Flexural strength and marginal adaptation of temporary restorative materials used in endodontically treated teeth

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ABSTRACT

Objective: This study evaluated the flexural strength and marginal adaptation of Clip F (CF), Bifix Temp (BT), System onlay (SO), Fill Magic Tempo (FT) and Provi Master F (PF) in endodontically-treated coronal dentin. Methods: Firstly, ten specimens of each restorative material were prepared, and submitted to flexural strength test using electromechanical testing machine. Then, the pulp chamber of 50 maxillary premolar were restored using one of the provisional restorative materials (n = 10) in order to evaluate the marginal desadaptation extension. After 7 days, the interface between dentin and temporary restorative material, in crown middle third, was subjected to scanning electron microscopy (500X). Marginal desadaptation and gaps extensions in dentin-temporary restorations interface were measured using Image J software. Results: CF and BT presented the highest and the lowest flexural strength values, respectively (p < 0.05). SO, FT and PF showed similar values (p > 0.05). In relation to marginal desadaptation (%) and gap extensions (μm), CF presented the lowest marginal desadaptation and gaps incidence values (p < 0.05). BT showed intermediate values, but lower than SO, FT e PF (p < 0.05), which were similar among them (p > 0.05). Conclusion: CF presented the best flexural strength and the lowest marginal desadaptation and gaps extension.

Keywords: Dental Restoration, Temporary. Dental Materials. Endodontics.


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INTRODUCTION
The choice of an adequate temporary restorative material to seal the coronal access between the endodontic treatment sessions is really important to avoid the contamination of the root canal system and to prevent the microbial leakage among dentin/endodontic filling, until definitive aesthetic restorations be performed.1–3
Several materials are recommended, among them the zinc oxide-eugenol is extensive used, however they don’t present good physical properties when associated with zinc sulfate (i.e. Coltosol) which may result in coronal fractures induced by the volumetric expansion of the material.4,6 On the other hand, new temporary resin composites restorative materials based of methacrylate has been proposed.3,6,7 These temporary materials were formulated based on the premise that resin components possess a suitable adhesion to dentin substrate, minimizing the marginal leakage.2,6 However, to this occurs is necessary the application of an adhesive system to allow the physical/chemical interaction between the dentin substrate and resinous materials.8,9
Such as these adhesive systems are not applied previously to the temporary restorative material, the hybridization of composite resins with the dentin didn’t occur.3,10 Therefore, these materials couldn’t be considered reliable to avoid the root canal system contamination. In addition, this composite contain methacrylate resin, which can have volumetric alterations after complete polymerization, increasing the failure incidence between the temporary restorations and dentin.7,11,12
Because of this, new temporary restorative materials presenting different chemical compositions and polymerization strategies were introduced in clinical dentistry, such Bifix Temp (Voco), Clip F (Voco), Fill Magic Tempo (Coltene), Provi Master F (Wilcos) and Systemp.onlay (Ivoclar). However, it’s not clear the behavior of these materials in respect to flexural strength and the marginal adaptation in endodontically treated coronal dentin..
Therefore, the aim of this study was to compare the flexural strength, marginal adaptation and gaps measurement between coronal dentin and temporary restorative materials, such as Clip F, Bifix Temp, Systemp.onlay, Fill Magic Tempo and Provi Master F. These evaluations were issued by scanning electron microscopy (SEM) in the middle third of dentin tissue in the coronal part of the tooth endodontically treated.

The null hypothesis tested in this study was that there was no difference among the flexural strength and the marginal adaptation values for the different temporary restorative materials applied in coronal dentin.

MATERIALS AND METHODS
This study was approved by the Research Ethics Committee of the Araraquara School of Dentistry, UNESP, São Paulo, Brazil (CAAE number: 68339217.2.0000.5416). The Table 1 describe the composition and origin of the temporary restorative materials used in the present study.

