Original Article

Microtensile Bond Strength of Translucent Glass Fiber Posts to Intra-radicular Dentin

N. Mohammadi 1, M. Abed Kahnamoui 1, ME. Ebrahimi Chaharom 1, S. Kimyai 2, M. Bahari 1

1Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran
2Associate Professor, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

Abstract:

Objective: The aim of the present study was to compare microtensile bond strengths (µTBS) of glass fiber posts to different parts of intra-radicular dentin using conventional method and one-shot technique under different light intensities.

Materials and Methods: Twenty-eight single-rooted teeth were prepared to receive fiber posts: Group 1: Conventional method at light intensity of 600 mW/cm²; Groups 2, 3 and 4: One-shot technique at light intensities of 600, 800 and 1000 mW/cm² respectively. Dumbbell-shaped slices were obtained from the samples and submitted to micro-tensile testing. The data were analyzed using two-way ANOVA and paired-samples t-test.

Results: There were no significant differences in µTBS values of the cervical and middle thirds between the groups (P>0.05). µTBS values in the cervical thirds in groups 2 and 3 were significantly higher than those in the middle thirds (P>0.05). However, there were no such differences in groups 1 and 4 (P>0.05).

Conclusion: It is proper to simultaneously cure the resin cement and the adhesive agent (one-shot technique); however, in that case, high light intensities (1000 mW/cm²) are recommended to achieve identical bond strength values in the cervical and middle thirds.

Key Words: Tensile Strength; Lightpost; Curing Lights, Dental

INTRODUCTION

The most common method to increase the retention of restorations in endodontically treated teeth is the use of intra-canal posts. Cemented cast or metallic prefabricated posts are routinely used in clinical settings [1]. For a long time it was believed that metallic posts could strengthen the remaining tooth structure; however, numerous clinical reports have indicated vertical root fractures [2]. Wedging effect produced by active posts or during cementation of passive posts in roots can result in root fracture [3,4]. Therefore, the method used for post cementation is an important factor in the long-term success of a restoration. Frictionless cemented posts (fiber posts) have been suggested to reduce the risk of fractures due to detrimental effects of metallic posts [5]. Originally, fiber posts were recommended for use with a three-step bonding system and proprietary resin cement. Recently, single bottle adhesive systems have been proposed to simplify the clinical bonding procedure [6,7]. Transmission of light through translucent posts makes it possible to simultaneously cure the resin cement and the adhesive in a single clinical step (one-shot technique) which results in simplicity, decrease in the chair time needed and low technique sensitivity of the bonding procedure [8,9]. One of the disadvantages of...
the conventional method, in which the bonding agent is cured separately, is lack of close adaptation of the post to canal walls in case there is adhesive resin excess.

In a previous study, efficacy of one-shot technique to form resin-dentin inter-diffusion zone (RDIZ), resin tags and lateral branches during cementation of glass fiber posts at a light intensity of 600 mW/cm² was evaluated under SEM and it was concluded that one-shot technique is less efficacious than the conventional method [10]. However, in another study, no statistically significant differences were observed in thickness of the hybrid layer and width of the gaps when these two different methods were compared [11]. Nevertheless, microscopic evaluations do not provide any information regarding the quality of RDIZ and it is extremely difficult to convert the results of these observations into numeric data and analyze them statistically [6,12]. Furthermore, since light can pass through glass fiber posts, its intensity can influence the penetration depth and affect the formation of RDIZ, resin tags and the lateral branches [10]. The purpose of the present study was to compare the microtensile bond strengths of glass fiber posts to different parts of intra-radicular dentin using the conventional method and one-shot technique using light intensities of 600, 800 and 1000 mW/cm².

**MATERIALS AND METHODS**

Extracted single-rooted teeth with rather same root sizes and previously stored in 0.5% chloramine T solution (Formula & Acao, Sao Paulo, Brazil) were used for this study (n=28). The crown of each tooth was transversely cut away 1 mm coronal to the CEJ using a low speed diamond saw (Isomet, Buchler, Lakebluff, USA) under constant water spray. Working lengths and root morphology were determined prior to root canal treatment by x-rays. Teeth demonstrating canal obstructions or working lengths less than 14 mm were excluded from the study. After canal preparation and obturation, 8 mm of each canal was prepared using #2 and #3 Peeso reamers (MANI) and the special drills provided by the manufacturer for #2 fiber posts (RTD, St. Egreve, France). Then, the roots were buried in a mold made of condensational silicone impression material with a putty consistency (Speedex, Coltene, Switzerland) to prevent polymerization of the adhesive as a result of the light filtered through lateral root walls and also to prevent propagation of the curing light beyond the root. Prior to bonding, the canals were irrigated with 0.5% sodium hypochlorite solution for one minute, rinsed with distilled water and dried using paper points.

