Rehabilitation of weakened premolars with a new polyfiber post and adhesive materials

Márcia Rachel Costa Braga, Danielle Cristine Messias, Luciana Martins Macedo, Yara Correa Silva-Sousa, Aline Evangelista Souza Gabriel

**ABSTRACT**

**Background:** Polyfiber posts used inside the root canal can help to restore the fracture resistance of weakened premolars.

**Aim:** To assess the fracture resistance of endodontically treated premolars restored with different techniques, including the new polyfiber post (Spirapost).

**Materials and Methods:** One hundred superior premolars were distributed into 10 groups (n = 10): Sound teeth (G1-positive control) and experimental (G2 to G10), which received MODP cavities and canal treatment. Groups were restored as follows: G2 - unrestored (negative control); G3 - microhybrid resin (MR); G4 - flowable resin (FR) + (MR); G5 - glass fiber post (Reforpost) + MR; G6 - Reforpost + FR + MR; G7 - polyethylene fiber (Ribbond) + MR; G8 - Ribbond + FR + MR; G9 - polyfiber post (Spirapost) + MR and G10 - Spirapost + FR + MR. After 24 h, the specimens were loaded until fracture. Data were analyzed by ANOVA and Tukey's test (P < 0.05).

**Results:** Premolars restored with Spirapost (G9 and G10) provided the highest fracture strength (P < 0.05), similar to sound teeth (G1), regardless of the composite resin. Intermediate values were achieved by G3, G4, G5, G6, G7, and G8, which were similar (P > 0.05) and different from the others (P < 0.05). Inferior values were found in G2 (P < 0.05).

**Conclusion:** Fracture resistance of premolars with MODP cavities and endodontic access was recovered with the direct rehabilitation with Spirapost, regardless of the type of composite resin.

Key words: Composite resin, dental post, fracture resistance
Recently, a new esthetic flexible post has been developed. This post, called “Spirapost”, is constructed of surgical stainless-steel wires that are twisted around a biocompatible polyfiber strand. \[10\] According to the manufacturer, the post perfectly adapts to the configuration of the root canal after minimum post space preparation and without the need of straight-line access. There is only one study published with this new type of post, in which the authors found that the Spirapost had significantly increased postretention when compared to the glass fiber post. \[10\]

Direct composite resin restorations are often used for root-filled teeth as a relatively low cost and esthetic alternative to cuspal coverage restorations. \[11,14\] The choice of the direct technique with composite resin will depend on the remaining tooth structure. \[12,15-18\]

The aim of the present study was to assess in vitro the fracture resistance of endodontically treated premolars restored with three intraradicular posts and two direct restorative techniques using composite resin. The null hypothesis is that there is no difference between the fracture resistance of intact premolars and reduced cusp premolars with access cavities and MOD preparations restored with different direct techniques.

**MATERIALS AND METHODS**

**Teeth selection**

The study protocol was approved by the local Ethics Committee (371/2011). Maxillary sound premolars, extracted for periodontal disease or orthodontic reasons, stored in 0.1% thymol solution at 4°C, were washed in running water for 24 h to eliminate thymol residues.

Premolars were examined at a magnification of x10 using a Stereomicroscope (Leica Microsystems, Wetzlar, Germany) to discard those with cracks. Next, they were radiographed and those with two root canals, without calcifications and resorptions were selected. The coronal portions of premolars should have had mesio-distal dimensions of 6.0–7.5 mm and vestibulo-palatal dimensions of 6.0–8.0 mm. One-hundred maxillary premolars were selected for the study.

**Root canal treatment and post space preparation**

All teeth, except those of the control group (G1), were submitted to root canal treatment. The working length was established 1 mm from the root apex and the canals were subjected to biomechanical preparation with ProTaper System (Dentsply-Maillefer, Ballaigues, Switzerland) using Sx, S1, S2, F1, F2, F3 at 250 rpm (SA Anthogyr, Sallanches, France), irrigation with 2 ml of 1% NaOCl at each change of instrument and a final rinse with 5 ml of 17% EDTA for 3 min. Then, canals were irrigated with distilled water and dried with paper points (Dentsply-Maillefer).