1. Flexural strength
Ten specimens of each material evaluated were prepared in a device elaborated for this purpose. The dimensions of the specimens were 20mm x 2mm x 2mm (length, width and thickness) (ISO 404920). After the material be placed in the device, a flat glass microscope slide (0.3mm thickness) were adapted on top of the restorative materials to obtain a regular and even surface. Immediately after, the specimens were photoactivated in two steps, from midpoint to the right and subsequently to the left. The photoactivation was performed with a LED device (Valo; Ultradent, South Jordan, UT, USA) with 1.200 mW/cm² light intensity for 40 seconds in each segment.
The specimens prepared were immersed in artificial saliva at 37°C for 7 days. Following this period, they were positioned in a support in the electromechanical universal testing machine (EMIC, São José dos Pinhais, PR, BR), at a crosshead speed of 0.5mm/min and 200N load cell. The force required (N) to rupture the specimen was obtained and converted in flexural strength (MPa).

Marginal adaptation
Fifty human newly extracted upper premolars were used in this study. The teeth were kept at 37°C in 1% thymol solution until the use.
Teeth preparation

The cavity pulp access was accomplished with high speed handpiece and spherical diamond burs 1012 (KG Sorensen, São Paulo, SP, BR) complemented with tapered diamond burs 3080 (K.G. Sorensen) under copious water cooling. After determination of glide path and apical patency with #10 LK, the root canals were instrumented until #25/.05 (Easy, Belo Horizonte, MG, BR), following the manufacturer’s instructions. The root canals were irrigated with 2.5% sodium hypochlorite (NaOCl; Asfer, São Caetano do Sil, SP, BR) in all biomechanical preparation. The root canals received a final irrigation with 17% EDTA (Biodinâmica, Ibiporã, PR, BR) and 2.5% NaOCl. Then, the intracanal aspiration was performed, followed by drying with sterile paper points.

A Teflon pellet was placed in the access opening and in this moment the occlusal surface of the teeth was worn with silicon carbide sandpaper #300 in a polishing machine. The pulp chamber final dimension was standardized with 8 ± 0.1mm length in buccolingual direction, 3 ± 1.0mm mesiodistal direction and 3mm of depth.

Preparation of resin replicas

At this point, the teeth were randomly allocated in 5 groups (n=10) as described in Table 1. The temporary restorative materials were inserted in the pulp chamber and photoactivated for 40 seconds, using the LED device (Valo; South Jordan, UT, USA), directly in the occlusal surface of the tooth. After restorative procedure conclusion, the teeth were kept immersed in artificial saliva for 7 days, followed by incubation at 20°C for 12 hours and then at 37°C for more 12 hours. Thereafter, the dental crowns were separated from the roots and were split with a diamond disc under copious water cooling in the buccolingual direction in the medial portion.

The pieces obtained from the dentin and temporary restoration interface were polished with silicon carbide sandpaper #1200, immersed in distilled water and cleaned in ultrasonic device, for 1 minute. In sequence, a replica was obtained using polyvinyl siloxane (Express XT; 3M ESPE, St. Paul, MN, USA) and epoxy resin ((Epoxi Cure; Buehler, Lake Buff, IL, USA). The replicas were submitted to sputter-coated with gold (approximately 50A° thick) (SCD 050 Bal-Tec AG; Balzers, Liechtenstein, AL).

Assessment of marginal adaptation

An image in the middle point of distance between the occlusal and cervical surface of each specimen was obtained by Scanning electron microscopy (SEM; JEOL JSM-5600LV; Tokyo, JPN), in 500x magnification. To determine the range of the gaps between the dentin and the temporary restorative material, 10 measures were obtained in 100µm reach with a distance of 10µm apart. The average among these measurements consisted in the final average of each specimen.

To evaluate gaps extension, 10 measurement were obtained in linear extension between dentin and temporary restorative material. The final average was considerate as average among these measurements.

To evaluate the marginal adaptation, the total extension (µm) of the adhesion interface was measured in microscopic images, using Image J software (National Institute of Health, Bethesda, USA). In sequence, the desadaptation linear extension (µm) between dentin and temporary restorative was obtained. The difference between total extension and desadaptation linear extension was converted to percentage.

STATISTICAL ANALYSIS

Initially, data obtained were submitted to Shapiro-Wilk test (p>0.05). In sequence, the data were analyzed by One-way ANOVA, followed by the Tukey test (p=0.05) for observation of the significant differences between the groups.

