A Professional Courtesy of:

Izchak Barzilay
D.D.S., Cert. Prostho., M.S., F.R.C.D.(C)

John P. Zarb
B.A., D.D.S., M.Sc. (Prostho), F.R.C.D.(C)

Howard F. Klaiman
D.D.S., Cert. Prostho., F.R.C.D.(C)

Effrat Habsha
B.Sc., D.D.S., Dip. Prostho., M.Sc., F.R.C.D.(C)

Vinay M. Bhide
B.ArtsSc.(Hons), D.D.S., M.Sc. (Perio), F.R.C.D.(C)

Hart J. Levin
D.D.S., F.R.C.D.(C), F.I.C.D.

2300 Yonge Street, Suite 905 • Box 2334 • Toronto, Ontario M4P 1E4
(416) 322-6862 • Fax: (416) 322-5282
www.buildyoursmile.com

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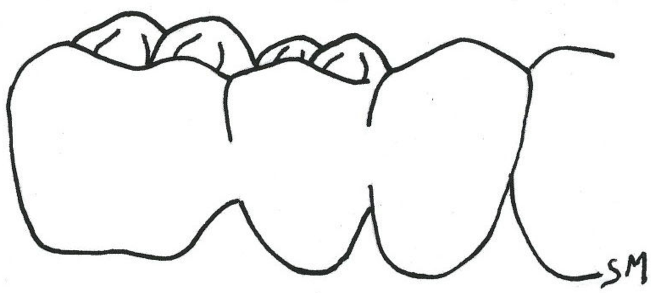

A clinical study evaluated the outcome of 65 posterior, 3-unit, all-ceramic fixed partial dentures. See CLINICAL EVALUATION OF THREE-UNIT ALL-CERAMIC FIXED PARTIAL DENTURES.

Physical Properties and Clinical Outcomes of Contemporary All-ceramic Restorative Systems

Ceramics are biocompatible and chemically stabile, but inherently brittle. Although Charles Henry Land introduced all-ceramic crowns more than 100 years ago, the crowns were not particularly popular because of their brittle nature. In the second half of the 20th century, metal crowns with ceramic veneers, referred to as metal-ceramic crowns, were introduced to improve the strength of the ceramics while still mimicking natural teeth with the porcelain veneer. More recently, all-ceramic restorative systems have been introduced with improved mechanical and optical properties. This issue of *Prosthodontics Newsletter* reviews a series of studies on contemporary all-ceramic materials and techniques.

Clinical Evaluation Of Three-unit All-ceramic Fixed Partial Dentures

In-Ceram Zirconia (Vita, Brea, Calif.) is a glass-infiltrated polycrystalline ceramic substructure for all-ceramic crowns and fixed partial dentures (FPDs). The polycrystalline component is alumina reinforced with 33% zirconia stabilized with cerium oxide. Its in vitro flexural strength is >500 MPa, and the manufacturer recommends this system for anterior and posterior 3-unit FPDs.

Eschbach et al from Christian-Albrechts University, Germany, conducted a clinical trial of posterior,

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Clinical Evaluation of Three-unit All-ceramic Fixed Partial Dentures

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3-unit In-Ceram Zirconia FPDs on 58 patients. Sixty-five FPDs were inserted to replace either a second premolar or a first molar. According to the recommendations of the manufacturer, the connectors for the premolars were 12 mm^2 and those for the molars were 16 mm^2.

Using computer-assisted design/computer-assisted manufacturing (CAD/CAM) technology, frameworks were milled from solid blocks of In-Ceram Zirconia with the Cerec 3 (Sirona, Chiswick, UK) system and were veneered with the appropriate ceramics. Minimal framework thickness was 0.7 mm axially and 1 mm occlusally. All FPDs were abraded with airborne particles and cemented with conventional glass ionomer cement. Mean observation time was 54.4 months (range, 24.0–67.5 months).

One patient was lost to follow-up. Cumulative survival rates were calculated with the Kaplan-Meier nonparametric method. Descriptive statistics evaluated clinical outcomes.

The calculated survival rate of the restorations after 60 months was 96.8%. Two restorations were lost: 1 from dental caries and 1 from fracture of the distal connector of the framework (Figure 1). The biologic and technical complication rate was 15.6% (10 FPDs). Four FPDs experienced fracture of the veneering ceramics (Figure 2).

Comment

The authors concluded that the performance of In-Ceram Zirconia FPDs compared favorably with that of metal-ceramic FPDs. The failure and complications of the In-Ceram Zirconia FPDs were similar to those reported in the literature for metal-ceramic FPDs.

