Aggressiveness of Preparation Necessary for the Passive Fit of Anterior and Posterior Zirconia Restorations in the Primary Dentition

<table>
<thead>
<tr>
<th>Journal:</th>
<th><em>Pediatric Dentistry</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuscript ID:</td>
<td>PediaD-2015-07-3683</td>
</tr>
<tr>
<td>Manuscript Type:</td>
<td>Scientific (In vitro, animal)</td>
</tr>
<tr>
<td>Study Design:</td>
<td>Laboratory or Animal Study</td>
</tr>
<tr>
<td>Keyword: Search for keywords from the website link above.:</td>
<td>pediatric dentistry, zirconium, crowns</td>
</tr>
<tr>
<td>Reviewer Selection Topics:</td>
<td>dental materials/biomaterials, infant oral health/early childhood caries, restorative dentistry</td>
</tr>
</tbody>
</table>
Aggressiveness of Preparation Necessary for the Passive Fit of Anterior and Posterior Zirconia Restorations in the Primary Dentition

Abstract

Purpose: Determine if the aggressiveness of tooth preparation of zirconia restorations varies across four crown brands in the primary dentition.

Methods: 100 primary typodont teeth were divided into 5 groups (of 10 samples each) for both anterior and posterior preparations: Cheng Crown (CC), EZ Pedo (EZP), Kinder Krown (KKZ), NuSmile (NSZ), and stainless steel crowns (SSCs). Teeth were weighed prior to preparation, were prepared by one operator, and weighed post-preparation. Weight changes served as a surrogate measure of the aggressiveness of tooth preparation required for each brand’s crown.

Results: ANOVA showed a significant difference among brands in both the anterior and posterior. Tukey’s HSD test applied to anterior data revealed that SSCs required significantly less tooth structure removal compared to the composite of the four zirconia brands, which showed no significant difference among them. Tukey’s HSD test applied to posterior data revealed CC required significantly greater removal of crown structure while EZP, KKZ, and NSZ were statistically equivalent, and SSCs required significantly less removal.

Conclusions: Zirconia crowns require more tooth reduction than SSCs. The amount of tooth reduction necessary for proper fit of the zirconia crowns differed statistically for posterior teeth, but the differences would not be clinically relevant.

Introduction

The Rocky Mountain Company introduced stainless steel crowns (SSCs) to pediatric dentistry in 1947. For decades they have outperformed other materials such as amalgam and composite to become known as the least likely restoration to require
retreatment. While durability is a significant advantage of this restoration, the esthetic outcome is not. In 2005, Woo et al. conducted a survey of dental professionals and parents and found that individuals within all groups questioned perceived anterior SSCs as esthetically unacceptable. Clinicians are encountering increased parental demands for esthetic restorations in the pediatric dental office. As parental involvement in the clinical decision-making process continues to increase, so does the necessity of providers to stay abreast of emerging esthetic techniques and treatment options. For over 30 years, the dental material sciences have spearheaded research into esthetically pleasing restorative materials that would meet or surpass the clinical properties of materials currently in use.

Today the dental practitioner has various options for the esthetic restoration of primary teeth with each technique providing its own sets of advantages and disadvantages based on technical, functional, and esthetic limitations. Open-faced SSCs provide an esthetic option but are limited by chair time, use of multiple materials, isolation requirements, and lack of published clinical data supporting their retention or durability. In 2010, a survey of pediatric dentists showed that only 4% of those surveyed consider this technique as their first choice. While celluloid strip crowns provide a highly esthetic option resulting in the establishment of more natural tooth contours, they are considered extremely technique sensitive by professionals due to the need for adequate isolation and high documented failure rates. The esthetic facings and decreased technique sensitivity of preveenered SSCs have allowed this restoration to gain favor over the last 25 years. Because these crowns are preveenered with esthetic facings, chair time and materials are reduced compared to open faced SSCs thus providing a convenient esthetic option for many practitioners. Today, these restorations are used commonly among pediatric dentists with parents reporting a high level of satisfaction; however, loss of facial resin can occur.
Prefabricated zirconia crowns are a comparatively newer treatment alternative that allows practitioners to provide patients with superior, highly polished, esthetic results.\textsuperscript{4, 5}

