

A Professional Courtesy of:



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

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

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

**T.T. Thuan Dao**  
D.M.D., M.Sc., Dip. Prosth., Ph.D., F.R.C.D.(C)

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

# PROSTHODONTICS™

## NEWSLETTER

WINTER 2009

### IN THIS ISSUE:

Clinical Outcome of  
Zirconia-based Fixed Partial  
Dentures

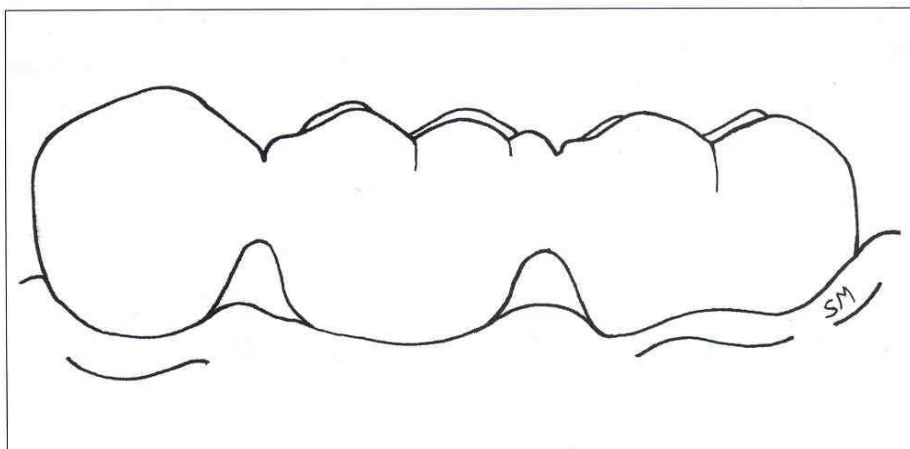
Fracture and Bond Strength of  
Bilayered Zirconia Restorations

Fracture Strength and Fatigue  
Resistance of  
All-ceramic Crowns

Fit of Zirconia-based  
Fixed Partial Dentures

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.

© 2009



A 5-year clinical study of zirconia-based, all-ceramic fixed partial dentures reported promising results. See *Clinical Outcome of Zirconia-Based Fixed Partial Dentures*, inside.

## CAD/CAM Technology in Fixed Prosthodontics

The acronym CAD/CAM stands for computer-aided design/computer-assisted manufacturing. First, a product is designed by using the CAD software. Then the design itself controls the manufacture (CAM) of the product. CAD/CAM has the potential to eliminate most human errors associated with hand-made prostheses and shows much promise for the fabrication of dental prostheses. This technology is especially useful for the manufacture of zirconia-based substructures for fixed dental prostheses. This issue of *Prosthodontics Newsletter* reviews a series of journal articles devoted to CAD/CAM applications in fixed prosthodontics.



## Clinical Outcome of Zirconia-based Fixed Partial Dentures

Zirconia is a popular substructure material for all-ceramic fixed partial dentures (FPDs). This very hard material can be milled with contemporary CAD/CAM technology. At this time, clinical data for the long-term outcome of these restorations are limited. One concern is the potential for fatigue of the zirconia substructure with time. Another potential problem is related to the quality and longevity of the veneering ceramics.

A 5-year prospective study by Molin from Umeå University, Sweden, and Karlsson from the Nordic Institute of Dental Materials, Norway, evaluated the clinical outcome of 19 3-unit zirconia-based FPDs in 18 patients. The FPD substructures were milled by using CAD/CAM technology. Solid, fully sintered, hot isostatic pressed yttria-partially-stabilized zirconia blocks (Denzir; Cad.esthetics) were used.

The substructures were milled to anatomic form with a minimal wall thickness of 0.5 mm. A feldspathic porcelain veneer (Vita Veneering Ceramic D; Vita Zahnfabrik) or a glass-ceramic veneer (IPS Empress; Ivoclar Vivadent) was used. Cross-sectional dimensions of the connectors were 3 × 3 mm. Ten FPDs were cemented with zinc phosphate cement (De Trey Zinc; Dentsply) and 9 with resin cement (Panavia F; Kuraray).

The FPDs were evaluated after 1 week, 1 year, 3 years and 5 years. The investigators evaluated all FPDs according to the California Dental Association's system for quality assessment of dental care, focusing on surface characteristics, color,

anatomic form and marginal integrity.

After 5 years, the survival rate was 100%, and all restorations were intact. One FPD that was cemented with Panavia F cement was dislodged after 12 months. This FPD was recemented with the same cement, without complications.

Surface roughness in the veneering porcelain was noted on 4 IPS Empress FPDs and 3 Vita D FPDs. Visible evidence of ditching at the margins was noted for 26% of all FPDs cemented with zinc phosphate cement at 5 years.