These comparisons must be viewed with caution, because only 3-unit FPDs were placed and treatment occurred under optimal conditions. Because many retrospective studies of metal-ceramic FPDs were made without any control of the treatment provided and with varying lengths of follow-up time, comparison with these results may not be valid.

Eschbach S, Wolfart S, Bohlsen F, Kern M. Clinical evaluation of all-ceramic posterior three-unit FDPs made of In-Ceram Zirconia. Int J Prosthodont *2009;22:490-492.*

Figure 1. Fracture of connector between first molar pontic and second molar retainer (arrows)

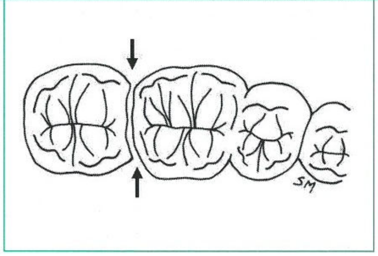
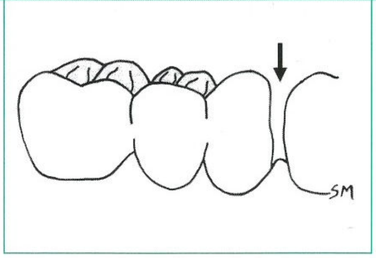


Figure 2. Fracture of veneering ceramics (arrow)



Subsurface Cracking Of Ceramic Materials

Ceramic materials are subject to fracture because of their brittleness. The microstructure of the ceramic material and its surface finish could potentially influence the magnitude of subsurface crack formation, as well as crack propagation.

Etman from the University of Saskatchewan, Canada, evaluated crack propagation in 3 ceramic materials with different microstructures: AllCeram (low-fusing feldspathic porcelain; Ducera Dental GmbH & Co. KG, Rosbach, Germany); Sensation SL (leucite-reinforced glass ceramics; Leach & Dillon Products, Cranston, R.I.); and IPS e.max Press (experimental glass ceramics with densely packed lithium disilicate crystals; Ivoclar Vivadent, Schaan, Liechtenstein).

Twenty cusp-shaped specimens of each ceramic material were prepared. Ten specimens in each group were glazed, and 10 were polished. Sixty antagonist specimens were prepared from the enamel of the facial surfaces of permanent human incisors. Specimens were attached to a wear-testing machine, arranged with the enamel at a 45° angle to the vertical movement of the abraders (ceramic specimens). The ceramic specimens slid across the enamel surfaces with a 2-mm path. Wear conducted in artificial saliva was induced for 80,000 cycles at 60 cycles/minute, with a load of 40 N.

All ceramic specimens were examined at baseline. Specimens were removed from the wear machine and examined at 5000, 10,000, 20,000, 40,000 and 80,000 cycles with an UltraVIEW Confocal Laser Imaging Microscopy System (CLSM; PerkinElmer, Salem, Mass.).

CLSM examination revealed varying microstructures and crack patterns for each of the 3 ceramic materials. After 80,000 cycles no IPS e.max Press ceramic specimens displayed cracks, but cracking occurred in AllCeram and Sensation SL ceramic specimens. After 80,000 cycles, cracks ≤70 µm in depth were evident in the Sensation SL specimens and ≤45 µm in the AllCeram specimens. Surface finish (glazed or polished) did not influence crack formation in the 3 materials.

Comment

After only 5000 cycles, subsurface cracks were noted on the Sensation SL and the AllCeram specimens. These cracks could continue to propagate in a clinical situation, resulting in eventual bulk fracture of the ceramic restoration.

The IPS e.max Press specimens displayed no cracks after 80,000 cycles, suggesting potentially better clinical performance than the other 2 materials. The IPS e.max Press specimens are filled with tightly packed crystals only a few micrometers in length, which likely prevented crack propagation. The IPS e.max Press specimens were fabricated by pressing molten ceramic material into a mold, which is likely to result in fewer internal flaws than with the hand build-up technique used for Sensation SL and AllCeram ceramics.

Etman MK. Confocal examination of subsurface cracking in ceramic materials. J Prosthodont *2009;18:550-559.*

Fracture Loads of Ceramic Crowns Under Wet and Dry Conditions

Fatigue fracture can occur in ceramic structures subjected to dynamic stresses, eventually leading to bulk fracture of the restoration. Along with the fracture resistance of a ceramic material, the properties of the luting agent can affect the longevity of a ceramic restoration. The environmental conditions under which the test was conducted (i.e., dry vs wet) also affect the strength of a ceramic specimen in vitro.

