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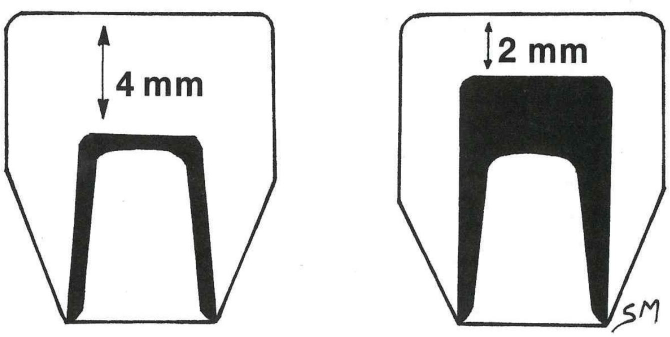

A study of metal-ceramic crowns evaluated the effect of 4 variables: incisal porcelain thickness (4 mm vs 2 mm) and type of alloy (noble vs base metal). See FAILURE RESISTANCE OF METAL-CERAMIC CROWNS.

Innovative Studies in Prosthodontics

Most areas of dentistry have advanced over the last 10 to 15 years as a result of new technology, but few areas have experienced the magnitude of innovation that the specialty of prosthodontics has seen. As new ideas, materials and techniques are introduced, new studies are necessary to ensure the potential for favorable outcomes for our patients. All that is new is not necessarily better. This issue of *Prosthodontics Newsletter* reviews innovative clinical and in vitro studies designed to test new ideas and materials in prosthodontics.

Retention of Pressed Ceramic Crowns

A recently introduced material for esthetic all-ceramic restorations, IPS e.max Press (Ivoclar Vivadent, Schaan, Liechtenstein) is a ceramic that has been reinforced with lithium disilicate crystals. This material can be heat-pressed by using the traditional lost-wax technique to form single crowns and fixed partial dentures (FPDs), and it possesses relatively high flexural strength (350–400 MPa). Heat-pressing avoids formation of internal flaws that can occur with sintered ceramics and simplifies the fabrication process compared with oven sintering.

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Inside this Issue

Retention of Pressed Ceramic Crowns

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All-ceramic crowns and FPDs are commonly cemented with adhesive luting agents that bond the restorations to the tooth preparations. Adhesive luting of the restoration increases the fracture resistance of the tooth as well as the restoration. To bond the restoration to the tooth structure, the intaglio surface of the crown is usually etched with hydrofluoric (HF) acid, followed by the application of a silane coupling agent prior to luting. An alternative surface treatment method involves airborne particle abrasion with aluminum dioxide particles modified with silica, followed by application of a silane coupling agent.

Madina et al from Mansoura University, Egypt, evaluated the retention of IPS e.max Press crowns conditioned with the traditional HF acid technique and with the airborne particle abrasion technique. The crowns were cemented to prepared extracted natural teeth with Panavia F 2.0 cement (Kuraray Medical Inc., Osaka, Japan). The teeth were prepared with 2 different taper angles, 10° and 26°, and each preparation was 3 mm in height.

Each crown was designed with an overhanging margin that allowed a universal testing machine to engage the overhang during the pull test. Cemented crowns were pulled off their tooth preparations parallel to the path of insertion with a crosshead speed of 10 mm/minute. The maximal force required to debond each crown was considered the retentive strength. Results indicated no difference in the retentive strengths with either surface conditioning method or taper angle (Table 1).

Table 1. Mean retentive strength (N ± standard deviations) of IPS e.max Press crowns

	10° taper angle	26° taper angle	*p* values
Silica coating and silanization	613 ± 190[a]	525 ± 90[a]	> .05
HF acid etching and silanization	550 ± 110[a]	490 ± 130[a]	> .05

Same superscript letters in a row indicate no significant differences (α = 0.05)

Comment

HF acid is caustic and considered hazardous. Based on the results of this study, the authors recommended the airborne particle abrasion technique over the HF acid-etching technique because retentive values were not significantly different. Nevertheless, these results should be viewed with caution. The specimens were not artificially aged with thermocycling and dynamic loading, so this experiment did not simulate clinical conditions. Retentive strengths are likely to reduce in vivo with crowns in normal function, and the differences in surface treatment and taper angle could make a difference over time.