All the prepared canals were etched with 35% phosphoric acid (Scotchbond™, 3M ESPE, USA) for 15 seconds, rinsed and dried using gentle air current and paper points before being randomly divided into 4 groups (n=7): Group 1: The bonding agent (Single Bond, 3M ESPE) was applied in two layers on the canal walls and the post surface using microbrushes (Microbrush X, Greyton CO, WI, USA) and separately cured according to manufacturer's instructions. (600 mW/cm², LITEX TM 680A, Dentamerica, Bedford Circle, City of Industry, CA91744, USA). Then, dual-curing resin ce-

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean μTBS (SD)</th>
<th>Cervical</th>
<th>Middle</th>
<th>t</th>
<th>df</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.87 (0.40)</td>
<td>1.83 (0.83)</td>
<td>0.16</td>
<td>13</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>1.82 (0.37)</td>
<td>1.43 (0.54)</td>
<td>2.22</td>
<td>13</td>
<td>0.03*</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>1.83 (0.29)</td>
<td>1.47 (0.45)</td>
<td>2.51</td>
<td>13</td>
<td>0.01*</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>1.85 (0.55)</td>
<td>1.54 (0.43)</td>
<td>1.66</td>
<td>13</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

*P<0.05 represents statistical significant differences, t: statistics of t-test, df: degree of freedom
ment (Rely X-ARC, 3M ESPE) was placed into the canals by a lentulo spiral. Double Taper Lightpost (DT) covered with the cement was then put inside the canal and finally, all the components were cured for another 20 seconds with the same unit and intensity. The curing tip was placed on the terminal end of the post parallel to the root long axis.

Group 2: The bonding agent (Single Bond) was applied in two layers on the canal walls and the post surface using microbrushes. Then, the resin cement was placed into the canals by a lentulo spiral before the cement-covered post was put inside the canal and then the whole unit was simultaneously cured for 30 seconds (600 mW/cm², LITEX TM 680A).

Group 3: Fiber posts were cemented in the same manner as in group 2 but at a light intensity of 800 mW/cm² using Degulux light-curing unit (Dentsply, DeTrey, GmbH, Germany).

Group 4: Fiber posts were cemented in the same manner as in group 2 but at a light intensity of 1000 mW/cm² using ASTRALIS 7 light-curing unit (Ivoclar-Vivadent, Germany).

Afterwards, root-post sets were retrieved from the silicone molds and were first kept in a 100% relative moisture environment for 24 hours and then stored in distilled water for another 24 hours. Subsequently, the roots were sectioned into 1 mm thick slices and trimmed into dumbbell-shaped sections until the bur touched the posts. The dumbbell-shaped sections were subjected to microtensile bond strength (µTBS) test (Micro Tensile Tester; Bisco, Schaumberg, IL, USA) and loaded to failure at a strain rate of 1 mm/min.

Finally, all the specimens were evaluated under a stereomicroscope at ×25 magnification to determine the mode of fracture. Failure modes were classified as: type I: adhesive failure between the resin cement and the post (RC-P), type II: adhesive failure between the resin cement and the canal wall (RC-RD), type III: mixed failure, when the fracture was partially at the resin cement-post and partially at the resin cement-root dentin interfaces and type IV: cohesive failure occurring only in the resin cement, post or root dentin.

The data were analyzed using two-way ANOVA and paired-samples t-test. In the present study, the statistical significance was defined at P<0.05. Normal distribution of the data was confirmed by Kolmogrov-Smirnov test.

RESULTS

Mean µTBS values (MPa) and standard deviations (SD) for each experimental group were separately calculated for cervical and middle thirds (Table 1).

Statistical analysis did not demonstrate any significant differences in mean µTBS values between the experimental groups (P>0.05). However, there were significant differences in means µTBS values between different root regions (P=0.006) (Table 2).

