumina and In-Ceram Zirconia. *Int J Prosthodont* 2002;15:339-346.

## Connector Design of All-ceramic Fixed Partial Dentures

All-ceramic artificial crowns have become popular because of their esthetic qualities. Although their strengths cannot compare with metal-ceramic crowns, resin-bonding techniques have substantially improved their success rates.

These successes with all-ceramic single crowns have encouraged the use of all-ceramic materials and techniques for the fabrication of short-span fixed partial dentures (FPDs). However, initial trials with all-ceramic FPDs have been disappointing because of the occurrences of catastrophic fractures, especially in the regions of the connectors between the pontics and the retainers.

The connector must be designed to reproduce the occlusal embrasure (OE) between natural teeth and to

avoid crowding of the interdental papilla. Consequently, there are occlusal and gingival "notches" in the connector that may cause stress concentrations, and the geometry of these notches may influence the strength of the prosthesis.

A study by Oh and Anusavice from the University of Florida compared the fracture strengths of all-ceramic FPDs as a function of the contours of the notches in the FPD connectors. Four FPD designs were evaluated in the study, based on the radii of curvature of the OE and the gingival embrasure (GE) of the connectors. Connector configurations, described as radii of curvature in mm, were: group I, OE 0.90 mm and GE 0.90 mm; group II, OE 0.90 mm and GE 0.25 mm; group III, OE 0.25 mm and GE 0.90 mm; and group IV, OE 0.25 mm and GE 0.25 mm (Figure 1).

The FPDs were bonded to epoxy-resin artificial teeth with Variolink II composite cement (Vivadent, Schaan, Liechtenstein). Specimens were loaded axially with a 14.3-mm diameter steel ball in a universal testing machine until fracture and fracture loads were recorded. After failure, the paths of crack propagation were evaluated microscopically.

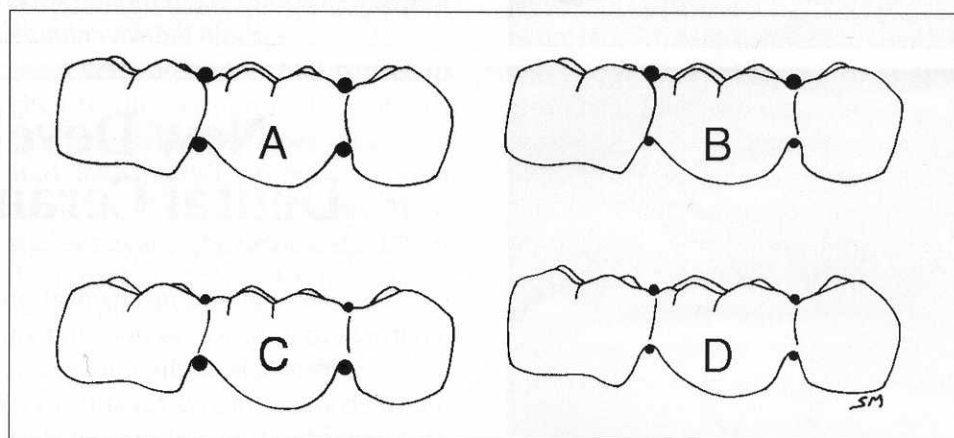
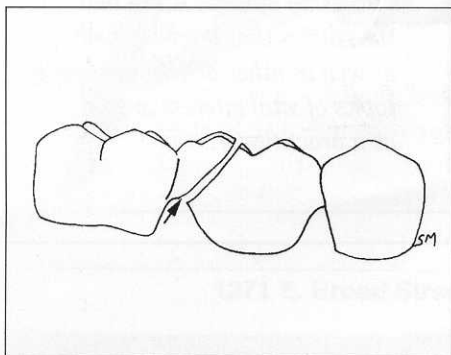


Figure 1. The 4 connector designs studied were: A (group I) OE 0.90 mm and GE 0.90 mm; B (group II) OE 0.90 mm and GE 0.25 mm; C (group III) OE 0.25 mm and GE 0.90 mm; and D (group IV) OE 0.25 mm and GE 0.25 mm.



**Figure 2.** Typical crack configuration originating at the GE and traveling obliquely to the occlusal contact area.

Mean failure loads were highest for the group with 0.90 mm OE and GE (group I), and lowest for the group with 0.25 mm OE and GE (group IV). Specimens with rounded GE (groups I and III) were statistically stronger than specimens with a sharp GE (groups II and IV). Fracture pathways were oblique gingivo-occlusally, traveling through the connector and pontic (Figure 2), and parallel bucco-lingually to the occlusal surface along the OE.

#### Comment

Results of this in vitro study suggest that the design of the GE is more critical than the design of the OE when fracture resistance is considered. The OE can be relatively sharp for maximal esthetics as long as the GE is designed with a more rounded contour.

Much is unknown about the prognosis for all-ceramic FPDs because there are very few clinical studies of these types of restorations. At this time, their inherent strength does not approach the strength of a metal-ceramic FPD. Further in vitro and in vivo studies are needed before these all-ceramic FPDs can be recommended for routine use.

*Oh W-S, Anusavice KJ. Effect of connector design on the fracture resistance of all-ceramic fixed partial dentures. J Prosthet Dent 2002; 87:536-542.*

## Shading of Milled All-ceramic Crowns

Computer-aided design/computer-assisted machining (CAD/CAM) has been used to fabricate all-ceramic dental restorations. Commonly, CAD/CAM procedures are used to make inlays for posterior teeth because the ceramic blocks used in the milling process are monochromatic. These monochromatic blocks are unlikely to produce acceptable esthetic results for artificial crowns on anterior teeth.

