the Journal of Contemporary Dental Practice at www.thejcdp.com
Volume 6 Number 4 November 15, 2005 Fall Issue

Load-to-fracture Value of Different All-ceramic Crown Systems

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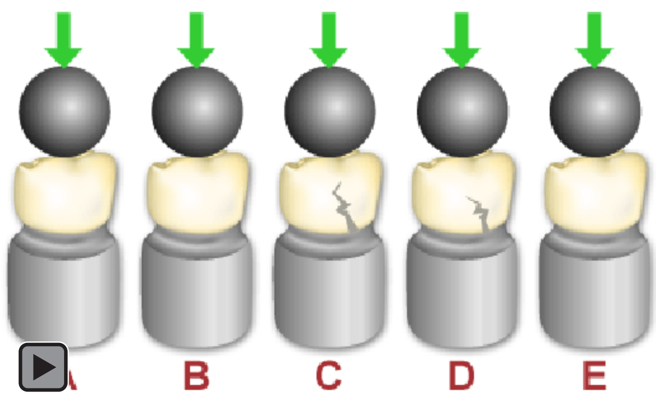

Abstract

Objectives: The purpose was to investigate the potential difference in the load-to-fracture values of several all-ceramic crown systems. Five different coping-reinforced all-ceramic crown systems were selected. Ten crowns from each system were fabricated and luted to standardized titanium dies.

Methods: The study consisted of five groups of ten samples each, all luted using G.C. Link Max resin adhesive cement. Group A: IPS Eris®, Group B: Cerac® In-lab Alumina coping, Group C: Cerac® In-lab Zirconia coping, Group D: Procera® AllCeram Alumina coping, and Group E: Procera® Zirconia coping. Following cementation, the samples were placed under a 5 Kg static load for 10 minutes insuring proper seating and stored in 100% humidity for one week. All samples were visually inspected prior to testing and were loaded to fracture at the rate of 0.5 mm/min using a universal-testing machine.

Results: Group A = 321.49 KgF ± 113.69 (S.D.), Group B = 288.63 ± 102.82 (S.D.), Group C = 266.58 ± 69.17 (S.D.), Group D = 295.49 ± 80.54 (S.D.), and Group E = 420.37 ± 82.45 (S.D.). The data were analyzed using an unpaired t-test; this indicated a statistical difference between group E and all of the others (P-value ≤0.039).
Conclusions: We concluded under these conditions, the Procera® Zirconia crown system has significant higher load-to-fracture value than several other all-ceramic crown systems.

Keywords: All-ceramic crowns, crown systems, coping-reinforced, load-to-fracture

Citation: Snyder MD, Hogg KD. Load-to-fracture Value of Different All-ceramic Crown Systems. J Contemp Dent Pract 2005 November;(6)4:054-063.

Introduction

With the increased patient demand for esthetic restorations, full coverage all-ceramic crowns have become very popular with both clinicians and patients because of their highly esthetic results. All-ceramic crowns are routinely placed not only in the anterior esthetic zone but also in the posterior where they are subject to greater occlusal forces and stress from cyclic loading.

As the demand for more natural-looking crowns has increased, dentists and porcelain manufacturers have investigated a number of methods to help reinforce ceramics with the goal of fabricating an all-ceramic restoration that delivers excellent esthetics and good biocompatibility. These restorations additionally need to have sufficient strength to allow its use as a single crown anywhere in the mouth.

With the number of all-ceramic crown systems available, the question arises; is there a significant difference between the various systems in the amount of occlusal force the crown can withstand without failure?

To begin investigating this question, a study was completed testing the load-to-fracture strength of five different coping reinforced all-ceramic crown systems. The five groups were as follows: IPS Eris® Lithium disilicate coping, Cerac® In-lab Alumina coping, Cerac® In-lab Zirconia coping, Procera® AllCeram Alumina coping, and Procera® Zirconia coping.

Materials and Methods

The purpose of this study was to investigate the difference in fracture strength of five different all-ceramic crown systems. The ultimate load-to-fracture strength of the all-ceramic crowns, when luted with G.C. Link Max resin adhesive cement (G.C. America Inc., Alsip, IL), was used as the determining factor for this study (Figure 1).

For this investigation, fifty Grade 2 titanium standardized dies, pre-milled to the dimensions of a lower molar crown, were obtained (Figure 2). Twenty of the dies were scanned following the protocol outlined by Procera®, using CAD/CAM technology (Nobel Biocare USA, Inc., Yorba Linda, CA) (Figure 3).

Figure 1. G.C. Link Max resin adhesive cement. (G.C. America Inc., Alsip, IL)

Figure 2. Grade 2 titanium standardized die with corresponding Procera® Zircoia coping.