Pediatric zirconia crowns were first manufactured by EZ-Pedo Inc., and became commercially available in 2008. Currently there are at least 4 commercial brands available, each with unique biomechanical properties (Table 1).\textsuperscript{12-16} While long term clinical research of primary zirconia full coverage restorations is lacking, it is known that these restorations have mechanical properties similar to metal, cannot be manipulated with crimping or contouring, require a passive fit and thus extensive tooth structure reduction, and have documented short term retention rates as high as 100\%.\textsuperscript{4, 7, 17}

According to Oueis et al., the greatest concerns for dentists providing full coverage esthetic restorative options are crown durability and the need for extensive reduction of tooth structure.\textsuperscript{8} Individual manufacturers of esthetic zirconia primary crowns readily state that their products require more tooth reduction when compared to alternative non-esthetic SSCs.\textsuperscript{12-16} The purpose of this study was to determine if one or more brands of zirconia crowns required more aggressive preparation than other brands.

**Methods**

One hundred primary typodont teeth (Kilgore International, Inc, Coldwater, MI) were obtained (50 primary maxillary right centrals and 50 primary mandibular right first molars) and divided into 5 groups – Zirconia Cheng Crowns (\textbf{CC}) (Peter Cheng Orthodontic Laboratories, Inc, Exton, Penn) EZ Pedo Anterior and Posterior V2 (\textbf{EZP}) (EZ-Pedo, Inc, El Dorado Hills, Cali), Zirconia Kinder Krowns (\textbf{KKZ}) (Mayclin Dental Studios, Minneapolis, Minn), NuSmile ZR (\textbf{NSZ}) (Orthodontic Technologies, Houston, Texas), and 3M ESPE SSCs (3M ESPE GA, St. Paul, Minn). Each group contained 10 anterior and 10 posterior samples. Each typodont tooth was weighed three consecutive times to the ten thousandths of a gram using a calibrated Mettler Toledo NewClassic MF ML 204 digital balance (Mettler-Toledo, LLC, Columbus, OH). All measured weights were recorded using
an Excel spreadsheet (Microsoft, Inc, Redmond, WA), and the arithmetic mean was calculated for each sample tooth.

The size of the zirconia and SSC crowns used for each group was determined by measuring the mesio-distal width of the typodont tooth to be prepped to receive the restoration (Table 2). Manufacturer’s recommendations for both tooth preparation and bur use were reviewed for each brand of restoration. EZ Pedo recommended the use of specific burs, EZ-prep burs (EZ Pedo, Inc, El Dorado Hills, Cali), while Kinder Krown and NuSmile ZR suggested various burs such as tapered diamonds or diamond footballs but did not require specific burs. Cheng did not provide manufacturer recommendations on preferred burs.\textsuperscript{12-16} The EZ-Prep bur system fulfilled the recommendations of all manufacturers in this study and was used in the preparation of all samples. Each group was assigned two EZ-Prep bur systems – one system for the preparation of the ten anterior typodont teeth in the group and the other for the preparation of the ten posterior typodont teeth.

Teeth were prepared by a single operator to properly receive the restoration (Figure 1 and 2). A veteran faculty member randomly selected three prepared teeth from each group to verify the proper, passive fit for the zirconia crowns and proper, retentive fit for the SSCs. If the operator, based on faculty evaluation did not achieve a proper fit, the sample in question was reduced to a greater extent until both operator and faculty member were in agreement. When this occurred, 2 additional samples from that group were randomly selected for evaluation for proper fit, resulting in 50% of the samples within that group being evaluated by the veteran faculty member. Additional tooth preparation was necessary for one sample in the KKZ posterior group.