Further analysis using paired-samples t-test revealed that µTBS values in the cervical thirds in of groups 2 and 3 were significantly higher than those in the middle third (P<0.05) (Table 1).

In addition, two-way ANOVA revealed that there were no statistically significant differ-

### Table 2. Results of the two-way ANOVA test

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different Curing Techniques</td>
<td>0.836</td>
<td>3</td>
<td>0.279</td>
<td>1.065</td>
<td>0.367</td>
</tr>
<tr>
<td>Different Root Regions</td>
<td>2.074</td>
<td>1</td>
<td>2.074</td>
<td>7.925</td>
<td>0.006*</td>
</tr>
<tr>
<td>Different Curing Techniques and</td>
<td>0.509</td>
<td>3</td>
<td>0.170</td>
<td>0.649</td>
<td>0.585</td>
</tr>
<tr>
<td>Different Root Regions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P<0.05 represents significant statistical differences, * the effect of two variables has been evaluated simultaneously.
ences in μTBS values between the experimental groups in the cervical and middle thirds when different curing methods and root regions are collectively taken into account (P>0.05) (Table 2).

DISCUSSION

Our results indicate that μTBS values of fiber posts to intra-radicular dentin using one-shot technique at different light intensities are the same as the conventional method. This finding is consistent with the results of an SEM study concluding that thickness of the hybrid layer formed in the middle and cervical thirds of intra-radicular dentin using conventional and one-shot techniques at identical light intensities do not demonstrate statistically significant differences [11]. Yet, it has been shown that the number of resin tags and the thickness of the hybrid layer formed in the apical and middle thirds using the conventional method are significantly more plentiful than those formed using one-shot technique but no significant differences were found in the cervical region. It has been advocated that curing for 20 seconds from the end of the translucent post is not sufficient to completely cure the adhesive in the middle and apical thirds [13].

Mean μTBS values of the adhesive system used in this study in all the groups were much lower than those in the mid-coronal dentin (40 MPa) reported through a previous study [14]. The different results might be attributed to factors such as morphologic differences between the substrates (coronal dentin versus intra-radicular dentin), root canal irrigation solutions, type of the sealer and finally different methods used in the studies. However, it has been demonstrated that polymerization shrinkage of the resin cement is believed to be the most important factor influencing the bond strength [15].

Some authors have accused one-shot technique to be less efficacious in forming RDIZ and resin tags compared to the conventional method and an increased curing times do is unable to compensate for it. Thus, some have suggested the effect of higher light intensities to be evaluated on the matter [10]. Furthermore, the results of the present study indicated that at 600 and 800 mW/cm² light intensities, μTBS values in the cervical third are significantly higher than in the middle third; but, there was such difference at 1000 mW/cm² intense light. These findings might be attributed to lower light intensities not being sufficient to properly cure the adhesive resin in dentinal tubules in the middle third of the root canal and resin tags not being formed in sufficient quantities. Therefore, as the light intensity increases, the adhesive that has penetrated into the etched dentinal tubules in the middle third of the root is completely polymerized, resulting in the formation of longer and more abundant resin tags.

Evaluation of debonded samples under stereomicroscope revealed that all the failures had occurred in the adhesive, consistent with the results of a formerly mentioned study in which some gaps were also observed at the cement-dentin and cement-post interfaces [11]. Thin layers of resin cement in the closed space inside the root canal generate stresses greater than 20 MPa due to resin polymerization [16]. This amount is close to the bond strength of the majority of current adhesive systems when bonded to dentin and is even greater than the bond strength of some available adhesive systems when bonded to fiber posts [17-19]. This is probably the reason why adhesive failures have been observed at the cement-dentin and cement-post interfaces. Accordingly, it is advisable to seek ways to increase bond strength between the fiber post and the root dentin. It should be pointed out that limitations may as well exist in direct application of the results of the present study in clinical situations. One of which is the absence of thermocycling or cyclic loading in the study design.
cycling or cyclic loading can provide more information about the longevity of the adhesive bonding. In addition, the bonding agent used in the present study is only one of the single-bottle adhesive systems available; therefore, the results might not be extended to other products.

CONCLUSION
It seems proper to simultaneously cure the resin cement and adhesive system through one-shot procedure; however, high light intensities (1000 mW/cm²) should be used to achieve identical bond strength values in the cervical and middle thirds.

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