Marginal fit of leucite-glass pressable ceramic restorations and ceramic-pressed-to-metal restorations

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Statement of problem. Fabricating a feldspathic porcelain margin on a metal-ceramic restoration with a clinically acceptable marginal fit has proven to be a technique-sensitive procedure. Pressable ceramics are advocated to solve this problem.

Purpose. The purpose of this in vitro study was to compare the marginal adaptation of a pressable ceramic system when used with both all-ceramic and metal-ceramic crowns, with a traditional metal-ceramic restoration.

Material and methods. A 1.5-mm, 360-degree chamfer margin was prepared on a typodont maxillary central incisor. Polyether impressions were made and poured in a Type IV dental stone, and the following crowns were fabricated on individual dies: 15 metal ceramic restorations (MCR) (Ceramco II, Ceramco, and Argelite 60), 15 pressed-to-metal restorations (PTM) (CPC-MK, and Argelite 60), and 15 pressed ceramic restorations (PCR) (CPC-MK). The marginal fit of the crowns was evaluated every 90 degrees around the crown margin circumference under a microscope at original magnification $\times 45$. A 1-way analysis of variance (ANOVA) was used to compare data ($\alpha=.05$).

Results. The mean marginal discrepancy for MCRs was $94 \pm 41 \mu m$, for PTMs, $88 \pm 29 \mu m$, and for PCRs, $81 \pm 25 \mu m$. The 1-way ANOVA showed no significant difference between groups ($P=.568$).

Conclusion. The marginal fit of pressed-to-metal (PTMs) and pressed all-ceramic crowns (PCRs) was similar to that of traditional metal-ceramic crowns (MCRs). (J Prosthet Dent 2005;93:143-7.)

CLINICAL IMPLICATIONS

A pressed ceramic restoration with or without metal has equal or better marginal adaptation than a traditional metal ceramic restoration. Restorations with pressed ceramic margins are less technique-sensitive for the technician to fabricate than conventional metal-ceramic restorations with porcelain margins.

For complete coverage restorations, achieving close marginal adaptation is important for the long-term prognosis of the restoration and the restored tooth. It is necessary to minimize the marginal gap since luting agent solubility over time may result in a space between the tooth and the restoration. This space can serve as a nidus for plaque accumulation. Plaque may result in inflammation of the periodontal tissues, caries, and subsequent failure of the prosthesis. The current clinically acceptable marginal opening is between 40 and 120 $\mu m$.1-3

Porcelain has been used in dentistry for over a century. Although the first all-ceramic restorations were esthetic, they were prone to fracture and therefore did not gain widespread popularity until the 1950s with the addition of leucite to the porcelain.4 This addition increased the porcelain’s coefficient of thermal expansion sufficiently to enable it to be added to cast metal substructures and was patented by Weinstein in 1962.4 One disadvantage of such metal-ceramic restorations (MCRs) is the dark metal collars that may compromise esthetic appearance, especially in the anterior region. Therefore, tooth preparations were modified for metal ceramic restorations such that a porcelain margin could be achieved. Using such preparations, only ceramic material is visible at the labial margin, thus addressing this esthetic concern. However, the sintering shrinkage of dental porcelain during the firing process can compromise the accuracy of the all-porcelain labial margin.5 In addition, the tendency for spheroiding of the porcelain

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margin requires multiple porcelain applications, which may be time-consuming for the laboratory technician to rectify and may still result in marginal discrepancies.\textsuperscript{5}

During the metal ceramic restoration fabrication process, distortions of both the metal substructure and the porcelain can be introduced, resulting in altered accuracy of fit, as shown by several investigators.\textsuperscript{3-12} Factors influencing these distortions include temperature of the oxidation cycle, mismatch of porcelain-metal thermal coefficients, alloy type, and margin design.\textsuperscript{6,8-11}

In a study of the margins of fixed partial dentures, Bridger and Nicholls\textsuperscript{13} found that distortion can occur between the final porcelain application and the glaze stage. Buchanan et al\textsuperscript{11} found that the marginal opening created from metal conditioning (degassing) and primary opaque application was partially closed during glaze firing. Current research indicates that the vast majority of dimensional change occurs at the degassing stage.\textsuperscript{4,8-11}

Many of the problems associated with sintered ceramic margins, such as sintering shrinkage and spheroiding during firing, may be avoided by using pressed ceramics that are fabricated by the lost wax technique. In this technique, the complete contour wax pattern is invested and a ceramic ingot is pressed into the resultant investment mold. The thermal expansion of the investment material is matched to that of the ceramic material. Because the ceramic is pressed directly into the investment to the full extent of the wax pattern, this method is simpler and quicker than multiple porcelain applications used in conventional sintering techniques. In addition, this method achieves marginal accuracies within acceptable limits.\textsuperscript{12,14,15}

Yet another technique has been developed that combines elements of sintered and pressed ceramics. First, a metal substructure is waxed to the axial wall of the die and cast. After the casting has been opaqued, a complete contour wax pattern is fabricated and the ceramic is heat-pressed onto the undercasting. The goal of this new technique is to combine the strength and durability of metal with the ease of fabrication and esthetics of pressed-ceramics.