### Comment

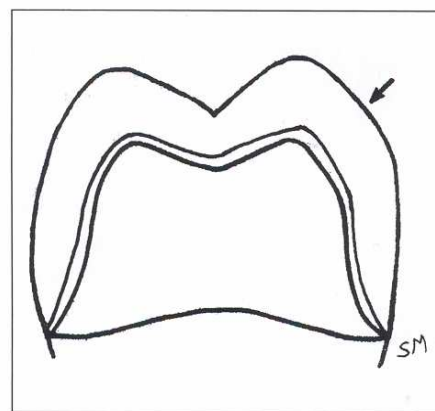
This study suggests favorable results with the materials and techniques used. A survival rate of 100% over a 5-year period is very impressive. It is important to note that the size of the connectors of all FPDs was 3 × 3 mm, considered optimal by most investigators.

The majority of the FPDs included posterior teeth; however, unlike other clinical studies, chipping of the veneering ceramics was not noted in this study. Only 3-unit FPDs were studied. Results with longer-span FPDs or with all-ceramic CAD/CAM FPDs made with other materials or techniques could be different.

*Molin MK, Karlsson SL. Five-year clinical prospective evaluation of zirconia-based Denzir 3-unit FPDs. Int J Prosthodont 2008;21:223-227.*

## Fracture and Bond Strength of Bilayered Zirconia Restorations

Substructures for dental restorations fabricated with CAD/CAM technology are commonly made from zirconia. These polycrystalline



**Figure 1.** A resin pattern of the planned form of the veneering ceramics (arrow) is seated on the zirconia coping.

ceramic substructures are then veneered with an esthetic porcelain. The CAD/CAM process is accurate, and cost effective; however, the veneering process is dependent on the skills of the ceramist.

Aboushelib et al from the Universiteit van Amsterdam and Vrije Universiteit, the Netherlands, evaluated the fracture strength and microtensile bond strength of zirconia substructures veneered by hand with conventional porcelain (IPS e.max Ceram; Ivoclar Vivadent) compared with substructures veneered with a new CAD/CAM method combined with a press-on technique (IPS e.max Zirpress; Ivoclar Vivadent).

For the fracture-strength tests, a mandibular right molar was prepared for a complete crown. The tooth preparation was then scanned (CYRTINA system; Oratio). Thirty-six identical zirconia substructures were milled with a thickness of 0.5 mm and sintered at 1450°C for 2 hours. Half the zirconia specimens were placed on the prepared die and scanned (CYRTINA CAD 20; Oratio). The design program was used to digitally design the desired contour of the veneering ceramics. A resin block (Matt



Carving Resin; Du-Matt) was then milled to the desired shape of the veneer.

The resin veneer replica was then seated on the zirconia substructure (Figure 1). The resin/zirconia assembly was invested (IPS pressVest; Ivoclar Vivadent), and the resin was burned out in a burnout furnace at 850°C for 60 minutes. Molten ceramics were pressed under vacuum into the mold. The remaining 18 zirconia substructures were veneered by hand and served as controls. Each specimen was bonded to a resin die and axially loaded until failure.

For the veneer bond strength tests, zirconia discs were veneered with the 2 types of ceramic as previously described. Microbars were cut from the discs. The bond strength was measured by delivering an axial load perpendicular to the bonded area. Scanning electron microscopy (SEM) was used to evaluate the quality of the zirconia/veneer interface.

Statistical analysis revealed that the fracture and bond strengths of the pressed specimens were significantly higher than those of the controls. SEM analysis revealed cohesive failure within the veneering ceramics for the pressed specimens and adhesive failure (delamination) for the control specimens.

#### Comment

The CAD resin pattern combined with the press-on technique is conducted under optimal conditions. The molten ceramic material is pressed against the zirconia under vacuum, producing a void-free interface. The hand-layering technique resulted in structural defects and air bubbles at or near the zirconia/veneer interface when viewed under SEM. Removal of the

human factor in the application of the veneering ceramic material appears to be the key to the favorable outcome. Results of this study suggest that this new veneering technology is superior to conventional methods.

*Aboushelib MN, de Kler M, van der Zel JM, Feilzer AJ. Effect of veneering method on the fracture and bond strength of bilayered zirconia restorations. Int J Prosthodont 2008; 21:237-240.*

## Fracture Strength and Fatigue Resistance of All-ceramic Crowns

The use of zirconia as a substructure material has been shown to enhance mechanical properties of an all-ceramic crown. The zirconia substructure is commonly fabricated by using CAD/CAM methods and then veneered with feldspathic veneering ceramics.

While the strength of the substructure has been reported to be high, the overall strength of the final restoration depends also on the strength of the veneering ceramics. Zahran et al from the University of Toronto, Ontario, evaluated the fracture strength and fatigue resistance of zirconia crowns and feldspathic porcelain crowns made with CAD/CAM technology.

An ivory mandibular molar replica was prepared to receive an all-ceramic crown with 1.5 mm of occlusal reduction, a minimum of 1 mm of axial reduction, and 6–8° total angle of convergence. With the prepared tooth used as a master die, 40 highly filled epoxy resin replicas were made.