Post-weights for each tooth were then obtained in triplicate and recorded in the same manner as pre-weights. Each tooth’s change in weight was calculated and used in statistical analysis as a surrogate measure of the degree of aggressiveness of tooth
preparation required for the proper fit of each brand’s crown. The data were normally
distributed as tested by Shapiro-Wilk tests, so differences were assessed with one-way
analysis of variance using the conventional alpha of 0.05 to identify any statistically
significant difference.\textsuperscript{18} The source of significance was assessed using Tukey’s HSD as
the post hoc test.\textsuperscript{19} Pre-treatment weights of the anterior teeth weighed an average 0.347
grams (sd = 0.001), with the range of all 50 specimens being from 0.345 gm to 0.349 gm.
The posterior (molar) typodont teeth weights averaged 0.731 grams (sd = 0.002) with a
range of 0.727 gm to 0.738 gm.

\textbf{Results}

\textbf{Results - Anterior Teeth}

By one-way ANOVA, there was a significant difference among brands, zirconia and
stainless steel, in the weight of material necessarily removed to properly fit the restoration
(df = 4, 45; F = 166). Of the five brands, the SSCs required significantly less removal of
tooth substance (P < 0.0001), while there was no significant difference between the four
zirconia brands, as tested by Tukey’s HSD. The mean difference between the most
aggressive reduction by brand of anterior zirconia restoration (KKZ) and the least
aggressive (EZP) was a mere 0.009 grams. The tooth substance removed for the 3M
SSC was 48\% of that required for the composite of the four brands of zirconia restorations
(Table 3 and Figure 3).

\textbf{Results - Posterior Teeth}

By one-way ANOVA, there was a highly significant difference among brands in the weight
of material necessarily removed to properly fit the restoration (df = 4, 45; F = 194; P <
0.0001). Of the five brands, the SSCs required significantly less removal of tooth
substance (P < 0.0001). Statistically, the Tukey-Kramer post hoc test recognized three
different groupings. SSCs required the least removal of crown substance. EZP, KKZ and
NSZ involved an intermediate degree of reduction, while CC required the most. Mean
weight loss due to preparing the crowns of the posterior teeth to receive an esthetic zirconia restoration ranged from 0.1523 grams (CC, most aggressive) to 0.1124 grams (EZP, least aggressive). The SSCs required the least preparatory crown modification, and tooth substance removed for this restoration was 54% of that required for the composite of the four brands of zirconia restorations (Table 3 and Figure 3).

Discussion

Typodont tooth weights prior to preparation had a standard deviation of 0.001 gms, meaning that the typical typodont tooth differed less than a thousandths of a gram from others in the sample and were considered homogeneous in size and weight as received from the manufacturer. This uniformity of the typodont teeth helped achieve statistically significant differences among brands. Homogeneity (small variability) was much smaller than if biologically real teeth had been used.

After reducing the anterior teeth to fit the crowns, there was a significant difference among the zirconia crowns compared to the stainless steel crown which is clinically relevant. The stainless steel crown requires much less tooth reduction which means mechanical exposure of the pulp is less likely. However, in general, the poor esthetics precludes its use in the anterior dentition. Statistically, there was no significant difference among the brands of anterior esthetic zirconia restorations, as all required the same degree of reduction. After adjusting for standard error, there was only a 3% difference among reduction required for the anterior brands of zirconia restorations, which would clinically be obscured by inter-patient variability.

Again, statistically, there was a large difference among the five brands of posterior restorations, with the SSCs requiring the least removal of crown substance, as one would expect. Clinically, mechanical exposure of the pulp is less likely to occur with the use of a SSC in the posterior region as well. Three brands (EZP, KKZ, and NSZ) required more reduction than SSC but did not differ significantly from one another while CC required the
largest reduction to fit the crown. After adjusting for standard error, there was only a 5% difference between the mean reduction required for the four brands of posterior esthetic crowns. We contend that this difference among posterior zirconia brands is also clinically trivial.