Borges et al from the University of Uberaba, Brazil, evaluated the effects of the test environment and luting agent on the fracture loads of fatigued ceramic specimens. A total of 180 bovine mandibular incisors were prepared for complete crowns made from 3 systems:

- In-Ceram Alumina (glass-infiltrated alumina ceramics; Vita Zahnfabrik, Seefeld, Germany)
- IPS Empress 2 (Lithia-disilicate-based glass ceramics; Ivoclar Vivadent, Schaan, Liechtenstein)
- Cergogold (leucite- reinforced glass-ceramic; Degussa Dental, Hanau, Germany)

For each ceramic system, 30 crowns were cemented with a composite resin cement (Variolink II, Ivoclar Vivadent) and 30 with a resin-modified glass ionomer cement (Rely X Luting, 3M ESPE Dental Products, St. Paul, Minn.). For each system and each cement, 10 specimens were loaded until fracture without prior fatigue loading. A second 10 of each system and each cement were subjected to cyclic fatigue loading and then loaded until failure in a dry environment. The final 10 of each system and each cement were cyclically fatigue tested and then loaded until failure in distilled water.

The fracture loads for all systems decreased significantly after fatigue loading, and crowns fatigued under water were significantly weaker than those fatigued in a dry environment. Crowns luted with composite resin cement recorded significantly higher fracture loads than those cemented with resin-modified glass ionomer cement. For all test conditions, fracture loads were not significantly different for In-Ceram Alumina and IPS Empress 2 crowns, but both systems recorded significantly higher fracture loads under all conditions than Cergogold crowns.

Comment

This study demonstrates that the interaction of many factors can influence the behavior of a ceramic material. The authors attempted to mimic intraoral conditions under which crowns were dynamically loaded in water as would occur in the mouth, and for all systems, strength degraded under these conditions. These results suggest that misleading results could occur in studies that perform load-to-failure tests without prior cyclic fatigue loading in a wet environment.

Borges GA, Caldas D, Taskonak B, et al. Fracture loads of all-ceramic crowns under wet and dry fatigue conditions. J Prosthodont *2009;18:649-655.*

CAD/CAM Single-tooth Restorations

Computer-assisted design/computer-assisted manufacturing (CAD/CAM) has resulted in new ways to fabricate all-ceramic restorations. When it was initially introduced to restorative dentistry, CAD/CAM dental technology was still in the developmental stages; however, this technology has dramatically evolved over the years.

A recent systematic review of the clinical performance of single-tooth CAD/CAM restorations by Wittneben et al from Harvard School of Dental Medicine, Massachusetts, searched articles from 1985 to 2007 to estimate clinical survival of these restorations. Restorations were followed for at least 3 years and were categorized as

- inlay/onlay
- core crown
- crown
- "endo" crown
- "reduced" crown
- veneer

An "endo" crown was used for an endodontically treated tooth that had lost all coronal tooth structure; the crown restored the tooth with an extension into a retentive cavity that represented the entire pulpal chamber. A "reduced" crown had a preparation height <3 mm.

A total of 16 articles representing 14 prospective and 2 retrospective studies were included in the review. The CAD/CAM systems included in the review were Cerec 1 (Sirona, Chiswick, UK), Cerec 2 (Sirona) and Celay (Mikrona AG, Spreitenbach, Switzerland). The mean exposure time was 7.9 years for 1957 restorations. The majority of the restorations were performed on posterior teeth. The calculated survival rate after 5 years was 91.6% (a failure rate of 1.75% per year).

There were no statistically significant differences among the failure rates of the 3 systems. The estimated failure rate was highest for endo crowns (3.90% per year), followed by that of reduced crowns (2.47% per year).

Although the difference between endo crowns and inlay/onlay restorations was statistically significant ($p = .026$), differences in outcomes with light-polymerized cements vs dual polymerized cements were not significant.

Comment

CAD/CAM technology allows the use of industrially prefabricated materials to be milled in a highly controlled fashion. The 3 systems studied were Cerec 1, Cerec 2 and Celay. There is currently a third generation of the Cerec system that is relatively new. At the time of the review, the authors could not find any long-term studies of single-tooth restorations with the use of the Cerec 3 system. Also, the Celay system is actually a copy milling system. At the time of the systematic review, these were the only 3 systems that the investigators could identify with at least 3 years of follow-up study.

The most common technical failure reported in the studies was fracture of the restoration or the tooth, and the most common biologic failures were dental caries and endodontic complications. Based on the results of this study, these single-tooth restorations appear promising.

Wittneben J-G, Wright RF, Weber H-P, Gallucci GO. A systematic review of the clinical performance of CAD/CAM single-tooth restorations. Int J Prosthodont *2009;22:466-471.*

In the Next Issue

- Implant–tooth-supported removable partial dentures
- Maxillary implant-supported overdentures
- Color stability of acrylic resin artificial teeth

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.

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.