Fit Analysis of Different Framework Fabrication Techniques for Implant-Supported Partial Prostheses

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Purpose: This study evaluated the vertical misfit of implant-supported frameworks made using different techniques to obtain passive fit. Materials and Methods: Thirty three-unit fixed partial dentures were fabricated in cobalt-chromium alloy (n = 10) using three fabrication methods: one-piece casting, framework cemented on prepared abutments, and laser welding. The vertical misfit between the frameworks and the abutments was evaluated with an optical microscope using the single-screw test. Data were analyzed using one-way analysis of variance and Tukey test (α = .05). Results: The one-piece casted frameworks presented significantly higher vertical misfit values than those found for framework cemented on prepared abutments and laser welding techniques (P < .001 and P < .003, respectively). Conclusion: Laser welding and framework cemented on prepared abutments are effective techniques to improve the adaptation of three-unit implant-supported prostheses. These techniques presented similar fit. Int J Prosthodont 2016;29:351–353. doi: 10.11607/ijp.4542

Implant-supported partial prostheses have high success rates, but clinical complications can and do occur. It has been suggested that perfect adaptation, or so-called passive fit, should exist to minimize stresses on prosthetic components and bone tissue.¹ An ill-fitting interface could have deleterious effects on mechanical and biologic aspects of the prosthesis. A passive fit that induces no stress or strains is utopic. Distortion is unavoidable, regardless of the method used to fabricate prosthetic frameworks. Still, minimum misfit should be sought when making implant prostheses. To accomplish this, alternatives to conventional one-piece casting (OPC) procedures were suggested in the literature, such as framework cemented on prepared abutments (FCPA) and laser welding (LW) techniques.²³ However, to date, there are no studies comparing adaptation between these techniques and OPC for implant-supported fixed partial dentures. Thus, the aim of this study was to compare the vertical misfit of three-unit implant-supported frameworks made by OPC, FCPA, and LW. The null hypothesis was that the values of vertical misfit are not influenced by the technique used.

Materials and Methods

A matrix was built with two multiunit abutments (Neodent) to enable standardization of the specimens obtained from waxing. The abutments were positioned parallel to one another at the regions of the second premolar and second molar with 16 mm between their centers and type IV special die gypsum (Durone, Dentsply). From this matrix, 30 frameworks for screw-retained implant-supported prostheses were waxed and obtained by three different techniques (n = 10): (1) OPC, (2) LW, and (3) FCPA (Fig 1). The sample size was calculated based on the means and standard deviations of a previous similar study.⁴

Waxing

For OPC, two cast-on UCLA copings (Neodent) were screwed to each multiunit abutment of the matrix and a framework of a three-unit metal ceramic prosthesis was waxed. For FCPA and LW, two machined titanium copings were positioned and screwed to the multiunit abutment of the matrix to be used as spacers. Over these titanium copings, cast-on UCLA copings were positioned and a framework of a three-unit metal ceramic prosthesis was waxed with the same dimensions as...
The OPC waxed frameworks. To do this, an impression of the OPC waxed framework was made using silicone (Aquasil Soft Putty, Dentsply) and this impression was used as a matrix to reproduce the framework waxing of the other groups.

**Casting**

All frameworks were cast using the lost-wax technique with an induction casting machine. The waxed frameworks were invested using a phosphate-bonded investment (Heat Shock, Polidental) according to the manufacturer’s instructions (100 g powder/25 ml liquid; using a vacuum mixer). The specimens were placed in an oven and the temperature was raised from room temperature to 320°C for 30 minutes and then raised again to 950°C for another 60 minutes, following the instructions of the manufacturer of the cobalt-chromium alloy (Starloy C-BEGO). After casting, all frameworks were sandblasted with aluminum oxide (100 m/80 psi) and internal parts were checked for irregularities that could affect adaptation.

In FCPA and LW frameworks, the titanium copings were tightened to the multiunit abutments (10 N/cm) and then submitted to additional procedures, as follows:

- FCPA: Titanium copings (Neodent) and inner parts of the frameworks were rinsed, then Metal/Zirconia Primer (Ivoclar Vivadent) was applied for 180 seconds. The frameworks were cemented on the machined copings using self-curing resin cement (Multilink, Ivoclar Vivadent).²
- LW: Frameworks were positioned and the border of the framework and copings were laser welded (Desktop-F, Dentaurum).