The root canals were filled with Gutta-percha cones and AH Plus sealer (Dentsply-Maillefer), using lateral compaction technique. Root canal was filled with a temporary restorative material (Cavit-G; 3M ESPE AG, Seefeld, Germany) and teeth were stored at 37°C for 7 days. The specimens of G2 were not filled with endodontic material.

Gutta-percha was removed with #1 and #2 Largo drills (Dentsply-Maillefer), removing two-thirds of the canal material and leaving a minimum of 4 mm of Gutta-percha at the apex. Root canals were irrigated with distilled water and dried with paper points (Dentsply-Maillefer).

**Periodontal ligament and alveolar bone simulation**

The external root surfaces of all specimens were covered with a thin layer of a polyether impression material (Impregum Soft; 3M ESPE, St. Paul, MN, USA) to simulate the periodontal ligament. The teeth were inserted into a metallic rectangular matrix (16.5 mm width × 31.0 mm length), and were embedded in auto-polymerized acrylic resin (Jet Clássico, São Paulo, SP, Brazil) up to 2.0 mm below the cemento-enamel junction (CEJ), to simulate the alveolar bone. \[3\]

**Cavity preparation**

Class II MOD cavities were prepared in all teeth, except those of the positive control group (G1), using a #1090 cylindrical diamond bur (KG Sorensen, Barueri, São Paulo, SP, Brazil), using a High-speed Handpiece (Dabi Atlante, Ribeirão Preto, SP, Brazil) with air-water spray. Proximal boxes were kept 1.0 mm above the CEJ. After, teeth preparations extended toward the palatal cusps (MODP). The cusps were reduced in such a way that the remaining structure was 3.5-mm high and 3.0-mm thick. The measurements were checked using the digital pachymeter (Mitutoyo).

The specimens were randomly assigned to 10 groups (n = 10), according to the restorative procedure, as described as below:

- **G1** - Intact premolars (positive control)
- **G2** - unrestored MODP cavity + post space preparation (negative control)
- **G3** - MODP cavity restored only with microhybrid resin (MR) (Filtek Z250; 3M ESPE, St. Paul, MN, USA).
- **G4** - MODP cavity restored with flowable resin (FR) (Filtek Z350; 3M ESPE) + MR (Filtek Z250; 3M ESPE).
- **G5** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + MR (Filtek Z250; 3M ESPE).
- **G6** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer).
- **G7** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer).
- **G8** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire).
- **G9** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire) + #1 and #2 Largo drills (Dentsply-Maillefer).
- **G10** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire) + #1 and #2 Largo drills (Dentsply-Maillefer) + #1 and #2 Largo drills (Dentsply-Maillefer).

The specimens were randomly assigned to 10 groups (n = 10), according to the restorative procedure, as described as below:

- **G1** - Intact premolars (positive control)
- **G2** - unrestored MODP cavity + post space preparation (negative control)
- **G3** - MODP cavity restored only with microhybrid resin (MR) (Filtek Z250; 3M ESPE, St. Paul, MN, USA).
- **G4** - MODP cavity restored with flowable resin (FR) (Filtek Z350; 3M ESPE) + MR (Filtek Z250; 3M ESPE).
- **G5** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer).
- **G6** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer).
- **G7** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire).
- **G8** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire) + #1 and #2 Largo drills (Dentsply-Maillefer).
- **G9** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire) + #1 and #2 Largo drills (Dentsply-Maillefer) + #1 and #2 Largo drills (Dentsply-Maillefer).
- **G10** - MODP cavity restored with composite resin (Jet Clássico, São Paulo, SP, Brazil) + AH Plus sealer (Dentsply-Maillefer) + Intracal (Dentsply-Maillefer) + Spirapost (Surgical Stainless Steel Wire) + #1 and #2 Largo drills (Dentsply-Maillefer) + #1 and #2 Largo drills (Dentsply-Maillefer).
The flowable (Filtek; Z350) was injected onto pulpar floor of the cavity and light-activated for 20 s (Ultralux; Dabi Atlante). The microhybrid resin (Filtek Z250; 3M ESPE) was inserted in increments over the FR (Filtek Z350; 3M ESPE) until completing the restoration, as described in G3