The purpose of this study was to measure the marginal adaptation of pressed porcelain restorations, with and without metal substructures, and sintered metal-ceramic restorations with a porcelain margin. The null hypothesis to be tested is that no difference in marginal adaptation exists among the restorations fabricated by each technique.

**MATERIAL AND METHODS**

A 1.5-mm, 360-degree chamfer preparation was made on a maxillary right central incisor dentoform tooth (Columbia Dentoform, Long Island City, NY). Forty polyether (Impregum/Permadyne; 3M ESPE, St. Paul, Minn) impressions were made in disposable anterior stock trays (Coe #32-D; GC America, Alsip, Ill) of the maxillary anterior segment of the dentoform. The impressions were then poured in Type IV dental stone (Die-Keen; Heraeus Kulzer, South Bend, Ind), pin indexed (Coltène/Whaledent Inc, Cuyahoga Falls, Ohio), and trimmed under original magnification ×2.6. Then, 1 layer of die spacer (Tru-Fit; George Taub, Jersey City, NJ) was applied (Fig. 1). The dies were then sent to the commercial dental laboratory utilized by the New York University Advanced Education Program in Prosthodontics. This laboratory is experienced in the fabrication of all 3 crown types. MCRs were fabricated from feldspathic porcelain fused to metal (Ceramco II; Dentsply Ceramco, Burlington, NJ and Argelite 60; Argen Corp, San Diego, Calif) with porcelain margins utilizing the direct lift technique (Table I). PTMs were fabricated from leucite-glass pressed-to-metal (CPC-MK; Chemichl, Vaduz, Liechtenstein and Argelite 60; Argen Corp) with porcelain margins using the lost wax technique. PCRs were fabricated with all leucite-glass pressed ceramic (CPC-MK; Chemichl) with porcelain margins utilizing the direct lift technique (Fig. 2, Table II).

![Fig. 1. Dentoform tooth preparation (A) and die (B).](image1)

![Fig. 2. Intaglio view of 3 crown types.](image2)
Restorations were examined upon return from the laboratory for deformity and debris and cleaned with steam. Restorations were then evaluated on the dies and on the prepared dentoform tooth under original magnification $\times 2.6$ for marginal discrepancy by both visual and tactile methods. Restorations with a margin deemed visually unacceptable by 2 or more investigators were rejected. An explorer (#23; Hu-Friedy, Chicago, Ill) was used to detect the presence of overcontour, undercontour, or marginal gaps. Overcontoured restorations were adjusted with porcelain finishing instruments (Brasseler USA, Savannah, Ga), and crowns with marginal gaps larger than the tip of the explorer were rejected. Undercontoured restorations were also rejected.

Originally, 30 dies resulting from 30 impressions were sent to the laboratory. However, several of the crowns were rejected as having clinically unacceptable fit. Therefore, new impressions were made and new dies were sent to the same laboratory with the same technician fabricating the restorations. When this group returned, additional crowns were rejected, spurring another round of impressions and die fabrication. By the end of the third round of crown fabrication, 15 acceptable crowns for each test group were achieved from a total of 62 impressions.

The following measuring protocol was established. The finish line of the dentoform tooth was marked with pencil, and 4 lines were scribed with an indelible marker at the midfacial, midmesial, midlingual, and middistal surfaces. The tooth was then mounted using acrylic resin (GC Resin; GC America) to a rotating platform perpendicular to the viewing angle. Four unique positions, each 90 degrees apart, were marked on the rotating device to ensure consistency of the measurement location. Disclosing medium (Occlude; Pascal Co Inc, Bellevue, Wash) was mixed with vinyl polysiloxane disclosing paste (Fit Checker; GC America) and applied to the intaglio margin of each crown before seating on the dentoform tooth to provide sufficient visual contrast between the ceramic restoration and the die. The crowns were seated with finger pressure, all excess disclosing material was wiped away with a gauze pad, and the material was allowed to polymerize. The crowns were then examined at original magnification $\times 45$ (SZX-12; Olympus, Tokyo, Japan) and digital images were captured at each of the 4 positions. One image was captured of a calibration slide at the same magnification and was referenced for calibration at each imaging session (Fig. 3). Using image analysis software (Image-Pro Plus; Media Cybernetics, Silver Spring, Md), 3 measurements were made at each of the 4 positions, for a total of