Also, loss of retention is only one cause of failure of an all-ceramic crown. The airborne particle abrasion technique has the potential to cause microdamage to the intaglio surface of the crown. Any microcracks that form as a result of the abrasion process could propagate with time as a result of dynamic loading, resulting in bulk fracture and failure of the crown.

Madina MMA, Özcan M, Badawi MF. Effect of surface conditioning and taper angle on the retention of IPS e.max Press crowns. J Prosthodont *2010;19:200-204.*

Fracture Rate of Pressed Ceramic Crowns

Crown fracture has been reported as the most common complication with all-ceramic crowns, followed by loss of retention and pulpal problems. Heintze and Rousson from Ivoclar Vivadent, Liechtenstein, and the University of Lausanne, Switzerland, respectively, evaluated the clinical fracture rate of crowns fabricated with pressable, leucite-reinforced ceramics, IPS Empress (now known as IPS Empress Esthetic; Ivoclar Vivadent).

The authors searched the SCOPUS scientific abstract and citation database (Elsevier) for clinical studies involving IPS Empress complete crowns; the outcome of interest was fracture of the crown. Other causes of failure were not considered in the analysis.

Ten clinical studies were identified. After 3 studies were rejected for various reasons, 7 studies were included in the analysis. A total of 1487 crowns that had been luted with adhesive resin cement were included in the review (mean observation time, 4.5 ± 1.7 years), along with 81 crowns cemented with zinc phosphate cement (mean observation time, 1.6 ± 0.8 years).

The largest number of crowns was placed on incisors (40.1%), followed by premolars (27.5%), molars (24.1%) and canines (8.2%). Fifty-seven (3.8%) of the adhesively luted crowns fractured. The majority of fractures (62%) occurred between the third and sixth year of service. The rates of fracture differed significantly, depending on the crown's location. The hazard rate for incisors was calculated to be 0.005, which means that an estimated 5 out of every 1000 incisor crowns would fracture annually. For the other locations, 12 canine crown fractures, 7 premolar crown fractures and 16 molar crown fractures can be expected annually per 1000 crowns. Only 1 tooth (a molar) cemented with zinc phosphate cement fractured.

Comment

In general, the fracture rate for IPS Empress crowns was low for incisors and premolars but higher for canines and molars. Although only 1 crown cemented with zinc phosphate cement fractured, the sample size was small (81 crowns) and the follow-up time was short (1.6 ± 0.8 years). Because the majority of the fractures in the review occurred between the third and sixth year of service, no conclusions can be drawn concerning the outcome of crowns cemented with zinc phosphate cement.

The flexural strength of IPS Empress ceramics has been reported to be approximately 160 MPa. IPS e.max Press ceramics have reported flexural strength of 350–400 MPa, more than double the strength of the IPS Empress material. The use of IPS e.max Press ceramics might offer a better prognosis for canines and molars; however, this material is relatively new, so definitive long-term data are lacking at this time.

Heintze SD, Rousson V. Fracture rates of IPS Empress all-ceramic crowns—a systematic review. Int J Prosthodont *2010;23: 129-133.*

Effect of Cuspal Inclination on Stress Distribution with Implant-supported Crowns

Implant dentistry has revolutionized prosthodontic treatment; however, these restorations are not trouble free. The biomechanical aspects of implant-supported restorations are different from those of natural teeth because implants lack a periodontal ligament. Therefore, it is important to ensure favorable distribution of occlusal loads to the prosthesis, the implant and the surrounding bone.

A finite element analysis (FEA) of implant-supported molar crowns was conducted by Falcón-Antenucci et al from São Paulo State University, Brazil. Three-dimensional models of a section of mandibular bone, an implant and a crown were developed. The bone block (25.46 mm high, 13.81 mm wide and 13.25 mm thick) was designed to represent a section of trabecular bone surrounded by 1-mm-thick cortical bone. The dental implant, 3.75 mm in diameter and 10 mm in length, was designed with screw threads.

The simulated screw-retained, implant-supported molar crowns were designed with 3 cuspal inclinations: 10°, 20° and 30°. The crowns were made of a nickel-chromium alloy with a 2-mm thick porcelain veneer on the occlusal surface. The measurements of the molar crown were taken from a dental anatomy atlas. Young's modulus and Poisson's ratio of all materials were incorporated into the design of the structures. All materials were assumed to be linearly elastic, homogeneous and isotropic.