**Vertical Misfit Evaluation**

Vertical misfit was evaluated by single-screw test with an optical microscope (VMM150, Walter Uhl) at eight points of framework-abutment interface, and an average value was obtained. This evaluation was realized in triplicate for each sample, and its mean value was defined.

Statistical analysis checked for differences among misfit values and fabrication technique using one-way analysis of variance (ANOVA). All tests were performed with 95% confidence level.

**Results**

Mean vertical misfit values, standard deviation (SD), standard error (SE), and confidence interval (CI) for the different techniques are shown in Table 1. FCPA presented the best misfit among the groups (27.4 µm), while OPC presented a fourfold increase on misfit values (111.0 µm). The SD of the FCPA was very small compared to the other groups.

One-way ANOVA showed statistically significant differences among the techniques \((P < .001)\). OPC frameworks presented higher misfit values than FCPA \((P < .001)\) and LW \((P < .003)\) techniques.

**Discussion**

The null hypothesis that vertical misfit is not influenced by fabrication method was partially verified.

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**Table 1** Vertical Misfit (µm) for the Different Techniques to Fabricate Partial Implant-Supported Prostheses

<table>
<thead>
<tr>
<th>Technique</th>
<th>Vertical Misfit</th>
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<tbody>
<tr>
<td>Framework cemented on prepared abutments</td>
<td>27.4b 3.3 1.04 2.36</td>
</tr>
<tr>
<td>One-piece casting</td>
<td>111.0a 42.6 13.5 30.5</td>
</tr>
<tr>
<td>Laser welding</td>
<td>61.1b 31.4 9.92 22.4</td>
</tr>
</tbody>
</table>

Different superscript letters indicate a statistically significant difference (one-way ANOVA).

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Fig 1 Frameworks obtained by different techniques \((n = 10)\). (a) One-piece casting. (b) Laser welding. (c) Framework cemented on prepared abutments.
Although a statistically significant difference was observed among OPC frameworks compared to FCPA and LW techniques, all misfit values observed were within the clinically acceptable threshold. A direct relationship could exist between vertical misfit and increase of stress/strains in biologic and mechanical components. Thus, professionals should pursue the most accurate frameworks possible to avoid introducing harmful forces to the system.

The techniques tested in this study aimed to reduce the effects of casting distortion, providing a better adaptation to OPC frameworks. All frameworks were cast with burnout patterns. This means that in OPC frameworks the body of the framework was directly cast on the coping and then screwed to the multiunit abutments (matrix), while in the experimental groups the obtained frameworks were cemented (FCPA) or welded (LW) to machined abutments that were attached to the multiunit abutments (matrix), which can explain the observed differences. Although no difference was found among LW and FCPA techniques, the latter is more affordable since it does not require expensive equipment (laser welding machine). This technique is also less sensitive to operator skills, which can be confirmed by the lower standard deviation values. One could say that the possibility of decementation of the framework in this technique should be considered a limitation, since loss of retention and need for recementation is one of the most commonly reported prosthodontics maintenance/complication issues for cement-retained implant prostheses. These complications could also negatively affect patient perception of the treatment. However, the presence of a resin cement layer, which is less resistant than metallic components (prosthetic screws, abutments, and implants), could avoid overloading of these prosthetic components. Thus, when the prosthesis is submitted to high stress, decementation of the framework could avoid screw loosening or fracture of any components and a simple recementation procedure could reestablish function. On the other hand, decamentation can be much more complex. When a decemented retainer/abutment is not detected promptly due to the inherent lack of mobility, and other abutments are still intact, the remaining abutments/retainers/implants could be overloaded during function.

The use of base alloys is considered a suitable alternative to noble alloys, mainly due to the high costs of the latter. However, noble alloys have some advantages over base-metal alloys in terms of biocompatibility, marginal adaptation, workability after casting, and metal-ceramic bonds. Also, the use of machined abutments for one-piece casting frameworks could provide better adaptation than castable ones.

A possible limitation of this study is that the misfit was measured by an optical microscope. Although this technique has been extensively used in the literature, a three-dimensional evaluation by digital scanning could provide more accurate results. While parallelism between the implants is not commonly observed in clinical practice, the parallel implants used in the current study simplified data collection and analysis.

Conclusions

LW and FCPA techniques could be recommended to improve adaptation of three-unit implant-supported prostheses. Both techniques presented similar adaptation.

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References