Figure 3. Computer setup for use with the Procera®, scanning protocol using CAD/CAM technology. (Nobel Biocare USA, Inc., Yorba Linda, CA)

The data files were then sent to their laboratory in New Jersey where ten alumina copings and ten zirconia copings were fabricated and returned.[1] Twenty additional dies were scanned utilizing the Cerac® In-lab equipment (Sirona, Charlotte, NC). The margins of these dies were marked, and the copings were milled in the University of

Computerized Dentistry Unit.[2] Ten copings were milled from Inceram Alumina blocks (Vita) and ten from Inceram Zirconia blocks (Vita). The milled copings were then glass infiltrated as specified by the manufacturer (Figure 4). The last ten dies were sent directly to Dental Art Laboratory of Lansing, MI for fabrication of IPS Eris, lithium disilicate copings (Ivoclar/Vivadent Inc., Amherst, NY) using the lost wax, pressed glass technique.[3] Upon completion, all copings were visually inspected under 2.5x magnification and matched to their specific titanium die (Figure 5).

All of the copings were then sent to Dental Art Laboratory for the application of the veneering porcelain. The specific instructions and materials recommended by each crown system were utilized in the respective fabrication of their crowns. One technician fabricated all of the crowns to maintain uniformity. The technician was given a replica of the head of the Instron universal testing machine to keep the contact zone at the loading point as uniform as possible in the completed crown.

Additionally, the technician was instructed to keep the porcelain and coping thickness standard for all fifty samples. Upon completion of the crowns, all samples were visually inspected under 2.5x magnification, measured for thickness on the center of the buccal, occlusal, and lingual surfaces, and then matched to their specific die (Figure 6).

All of the crowns were then luted to their respective titanium die using G.C. Link Max resin adhesive cement. The cement was mixed according to the manufacturers' instructions and placed into the crowns with a sponge-tip applicator. The crowns were then luted to the titanium dies (Figure 7).

The excess cement was removed, and the crowns were placed under a load of 5 kg for 10 minutes to ensure proper seating. The cemented crowns were stored in 100% humidity, following cementation, until the time of testing one week later. At the time of testing, all fifty samples were again visually inspected using 2.5x magnification and found to be free of any detectable fractures.

Figure 4. Hot Cerac® In-lab copings following glass infiltration process. (Sirona, Charlotte, NC)

Figure 5. All ceramic crowns matched with respective dies.

Figure 6. Crowns being measured for thickness on the center of the buccal, occlusal, and lingual surfaces.

The samples were divided into five groups:

- Group A – IPS Eris® Lithium disilicate coping
- Group B – Cerac® In-lab Alumina coping
- Group C – Cerac® In-lab Zirconia coping
- Group D – Procera® AllCeram Alumina coping
- Group E – Procera® Zirconia coping

The samples were then loaded to fracture at the rate of 0.5 mm/min using an Instron (Instron Corporation, Canton, MA) universal testing machine (Figures 8 and 9).

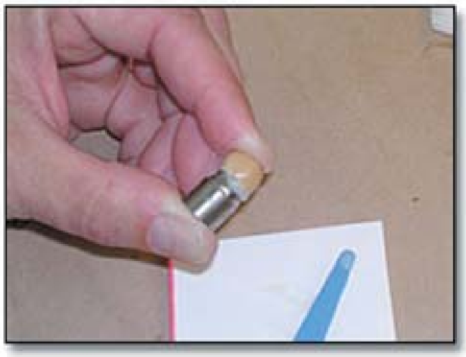

Figure 7. Crown luted to a titanium die.

Figure 8. An Instron (Instron Corporation, Canton, MA) universal testing machine.

Figure 9. Fractured crown on titanium die.

Results

In this study fifty all-ceramic crowns were divided into five groups of ten samples each based upon their crown system and coping type. The crowns were luted to titanium dies using G.C. Link Max resin cement. The crowns were loaded to fracture and the load-to-fracture value was obtained for each sample. The mean load-to-fracture value for each group is as follows: (Figure 10 and Table 1)

- Group A = 321.49 KgF ± 113.69 (S.D.)
- Group B = 288.63 KgF ± 102.82 (S.D.)
- Group C = 266.58 KgF ± 102.82 (S.D.)
- Group D = 295.49 KgF ± 80.54 (S.D.)
- Group E = 420.37 KgF ± 82.45 (S.D.)