Table 2. Maximum stress values (MPa) in the cusp inclinations analyzed

Model	10°	20°	30°
Cortical bone	28.23	27.98	22.51
Implant	115.60	137.18	160.68

A 45° oblique load of 200 N was applied to each crown design, and stresses were mapped. Maximal stress areas occurred at the point of load application. Stress propagated from the interface between the crown and retaining screw to the first or second thread of the implant. The implant showed higher stress values on the crown with the 30° cusp (160.68 MPa); the stresses on the cortical bone (occurring primarily at the neck of the implant) were higher on the crown with the 10° cusp (Table 2).

Comment

The results of this study suggested that the use of a 30° cusp on a mandibular molar will improve the biomechanics and potentially reduce cortical bone loss. However, because the amount of stress reduction in the cortical bone was minimal (28.23 MPa for a 10° cusp vs 22.51 MPa for a 30° cusp), it is unknown whether this small reduction in stress has any clinical relevance. Also, molars are commonly supported by wider-diameter implants. Studies have shown that increasing the diameter of the implant can significantly improve the biomechanics of a mandibular molar crown. Results would likely be different if the FEA study design included a 5-mm-diameter implant as well.

Falcón-Antenucci RM, Pellizzer EP, Perri de Carvalho PS, et al. Influence of cusp inclination on stress distribution in implant-supported prostheses. A three-dimensional finite element analysis. J Prosthodont *2010;19:381-386.*

Failure Resistance of Metal-ceramic Crowns

Metal-ceramic crowns are commonly used to restore natural teeth and dental implants. In some clinical situations, the occluso-gingival height of the tooth preparation or implant abutment is shorter than optimal, leading to a relatively thick layer of incisal veneering porcelain.

Geminiani et al from the University of Rochester Eastman Dental Center, New York, conducted a study evaluating the influence of the thickness of incisal veneering porcelain on the failure resistance after cyclic loading. Thirty metal-ceramic crowns were fabricated with each of 2 alloys:

- a high noble alloy (Leo; Ivoclar Vivadent AG)
- a base metal alloy (Pisces Plus; Ivoclar Vivadent AG)

Veneering ceramics (IPS Classic; Ivoclar Vivadent AG) was applied with 2 different incisal thicknesses: 2 mm and 4 mm (see cover illustration). This combination of variables resulted in 4 groups ($n = 15$).

Crowns were cemented to implant abutments with a resin cement (PANAVIA 21; Kuraray Medical, Inc.). After cementation the crowns were thermocycled and cyclically loaded (load = 49 N) for 2,000,000 cycles or until failure. The specimens were then evaluated for any cracks and/or bulk fracture, and scored with the naked eye as "success," "survival" or "failure." Success was defined as an unaltered ceramic surface free of bulk fracture or cracks; survival was defined as a cracked ceramic surface confined to the lingual aspect of the crown; and failure was defined as a facial surface crack or bulk fracture. Specimens without bulk fracture were then loaded along the long axis of the crown at the incisal edge in a universal testing machine until failure.

Results indicated a significantly higher success rate for high noble metal-ceramic crowns after cyclic loading compared with the base metal-ceramic crowns. Specimens with 2 mm of incisal porcelain recorded a higher success rate than did those with 4 mm of incisal porcelain. When the incisal porcelain was 2 mm in thickness, the type of alloy did not significantly affect success rate. For the load-to-failure tests, the crowns with 2 mm of incisal porcelain recorded higher mean loads than did the crowns with 4 mm of incisal thickness.

Comment

Results of this study confirm that the thickness of the incisal porcelain and the type of alloy used can affect the overall success rate of metal-ceramic crowns. Crowns with a 2-mm thickness of incisal porcelain and crowns made from noble alloy were less prone to cracking and bulk fracture. Results are applicable only for the materials studied and may not be applicable for other brands of noble and base metal alloys or with other brands of veneering porcelains.

Geminiani A, Lee H, Feng C, Ercoli C. The influence of incisal veneering porcelain thickness of two metal ceramic crown systems on failure resistance after cyclic loading. J Prosthet Dent *2010;103:275-282.*

In the Next Issue

- Ten-year crossover clinical trial of implant-supported overdentures
- Fracture resistance of implant-supported single crowns
- Implant-supported, complete-arch zirconia fixed dental prostheses

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.