Conclusion

Minimally invasive procedures generally are preferred in dentistry. This study found that conventional stainless steel crowns require significantly less removal of coronal tooth structure to obtain proper fit, as one would expect. When compared to stainless steel crowns, the composite of the four anterior zirconia restorations required more than twice as much tooth structure removal as the SSC (205%). While in the posterior, the composite of the four zirconia restorations required slightly less than twice as much tooth structure removal when compared to the SSC (185%). While zirconia crown preparations are significantly more aggressive than SSC preparations, determining the clinical repercussions of aggressive tooth reduction, such as mechanical exposure of the pulp, is beyond the scope of this study. In today’s society, practitioners and parents are often driven by esthetic concerns when choosing among restorative options, especially in the anterior region. Pooling the four zirconia brands tested in this study:

1. EZ Pedo, Kinder Krown, Cheng Crowns, and NuSmile brands are statistically equivalent esthetic choices in the anterior region based on aggressiveness of preparation.

2. In the posterior region, Cheng Crowns required the removal of significantly more tooth substance to obtain proper fit when compared to the other brands of zirconia restorations; however, this difference is clinically insignificant.

Clinically, the minor differences in the reduction of tooth structure necessary for the proper fit of the zirconia restorations would go unnoticed and be mitigated by variations in morphology, size of the carious lesion, sex differences, and race differences.
Consequently, clinicians should consider other product features and requirements when choosing among the zirconia brands studied.

REFERENCES


<table>
<thead>
<tr>
<th>Brand</th>
<th>Sizes</th>
<th>Color/Contour</th>
<th>Manufacturer Recommended Bur Use</th>
<th>Manufacturer Reduction Requirements</th>
<th>Manufacturer Suggested Cement*</th>
<th>Key Features*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheng Crown</td>
<td>1 - 6</td>
<td>Single Color Left/Right Contoured</td>
<td>No information provided</td>
<td>Not specifically outlined / Videos available</td>
<td>No information provided</td>
<td>Smart Polish Technology Crimp-Lock Retentive Margins Light and Extra Light Shades</td>
</tr>
<tr>
<td>EZ Pedo</td>
<td>1 - 6 Prime SL™ for Cuspids and molars</td>
<td>Color enhancers are applied by hand to gingival one third of the margin Left/Right Contoured Upper Anteriors Universal Options for Lower Anteriors Only</td>
<td>Promotes use of EZ Prep™ burs</td>
<td>Incisal Edge/Occlusal: 1.5mm – 2.0 mm Circumferential axial reduction: 0.5mm – 1.0mm (0.85 – 1.5mm for posterior) Lingual: 0.75 – 1.25 mm Circumferential subgingival reduction 2mm below gumline Final Seat: Passive</td>
<td>Pure Glass Ionomer Cements</td>
<td>Zir-Lock® Ultra – precision milled retention grooves extending all the way to crown margins Zir Plus™ - mirror polished surface and anti-reflective coating EZ Seat™ Contours EZ Prep Bur System</td>
</tr>
<tr>
<td>Kinder Krown</td>
<td>1 - 6 Mid-sized options for cuspids and molars Short and Regular Lengths for anterior crowns</td>
<td>Single Color Universal and Left/Right Contoured available for Upper anteriors LP™ (&lt;Less Prep™) option for anterior and posterior crowns</td>
<td>Recommendations are provided Kinder Krown Prep Kit is Available</td>
<td>Incisal Edge/Occlusal: 1.0mm Interproximal: 1.0 mm Facial/Buccal: 1.0 mm Lingual: 1.0mm Subgingival: feather margin circumferentially Final seat – Passive and subgingivally 1 - 2mm</td>
<td>Resin Modified GI Cement Pure Glass Ionomer Cement</td>
<td>Wear-Kind Polish-Glaze-System Internal retention bands provide increased surface area High Gingival Acceptance finely feathered margins Fit Check Crowns available – avoids contamination of the crown actually cemented Prep Kit and Adjustment Kit available</td>
</tr>
<tr>
<td>NuSmile</td>
<td>0 – 6 Posterior primary first molars are available in regular or narrow mesiodistal widths</td>
<td>Light and Extra Light Color Options Left/Right Contoured Anteriors Universal Options for Lower Anteriors Only</td>
<td>Recommendations are provided</td>
<td>Incisal Edge: 1.5 – 2.0 mm Occlusal: 1.0 – 1.5 mm Circumferential axial reduction: 0.5 – 1.25mm (or 20-30%) Subgingival – feather margin circumferentially 1 – 2mm Round all line and point angles Final seat – Passive</td>
<td>NuSmile BioCem™ Resin Cement Resin Modified Glass Ionomer</td>
<td>NuSmile Try In Crowns - avoids contamination of the crown actually cemented NuSmile ZR Adjustment Burs available Light and Extra Light Shades</td>
</tr>
</tbody>
</table>