RESULTS

Flexural strength

The groups CF and BT showed the highest and the lowest flexural strength values (MPa) in comparison with the other temporary restorative materials (p<0.05). No significant difference was observed with regard to flexural strength values between SO, FT e PF groups (p>0.05). Table 2 presents the arithmetic average and standard deviation of the flexural strength (MPa) of the temporary restorative materials.
Marginal adaptation

CF group showed the lowest results for the gap formation range (p<0.05) in comparison with SO, FT and PF groups that showed the highest measurements in relationship with the other temporary restorative materials (p<0.05), but there was no significant difference among the groups SO, FT e PF (p>0.05). However, intermediate measures were observed for BT group in comparison with others (p<0.05). The Figure 1 demonstrates the representative images of the gap formation and the interface of marginal maladaptation between the temporary restorative material and dentin pulp chamber.

With regard to the linear marginal desadaptation, CF showed the lowest marginal desadaptation interface, in comparison with the other materials (p<0.05). Whereas, SO, FT e PF groups demonstrated the highest maladaptation extension with dentin (p<0.05), without any difference among these groups (p>0.05). Despite this, BT group revealed a middle value with respect to marginal maladaptation and it was different from the other materials (p<0.05).

The table 3 shows the average and standard deviation referent to gaps extension and the marginal maladaptation incidence at the interface between dentin and the different temporary restorative material tested in this study.

Table 1. Name, composition and origin of the temporary restorative materials.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Commercial name</th>
<th>Composition</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>Clip F</td>
<td>Diurethane dimethacrylate, BHT, polymers and fluoride</td>
<td>Voco, Cuxhaven, Germany</td>
</tr>
<tr>
<td>BT</td>
<td>Bifix Temp</td>
<td>Dimethacrylate, diacylate, benzoyl peroxide, amides and BHT</td>
<td>Voco, Cuxhaven, Germany</td>
</tr>
<tr>
<td>SO</td>
<td>Systemp.onlay</td>
<td>Dimethacrylates, Inorganic Fillers and Catalysts and Pigments</td>
<td>Ivoclar Vivadent, Baueri/SP, Brazil</td>
</tr>
<tr>
<td>FT</td>
<td>Fill Magic Tempo</td>
<td>UDMA, TEGMA, EDAB, BHT, photoinitiator and inorganic load compounds</td>
<td>Coltene Vigodent, Rio de Janeiro/RJ, Brazil</td>
</tr>
<tr>
<td>PF</td>
<td>Provismaster F</td>
<td>UDMA, TEGMA, EDAB, BHT, photoinitiator and inorganic load compounds and fluorine</td>
<td>Wilcos, Petrópolis/RJ, Brazil</td>
</tr>
</tbody>
</table>

Table 2. Arithmetic average and standard deviation of flexural strength values (MPa) demonstrated by temporary restorative materials.

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>BT</th>
<th>SO</th>
<th>FT</th>
<th>PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>8,83a</td>
<td>2,47c</td>
<td>4,46b</td>
<td>5,67b</td>
<td>6,21b</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>10,84</td>
<td>0,47</td>
<td>0,90</td>
<td>1,43</td>
<td>1,15</td>
</tr>
</tbody>
</table>

abc Different letters indicate significant differences between groups. (p<0.05). CF, Clip F; BF, Bifix; Temp; SO, Systemp.onlay; FT, Fill Magic Tempo; PF, Provi Master Flúor.

Table 3. Average and standard deviation of gap extension (µm) and incidence of marginal desadaptation (%) in the interface between the dentin and the temporary restorative material.

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>BT</th>
<th>SO</th>
<th>FT</th>
<th>PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaps extension Média</td>
<td>1,17a</td>
<td>4,03b</td>
<td>10,49c</td>
<td>10,54c</td>
<td>10,61e</td>
</tr>
<tr>
<td></td>
<td>D.P.</td>
<td>0,12</td>
<td>0,21</td>
<td>0,33</td>
<td>0,41</td>
</tr>
<tr>
<td>Incidence of marginal maladaptation Média</td>
<td>23,1a</td>
<td>83,4d</td>
<td>95,3e</td>
<td>97,1f</td>
<td>98,0g</td>
</tr>
<tr>
<td></td>
<td>6,8</td>
<td>5,9</td>
<td>4,6</td>
<td>3,6</td>
<td>1,3</td>
</tr>
</tbody>
</table>

abc Different letters indicate significant differences between groups. (p<0.05). CF, Clip F; BF, Bifix; Temp; SO, Systemp.onlay; FT, Fill Magic Tempo; PF, Provi Master Flúor. SD, standard deviation.
DISCUSSION

The flexural strength test and the marginal adaptation analysis showed differences between the temporary restorative materials tested in the dentin pulp chamber, which permit to assume that the null hypothesis could be rejected.