- **G5** - MODP cavity restored with intraradicular glass fiber post (Reforpost; Ângelus, Londrina, PR, Brazil) + MR (Filtek Z250; 3M ESPE). The post space was prepared using Largo burs (Dentsply-Maillefer) to remove 2/3 of the filling material from the root canal. Acid etching was applied for 15 s in canal walls and cavity was washed for 15 s. Later, a layer of the adhesive system (Scotchbond Multi-Purpose Plus; 3M ESPE) was applied to canal walls according to the manufacturer, using a micro brush. The adhesive system was light-cured for 20 s. The glass fiber post (Reforpost; Ângelus) was selected and precutted to a suitable length, cleaned with alcohol and a layer of silano (Ângelus) was applied over its surface. The excess of silano was removed with compressed air for 5 s. The post was luted with dual-cure resin cement (RelyX ARC; 3M ESPE), according to the manufacturer’s recommendations. The final restoration was carried out with microhybrid composite resin as described for G3

- **G6** - MODP cavity restored with intraradicular glass fiber post (Reforpost; Ângelus) + FR (Filtek Z250; 3M ESPE) + MR (Filtek Z250; 3M ESPE). After the glass fiber post cementation in root canal, the cavities were restored as described in G3 and G4

- **G7** - MODP cavity restored with intraradicular polyethylene fiber (Ribbond, Ribbond Inc., Seatle, WA, USA) + MR (Filtek Z250; 3M ESPE). The Ribbond was wetted with Adper Single Bond adhesive (3M ESPE) and protected from exposure to light until ready for use. The dual-cure resin cement (RelyX ARC; 3M ESPE) was used to lute the Ribbond. The fiber was inserted into the canal with a clinical clamp and adjusted such that it extended 2 mm outside of the canal and was cured for 20 s. After cementation, the final restoration was carried out with composite resin, as described for G3

- **G8** - MODP cavity restored with intraradicular polyethylene fiber (Ribbond, Ribbond Inc., Seatle, WA, USA) + FR (Filtek Z250; 3M ESPE) + MR (Filtek Z250; 3M ESPE). The post space was prepared, and the Ribbond was cemented as G7. After cementation, final restoration was carried out with composite was cemented resin, in the same way as described for G3 and G4

- **G9** - MODP cavity restored with intraradicular flexible post (Spirapost, DMG) ++ MR (Filtek Z250; 3M ESPE). The Spirapost was covered with the dual-cure resin cement (RelyX ARC; 3M ESPE) inserted into the root canal and light-cured for 20 s. The coronal restoration was carried out with composite resin, as described for G3

- **G10** - Teeth restored with the intraradicular flexible post (Spirapost, DMG) + FR + MR. The post space was prepared, and the Spirapost was cemented as in group G5. The coronal restoration was carried out as described for G3 and G4. Figure 1 illustrates the intraradular posts used in the study.

After 24 h, the specimens were subjected to the fracture strength test, using a universal testing machine (Instron 4444; Instron Corp., Canton, MA, USA) at a crosshead speed of 1 mm/min. The specimens were positioned at 45° in relation to the root long axis, and the load was applied to the palatal cusp. The moment of fracture was determined by a sudden decrease in force measurement in the testing machine.

After testing, the teeth were removed from the acrylic resin blocks, and the specimens were observed at ×10 to classify the fracture according to the direction (longitudinal, transverse, or oblique) and localization – crown (occlusal, medium, and cervical) or root (cervical, medium, and apical).

Fracture resistance values were statistically compared. The Kolmogorov–Smirnov test showed that the results were consistent with a normal distribution curve. Parametric statistical analyzes were performed (one-way ANOVA and post-hoc Tukey’s test) at 5% significance level (SPSS 17, SPSS Inc., Chicago, IL, USA).