Table 1. Manufacturer specific zirconia crown product features as outlined on manufacturers’ websites in 2015.
<table>
<thead>
<tr>
<th>Brand</th>
<th>Measured Width of Crown (in millimeters)</th>
<th>Measured Width of Typodont Tooth (in millimeters)</th>
<th>Size Used</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3M ESPE SSCs</td>
<td>6.3 mm</td>
<td>6.3 mm</td>
<td>R2</td>
</tr>
<tr>
<td>Zirconia Cheng</td>
<td>6.2 mm</td>
<td>Kilgore International Primary Tooth E</td>
<td>CR2</td>
</tr>
<tr>
<td>Zirconia Kinder</td>
<td>6.2 mm</td>
<td>Kilgore International Primary Tooth E</td>
<td>E2S</td>
</tr>
<tr>
<td>EZ Pedo Anterior</td>
<td>6.3 mm</td>
<td></td>
<td>E2</td>
</tr>
<tr>
<td>NuSmile ZR</td>
<td>6.3 mm</td>
<td></td>
<td>A1R</td>
</tr>
<tr>
<td><strong>POSTERIOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3M ESPE SSCs</td>
<td>8.6 mm</td>
<td>8.6 mm</td>
<td>LR D4</td>
</tr>
<tr>
<td>Zirconia Cheng</td>
<td>8.6 mm</td>
<td>Kilgore International Primary Tooth S</td>
<td>DLR5</td>
</tr>
<tr>
<td>Zirconia Kinder</td>
<td>8.7 mm</td>
<td>Kilgore International Primary Tooth S</td>
<td>S5</td>
</tr>
<tr>
<td>EZ Pedo Posterior</td>
<td>8.6 mm</td>
<td></td>
<td>S5</td>
</tr>
</tbody>
</table>

Table 2. Size of anterior and posterior zirconia crowns selected for comparison
Figure 1. Anterior crowns and typodont tooth preparation. L to R: Kinder Krown, EZ Pedo, Cheng Crown, NuSmile ZR, Stainless Steel crown.
Figure 2. Posterior crowns and typodont tooth preparation. L to R: Kinder Krown, EZ Pedo, Cheng, NuSmile ZR, and Stainless Steel crown.
Table 3. Mean ± SD weight of tooth substance removed (grams) for the 5 brands of anterior and posterior crowns. One-Way ANOVA showed significant difference in tooth reduction between the crowns tested. (ANTERIOR: df = 4, 45; P < 0.0001; POSTERIOR: df = 4, 45; P < 0.0001).

Uppercase superscripts denote weights that are not significantly different.
Figure 3. Average weights of typodont tooth structure removed (± SE) when preparing teeth for crowns, by brand.