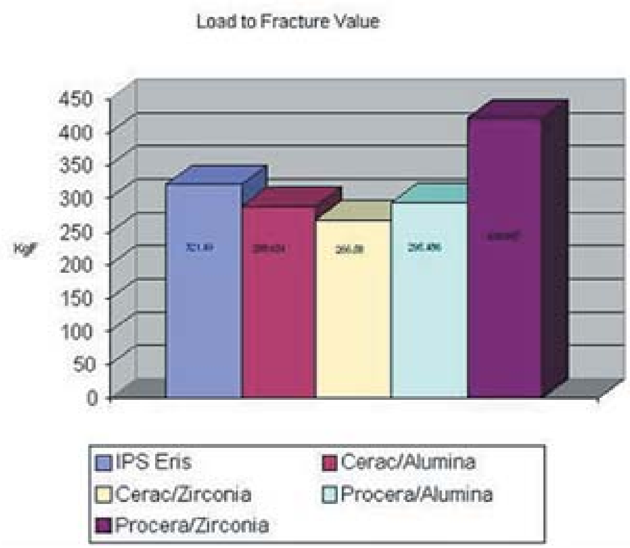

Figure 10. Load-to-fracture values.

Statistical significance was determined at a level P≤ 0.05. The unpaired t-test was applied to the data, which indicated there was a statistical difference between Group E (Procera/Zirconia) and all of the other groups. All of the remaining groups were not statistically different.

Discussion

Patient and dentist emphasis on esthetics has increased dramatically in the last several years resulting in the creation of a number of all-ceramic crown systems. As the interest for esthetic restorations grows, more and more patients are requesting all-ceramic restorations. Translucency, light transmission, and good

Table 1. Unpaired t-test for load-to-fracture in KgF.

Comparison	Mean Diff.	P-Value
IPS Eris, Cerac/Alumina	32.856	0.5195
IPS Eris, Cerac/Zirconia	54.91	0.2271
IPS Eris, Procera/Alumina	26.004	0.5624
IPS Eris, Procera/Zirconia	-98.875	**0.039 ***
Cerac/Alumina,Cerac/Zirconia	22.054	0.6007
Cerac/Alumina,Procera/Alumina	-6.852	0.8727
Cerac/Alumina,Procera/Zirconia	-131.731	**0.0066 ***
Cerac/Zirconia,Procera/Alumina	-28.906	0.4157
Cerac/Zirconia, Procera/Zirconia	-153.785	**0.0004 ***
Procera/Alumina, Procera/Zirconia	-124.879	**0.003 ***

* indicates statistically significant value

biocompatibility give dental ceramics excellent esthetic properties. However, the brittle characteristics of dental porcelains, which are basically non-crystalline glasses composed of structural units of silicon and oxygen, have traditionally limited the use of these materials.[4] The advent of the porcelain fused to metal (PFM) crowns provided better mechanical properties due to the metal coping reinforcing the dental porcelain, but did so at the expense of esthetic properties. Recently a number of new all-ceramic crown systems with ceramic, rather than metal, copings have been developed with the intent of providing good mechanical performance as well as superior esthetic results.

With the number of all-ceramic crown systems available on the market today the question arises; is there a significant difference between the various systems in the amount of occlusal force the crown can withstand without failure? This would be valuable information when selecting between different systems for various applications. The intent of this study was to determine if there were indeed differences in load-to-fracture values of five all-ceramic systems.

Studies on this topic have shown a number of variables influence the mechanical properties of dental ceramics. Important test parameters include: specimen thickness, contact zone at loading, homogeneity and porosity of the material, and loading rate.[5] Steps were taken to reduce the chance these variables, and not the materials themselves, would influence the outcomes of the load-to-fracture values. One lab technician placed all of the veneering porcelain on all of the samples with instructions to maintain a uniform thickness. Copings were fabricated according to the requirements for coping thickness of the specific system. The technician used a replica of the Instron machine head to create a uniform contact zone in each crown. All crowns were fabricated using the respective manufacturer's specifications and materials. Finally, the loading rate was held constant at 0.5 mm/min using the Instron machine.

As can be seen by the results, a significant difference between the mean load-to-fracture value of the Procera® Zirconia coping crown system and all of the other systems exists. In addition, three samples of the Procera® Zirconia coping crown group exceeded the loading parameters of the Instron machine set for this study and did not fracture. This then indicates the mean load-to-fracture value for group E would actually have been higher then reported had the load been applied until fracture occurred. This data suggests the Procera® Zirconia coping crown system provides the best mechanical properties among the all-ceramic crown systems included in the study. The remaining sample groups did not show a statistically significant difference; however, the mean load-to-fracture values themselves may provide an indication of slight differences among the groups.

Conclusion

Based on the conditions of this study, the following conclusions can be made. The load-to-fracture values of the Procera® Zirconia coping crown system was the only all-ceramic system to show significantly higher load-to-fracture values then all other systems tested in this study. Additional research is needed in this area to provide data to practitioners on the strength of other all-ceramic crown systems available for clinical use.

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Acknowledgements

The authors are grateful for the support provided for this study by the University of Michigan Nobel Biocare Center for Excellence, the University of Michigan Computerized Dentistry Unit, and the Dental Art Laboratory in Lansing, MI.