![Figure 1: Intraradicular post used to restore weakened premolars. (a) Glass fiber post (Reforpost). (b) Polyethylene fiber (Ribbond). (c) Polyfiber post (Spirapost)](image-url)
RESULTS

ANOVA indicated a significant difference in fracture resistance mean values of the tested groups (P < 0.05). Tukey’s test revealed that weakened premolars restored with polyfiber post (Spirapost), regardless of the composite resin (only microhybrid or microhybrid combined with flowable) (G9 and G10) provided the highest fracture strength (P < 0.05), without significant difference from intact premolars (positive control) (G1) (P > 0.05).

Intermediate bond strength values were achieved by the teeth restored with glass fiber post and polyethylene fibers (Ribbond), regardless the type of composite resin (G5, G6, G7, and G8), which were statistically similar (P > 0.05). Premolars restored with MR (G3) or flowable + MR (G4) also did not present significant difference (P > 0.05).

Inferior value were found in teeth only prepared (negative control) (G2), which is different from the others (P < 0.05). The mean values and standard deviations of forces required (kN) to fracture the premolars in each group are displayed in Table 1.

Table 1: Mean and SD of teeth fracture resistance (kN) restored with different direct techniques

<table>
<thead>
<tr>
<th>Experimental groups</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 - Sound teeth (positive control)</td>
<td>0.83±0.15</td>
</tr>
<tr>
<td>G2 - Teeth only prepared (negative control)</td>
<td>0.14±0.05</td>
</tr>
<tr>
<td>G3 - MR (Z250/3M)</td>
<td>0.43±0.09</td>
</tr>
<tr>
<td>G4 - FR (Z350/3M) + MR (Z250/3M)</td>
<td>0.53±0.07</td>
</tr>
<tr>
<td>G5 - Glass fiber post (Reforpost) + MR (Z250/3M)</td>
<td>0.41±0.12</td>
</tr>
<tr>
<td>G6 - Glass fiber post (Reforpost) + FR (Z350/3M) + MR (Z250/3M)</td>
<td>0.48±0.13</td>
</tr>
<tr>
<td>G7 - Polyethylene fibers (Ribbond) + MR (Z250/3M)</td>
<td>0.50±0.17</td>
</tr>
<tr>
<td>G8 - Polyethylene fibers (Ribbond) + FR (Z350/3M) + MR (Z250/3M)</td>
<td>0.54±0.14</td>
</tr>
<tr>
<td>G9 - Polyfiber post (Spirapost) + MR (Z250/3M)</td>
<td>0.79±0.16</td>
</tr>
<tr>
<td>G10 - Polyfiber post (Spirapost) + FR (Z350/3M) + MR (Z250/3M)</td>
<td>0.84±0.11</td>
</tr>
</tbody>
</table>

Different letters indicate significant difference (Tukey critical value=0.18, P<0.05). SD=Standard deviation, MR=Microhybrid resin, FR=Flowable resin.

The cervical crown fractures were found in all groups. The average amount of fracture mode (%) in the tested groups is shown in Table 2.

DISCUSSION

Fracture resistance is one of the most important characteristics of restored teeth. It depends on the material resistance to crack propagation from its internal structure.[17] Adhesive materials contribute to increase the fracture resistance of weakened teeth.[14,19‑21] Therefore, this study attempted to compare the fracture resistance of weakened premolars restored with different direct restorative techniques, using three different posts: A new polyfiber post (Spirapost), glass fiber post (Reforpost), and polyethylene fiber (Ribbond).