### Table I: Properties of metal used in this study (information provided by manufacturer)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Composition (%)</th>
<th>Elastic modulus (MPa)</th>
<th>Vickers hardness (HV/10)</th>
<th>Tensile strength (MPa)</th>
<th>Yield strength (MPa)</th>
<th>Elongation (%)</th>
<th>Melting range (°C)</th>
<th>Casting temp. (°C)</th>
<th>CTE ($\times 10^{-6} °C$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argelite 60 (Noble)</td>
<td>Pd 59.9 Ag 28.0 In 5.0 Sn 5.0 Zn 2.0 Ru 0.1</td>
<td>137.00</td>
<td>250</td>
<td>640-697</td>
<td>460-540</td>
<td>20-25</td>
<td>1230-1305</td>
<td>1370</td>
<td>14.5-14.6</td>
</tr>
</tbody>
</table>

### Table II: Properties of ceramics used in this study (information provided by manufacturer)

<table>
<thead>
<tr>
<th>Ceramic</th>
<th>Fusion temp. (°C)</th>
<th>Flexural strength (MPa)</th>
<th>CTE ($\times 10^{-6} °C$)</th>
<th>Solubility (µg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPC-MK (Pressed)</td>
<td>920</td>
<td>114</td>
<td>13 ± 0.5</td>
<td>20</td>
</tr>
<tr>
<td>Ceramco II (Feldspathic)</td>
<td>940</td>
<td>70</td>
<td>12.5 ± 0.5</td>
<td>17</td>
</tr>
</tbody>
</table>

Fig. 3. Microscopic evaluation of study crown. A, Restoration. B, Colored disclosing medium. C, Dentoform tooth. D, Orientation marker.
RESULTS

A total of 62 restorations were fabricated. Seventeen restorations were rejected prior to measurement due to clinically unacceptable fit: 11 conventional metal-ceramic restorations, 3 pressed-to-metal restorations, and 3 pressed ceramic restorations. After fabrication, the mean marginal discrepancies were 94 ± 41 μm, 88 ± 29 μm, and 81 ± 25 μm for the metal-ceramic, pressed-to-metal, and pressed ceramic restorations, respectively (Fig. 4). The 1-way ANOVA showed no significant differences between groups (P=.568). A power analysis (α=.05) revealed that the power of this study was 14%.

DISCUSSION

All restorations exhibited an average marginal gap that was within clinically acceptable limits of less than 120 μm as reported by McLean and von Fraunhofer. Other authors used steel die techniques or different direct fabrication methods than those used in this study. An attempt was made to mimic the clinical scenario as closely as possible. By impressing the “master tooth,” fabricating stone dies, and having the restorations made in a commercial laboratory, many elements of clinical error could have occurred. The definitive restoration was then evaluated on the “master tooth,” the patient analog. Using this method, it was necessary to evaluate each crown as if it were to be placed intraorally. Therefore, exclusion criteria were applied at the clinical level. Although a few pressed ceramic restorations were rejected, many more feldspathic restorations were rejected. Given the exclusion criteria, the results might have shown a statistically significant difference between restorations if all restorations were evaluated as returned from the laboratory. Eleven metal ceramic restorations, 3 pressed-to-metal restorations, and 3 pressed ceramic restorations were rejected due to clinically unacceptable fit. Therefore, over 3 times as many metal-ceramic restorations were rejected than pressed-to-metal restorations or pressed ceramic restorations, suggesting that fabricating adequate metal ceramic restorations with feldspathic porcelain facial margins is more technique-sensitive than with pressed ceramic. Upon discussion with the laboratory technician responsible for fabrication of the crowns, the technician stated that he could produce an all-ceramic margin using the pressing technique much more quickly and easily than by using the feldspathic technique.

Although there was no significant difference between groups with regard to marginal discrepancy, a trend was noted that pressed ceramic restoration margins had better fit and less variation than metal-ceramic restorations with feldspathic margins. To detect a significant difference between specimens with a power of 80%, at an alpha of .05, it would be necessary to have 113 specimens in each group. Thus, sample size is a limitation of the present study. Another limitation of this in vitro study is that the restorations were not luted.

CONCLUSION

The marginal fit of the all-ceramic pressed restorations and the pressed-to-metal restorations was similar to metal-ceramic restorations with a 360-degree ceramic margin. There was no significant difference found between the all-ceramic and metal-ceramic materials tested. Since more of the conventional metal-ceramic crowns had to be remade due to fit or contour deficiencies, the fabrication of the ceramic-pressed-to-metal was judged to be less technique-sensitive than the fabrication of the feldspathic MCR.

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REFERENCES


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