A clinical study by Reich and Hornberger from the University of Erlangen-Nuremberg, Germany, evaluated the esthetic outcome of CAD/CAM single crowns fabricated from experimental, multicolored ceramic blocks.

Ten patients who required a maxillary anterior single crown were included in the study, and 6 crowns were made for each tooth with the use of a CEREC 2 machine (Sirona, Bensheim, Germany). For each tooth, 1 crown was made with each of the following 6 methods:

- CEREC Vitablocs Mark II single-shade ceramic block (classical shades);
- CEREC Vitablocs Mark II 3-D Master Shade (single-shade) ceramic block;
- 1 of the above 2 blocks individually stained and characterized by a technician after milling;
- experimental multilayered ceramic Mark II block with 3 different layers of translucency;
- experimental leucite-ceramic block with 3 layers of translucency; and
- commercially available multishaded blocks (Megadenta, Radeberg, Germany).

The esthetic qualities of the resultant crowns were evaluated clinically and scored by 3 examiners. A scale of 1–6 was used to score the shade match and esthetics of each crown, with 1 representing a score of excellent and a score of  $\leq 3.5$  indicating the threshold for clinical acceptability.

In general, esthetic results with the multicolored ceramic blocks were disappointing. Only the individually stained restorations made from single-shade ceramic blocks obtained a mean score of  $< 3.5$  for all 10 patients.

#### Comment

The use of CAD/CAM techniques has promise for the future, but the esthetic limitations of the system are highlighted in this study. Machining a complete crown from a ceramic block will produce an artificial crown that does not mimic the surrounding teeth. This milled artificial crown must be custom-stained by the technician to achieve a reasonably acceptable esthetic match. Best esthetic results are likely achieved when the system is used to mill ceramic copings that are then hand-veneered with conventional fired ceramic materials.

*Reich S, Hornberger H. The effect of multicolored machinable ceramics on the esthetics of all-ceramic crowns. J Prosthet Dent 2002; 88:44-49.*

## Resin Bond to Densely Sintered Alumina Ceramic

The prognosis for an all-ceramic restoration depends on an enduring resin bond of the restoration to the tooth. A study by Friederich and Kern from the University of Ulm, Germany, evaluated the strength and durability of resin bonding to densely sintered aluminum oxide.

*Next:*

- New treatment options in prosthodontics
- Ceromer artificial crowns
- Twenty years of progress in implant dentistry in North America

*Our next report features a discussion of these issues and the studies that analyze them, as well as other articles exploring topics of vital interest to you as a practitioner.*

Five different combinations of surface treatments and bonding systems were applied to the aluminum-oxide surfaces. Bonding was accomplished with a dual-polymerizing bis-GMA composite (Adhesive Bond II/Twinlook, Heraeus Kulzer) and a phosphate-monomer composite (Panavia 21 EX, Kuraray). Specimens were ultrasonically cleaned in 96% isopropanol for 3 minutes and stored in distilled water at 37°C for 3 days. Additional specimens were stored in water for 150 days and thermocycled 37,500 times.

Regardless of the surface treatments used, only the specimens bonded with phosphate-monomer composite recorded an acceptable bond after the thermocycling procedure. The bonds for the groups with the bis-GMA composite failed spontaneously after thermocycling.

**Comment**

A number of studies have reported reduction in bond strength of restorations after thermocycling. This study suggests that phosphate-monomer composite can produce superior long-term results when bonding densely sintered aluminum-oxide restorations.

The investigators only evaluated the bond of the resin to the ceramic. Nevertheless, the bond to dentin, which is generally the weaker of the 2 bonds, is also an important factor.

This bond to dentin will also decrease with thermocycling.

*Friederich R, Kern M. Resin bond strength to densely sintered alumina ceramic. Int J Prosthodont 2002;15:333-338.*

## Stresses in Single All-ceramic Premolar Crowns

A finite element analysis (FEA) study of an all-ceramic premolar crown was conducted by Proos et al from the University of Sydney, Australia. The FEA model evaluated the stress magnitudes generated with 4 different core materials: (1) In-Ceram Alumina (Vita), (2) In-Ceram Zirconia (Vita), (3) In-Ceram Spinel (Vita) and (4) Alumina (Nobel Biocare).

A vertical load of 600 N was applied to the occlusal surface of each crown model, and stresses were evaluated. Radial tensile stresses predominated for all 4 crown systems. These stresses were approximately 17% of the reported fracture strength values of the coping materials.

**Comment**

This FEA investigation suggests that the inherent strengths of the 4 core materials studied are adequate to support an all-ceramic crown for a single premolar tooth. Although these

models shed light on the mechanical behavior of the materials studied, the models did not entirely mimic clinical conditions. For example, no cement layer was incorporated between the copings and the teeth. The strength of most all-ceramic crown systems can be improved substantially with the use of an adhesive resin cement that bonds the restoration to the underlying tooth structure.

Furthermore, the design of the study did not account for the effects of microcracks on stress distribution and propagation within the ceramic materials. Most catastrophic failures of all-ceramic crowns begin as microcracks in the fitted surface of the crown that eventually propagate to cause overt fracture. Internal grinding of the fitted surface of the crown by the dentist or technician can increase the number of microcracks and weaken the restoration.

*Proos KA, Swain MV, Ironside J, Steven GP. Finite element analysis studies of an all-ceramic crown on a first premolar. Int J Prosthodont 2002;15:404-412.*

*Do you or your staff have any questions or comments about Prosthodontics Newsletter? Please write or call our office. We would be happy to hear from you.*