The fracture testing remains a common experimental method of evaluating restorative procedures for root-filled teeth. Although the fracture load is typically much higher than functional occlusal loads, it is still a valid method for comparing restorative materials and different cavity designs.[12]

In the present study, the teeth were loaded in the palatal cusp at 45° to the horizontal plan, using a stainless-steel tip, as recommend by the literature.[13‑6‑9] This pattern of loading was intended to simulate normal working side occlusal contacts.[19]

In previous studies, the direction of the applied load has included axial loading on both buccal and palatal cusps.[12,30,21]

Maxillary premolars were used in the resistance test because they are highly susceptible to fracture.[15,16] A simulation of the periodontal ligament was undertaken using an elastomeric material, in order to reproduce the elastic deformation and the accommodation of the tooth in the alveolus during occlusal forces.[17,18]

The final result of endodontic treatment is dependent on the appropriate and timely coronal restoration of the
endodontically treated tooth.\textsuperscript{[12]} Dentine provides the solid base required for tooth restoration. Its structural strength depends on the quality and integrity of its anatomic form, so the fundamental problem is the increased quantity of sound dentine remaining to retain and support the restoration.\textsuperscript{[3,7]} Therefore, selecting the optimum restorative modality to compensate for the loss of coronal tooth structure is considered the key to restorative success.\textsuperscript{[2]}

The null hypothesis of the present study was partially rejected. The fracture strength of endodontically treated premolars restored with Spirapost provided the highest fracture strength and similar to that of the intact teeth maybe due to the fact that the luting agent penetrates the polyfiber strands of the post and creates a homogenous unit.\textsuperscript{[10]} Spiraposts are not really posts but interproximal brushes used to fill the root canal space in combination with resin composite, the geometry may play a role in the setting reaction of the luting material and better polymerization may explain the improved adhesion to dentinal walls because the resin cement is mechanically interlocking at different planes around the polyfiber.\textsuperscript{[10]} Additionally, the flexibility and adaptability of polyfiber strands to the root canal may provide additional retention.\textsuperscript{[10]}

Direct composite restorations are considered predictable to restore endodontically treated premolars.\textsuperscript{[16,19]} Contraction stress on adhesive interfaces during polymerization was reduced by using the composite-layering technique.\textsuperscript{[17,22]} All composite restorations were undertaken by the same operator to ensure standardization.

The findings of this study indicate that premolars with MOD cavities restored with both direct resin technique (MR or flowable composite plus MR) showed statistically similar values. Microhybrid composite resins are indicated to restore anterior and posterior teeth. This resin has increased filler content in its formula. Thus, the slight deformation occurs under functional loads and crack formation following functional loads will not occur so easily.\textsuperscript{[22]} Flowable composite resin is a less viscous material, improving the wettability by flowing into all prepared surfaces creating an intimate union with the microstructural defects in the floor and the walls of the cavity preparation.\textsuperscript{[23,24]} In addition, it acts as a flexible intermediate layer that helps to relieve stresses during polymerization shrinkage of the restorative resin\textsuperscript{[24-26]} which can reduce or eliminate the formation of gaps and microleakage.\textsuperscript{[1]} The low stiffness of composite may compensate the polymerization contraction of the low modulus restorative composites and they also shrink more because of their reduced filler content.\textsuperscript{[27,28]}

Despite the advance in adhesive materials and technology, the total etching adhesive system (Adper Single Bond/3M) and microhybrid composite resin (Filtek Z250/3M) used in this study were not able to restore the fracture strength of premolars with MOD cavities without using another reinforcement material, probably due to the excessive stress along the dentine/resin interface, causing material debonding.\textsuperscript{[3]}

Considering the above-mentioned facts, our findings recommend the use of flowable and microhybrid composite or only MR in combination with Spirapost to restored weakened premolars, due to the good stress distribution of the restoration system. The encouraging finding is that the fracture resistance of premolars with MODP cavities and endodontic access was recovered with the direct rehabilitation with Spirapost. An in vivo long-term study is being conducted to check if this promising laboratorial result will be also found in the clinical situation.

CONCLUSION

The fracture resistance of premolars with MODP cavities and endodontic access was recovered with the direct rehabilitation with Spirapost, regardless of the type of composite resin.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

10. Mastoras K, Vasiliadis L, Koulaouzidou E, Gogos C. Evaluation of
Resistance of premolars restored with adhesive materials