An optical occlusal impression of the epoxy resin tooth replicas was made with the CEREC 3 intraoral camera (Sirona Dental Systems GmbH). Twenty monolithic crowns were milled from feldspathic porcelain (Vita Mark II; Vita Zahnfabrik), and 20 zirconia copings (In-Ceram YZ; Vita Zahnfabrik) were also milled by using the CEREC 3 milling unit. The In-Ceram YZ copings had an occlusal thickness of 0.7 mm and a circumferential wall thickness of 0.5 mm.

The zirconia copings were sintered and veneered with VM9 ceramics (Vita Zahnfabrik). All crowns were cemented to the epoxy resin tooth replicas with a resin cement (Panavia F 2.0; Kuraray America, Inc.). Ten crowns from each group were loaded until fracture by using a universal testing machine (Instron 8501), and 10 from each group were subjected to mechanical cyclic loading at loads ranging from 50–600 N for 500,000 cycles at a frequency of 20 Hz. After cyclic loading, the crowns were examined with a light microscope.

All of the Vita Mark II crowns survived the fatigue test without evidence of fractures or cracks. Four of the In-Ceram YZ crowns experienced fracture of the veneering porcelain, and the remaining crowns had cracks in the veneering porcelain. Nine of the 10 Vita Mark II crowns displayed total fracture of the crown after the fracture-strength test. All In-Ceram YZ crown fractures occurred within the veneering porcelain only. There was no statistically significant difference between the fracture loads of the 2 types of crowns.

#### Comment

An SEM examination of the In-Ceram YZ crowns revealed multiple



voids within the veneering porcelain. This study reported better fatigue strength compared with the In-Ceram YZ crowns. The Vita Mark II crowns were monolithic and milled from industrially manufactured porcelain blocks, which are likely to be free of such defects as internal voids and microcracks. With the In-Ceram YZ crowns, the substructures were milled from manufactured blocks, but the veneering porcelain was applied by hand. It appears that the weak link with the In-Ceram YZ crowns is the strength of the veneer, rather than the strength of the substructure. The Mark II crowns are made entirely by CAD/CAM technology, saving both time and labor costs. This type of crown seems to be a viable alternative to zirconia-based crown systems.

Zahran M, El-Mowafy O, Tam L, et al. Fracture strength and fatigue resistance of all-ceramic molar crowns manufactured with CAD/CAM technology. *J Prosthodont* 2008;17:370-377.

## Fit of Zirconia-based Fixed Partial Dentures

A study by Vigolo and Fonzi from the University of Padova, Italy, investigated the marginal fit of 4-unit FPDs made by 3 different CAD/CAM systems. An acrylic resin model of a maxillary dental arch was fabricated. The maxillary right canine and left central incisor were then prepared for all-ceramic

crowns. The maxillary right lateral and central incisors were missing.

The investigators used the Everest system (KaVo Dental GmbH), the Procera system (Nobel Biocare) and the Lava system (3M ESPE) to fabricate the 4-unit FPDs. There were 15 specimens in each of the 3 groups.

Marginal gap measurements were made on the mesial, distal, buccal and palatal surfaces of each abutment (total of 8 measurements per FPD). Clear landmarks had been placed on the canine and central incisor to ensure standardization of the location of the measurements. Measurements were made with a microscope (Axioskop) at 50× magnification, connected to a digital camera (Leica). Measurements with the program QWINLITE (Leica) were made 3 times:

- before porcelain application (time 0),
- after porcelain application (time 1) and
- after glazing the veneering porcelain (time 2).

Mean marginal gaps (µm) for the 3 systems were as follows:

- Everest system: 63.37 (time 0), 65.34 (time 1), 65.49 (time 2);
- Procera system: 61.08 (time 0), 62.46 (time 1), 63.46 (time 2); and
- Lava system: 46.30 (time 0), 46.79 (time 1), 47.28 (time 2).

Statistical analysis of the mean measurements indicated no statistically significant differences among the time periods of the measurements for each system. However, for

each landmark, the Lava system produced statistically significantly smaller mean marginal gaps when compared with the Everest and Procera systems.

## Comment

The use of CAD/CAM technology to fabricate multi-unit, all-ceramic fixed prostheses is relatively new. Although the Lava system produced the best marginal fit, all systems produced clinically acceptable marginal adaptation for the FPDs. The firing cycles for the veneering ceramics did not significantly affect the marginal adaptation of the prostheses. This result is contrary to most in vitro studies of metal ceramic FPDs. Generally, when the substructure is metallic, porcelain-firing cycles and glaze cycles did have an overall effect on the marginal fit of the prosthesis.

Vigolo P, Fonzi F. An in vitro evaluation of fit of zirconium-oxide-based ceramic four-unit fixed partial dentures, generated with three different CAD/CAM systems, before and after porcelain firing cycles and after glaze cycles. *J Prosthodont* 2008; doi:10.1111/j.1532-849X.2008.00366.x.

## NEXT:

- Accuracy of implant impressions
- Seating velocity and pressure within impressions
- Fracture resistance of zirconia implant abutments

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.