The flexural strength study of temporary restorative materials in dentistry is very interesting to evaluate the performance of these materials when they are submitted to masticatory forces. In contrast, this method does not assess other factors that can have effects on the flexural strength of temporary restorative materials, such as thermocycling, oral environment conditions and the force type applied. 14,16

The Clip F (Voco) is a new version of Clip (Voco) added with fluorides. Essentially, this material is constituted by dimethacrylate resin groups, which relatively keeps the flexible characteristic of the material even after the photoactivation by halogen light or LED. This may explain the higher values obtained for the flexural strength, once until the total failure the specimens were submitted to a large horizontal deflection after the axial strength incidence by electromechanical testing machine. Additionally, this flexibility also can be explained by the material microhardness which was the lowest when in comparison with other groups, data also observed by Bodrumlu et al. 18

Clip F material also showed the best results for the marginal adaptation with the dentin tissue from the pulp chamber, after 7 days. This was confirmed by the satisfactory potential to promote the marginal sealing between the tooth and restoration with minimal infiltration. This might be explained by the excellent plasticity of the material at the insertion in the cavity, and also by the low polymerization shrinkage, as recorded in resinous compounds containing similar composition. 11

In the present study, specifically the Bifix Temp (Voco) has been used for a different purpose to recommended by the manufacturer, since this material is most indicated for esthetic restoration temporary cementation. Although, many clinical studies have also been applied the Bifix Temp directly in tooth cavity as temporary restorative material among the treatment sessions. 17

As described in table 1, this material has substances that allow dual polymerization but as described by manufacturer’s instructions, also is recommended an additional photoactivation for only 2 seconds. However, in order to standardize the methodology, the time of photopolymerization for Bifix Temp was set to 40 seconds what could affect negatively its physical properties regarding flexural strength, since the different polymerization cycles directly affect the fracture resistance in resinous compounds. 20

With regard to marginal adaptation, when in comparison with CF group, BT group demonstrated a large gap extension and higher marginal adaptation failure. The large gap extension result could be explained by the plasticity of the material even after photopolymerization. Whereas, the good marginal adaptation found for SO, FT and PF groups also can be explained to the polymerization method applied, but it is important to mention the great participation of the benzoyl peroxide and tertiary amines in the polymerization processes which affords a certain reduction in the polymerization shrinkage. 21

Figure 1. Representative image of scanning electron microscopy (500x) of the gap extension and marginal adaptation from temporary restorative materials (A) Clip F, (B) Bifix Temp and (C) System.onlay, Fill Magic Tempo and Provi Master F. Scale bar 50µm.
The temporary restorative materials SO, FT and PF have similar chemical composition with respect to dimethacrylate resin groups, inorganic load compounds and silicon dioxide, which may explain the similarity of results obtained among these materials. The unfavorable results with respect to CF and BT group can be assigned with a large presence of inorganic load compounds in these materials, which possibly increased the polymerization contraction, stimulating the formation of gaps and/or increasing the extent of the marginal maladaptation.3,22

Therefore, while the methodology used in the present study is different of the clinical conditions found in oral cavity, these previous results allow to prioritize these materials for a possible indication as temporary restorative materials to seal the coronal access in teeth endodontically treated. Thus, further studies are required to establish the best temporary restorative material to be used in teeth endodontically treated.

CONCLUSION

The CF group show the higher flexural strength, lower marginal failure and gap extension when in comparison with other temporary restorative materials tested in this study. Conversely, the groups SO, FT and PF demonstrated worst results for flexural strength, marginal adaptation and gap extension, but no difference was found in each other.

References

7. Keinan D, Moshonov J, Smidt A. Is endodontic re-treatment in oral cavity, these previous results allow to prioritize these materials for a possible indication as temporary restorative materials to seal the coronal access in teeth endodontically treated. Thus, further studies are required to establish the best temporary restorative material to be used in teeth endodontically treated.