Strength of a Resin Composite Core Build-Up with Prefabricated Posts: An In Vitro Study

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ABSTRACT

Purpose: Determine the diametral tensile strength (DTS) of a resin composite core (Filtek Z250 - 3M) bonded to glass and carbon fibre posts of varying diameter.

Material and Methods: Part I, cylindrical samples of resin composite (C), measuring 6 mm × 3 mm, were fabricated (*n* = 10). Another two groups consisted of 1.5 mm glass-fibre posts (Reforpost - Angelus) (GF1.5) and 1.5 mm carbon-fibre posts (Reforpost - Angelus) (CF1.5) bonded to the resin disks. Part II, specimens were made using 1.1 mm glass-fibre post (GP1.1), and 1.1 mm carbon-fibre post (CF1.1). Specimens were light cured for 40 seconds each side, stored in 37°C distilled water for 7 days and submitted to a DTS test in a universal testing machine (EMIC DL2000). Data was recorded and analyzed using ANOVA with post-hoc pairwise test. Results revealed a statistically significant difference (p <.001) among the groups.

Results: Part I, the mean force (MPa) required to fracture the specimens for each group was: C: 52.33 (± 5.97), GF 1.5: 33.46 (± 4.35), CF 1.5: 35.74 (± 4.49). Control Group was significantly greater than the experimental groups but there was no difference between the two experimental groups. Part II, the mean force (MPa) for each group was: GF 1.1: 37.81 (± 4.46), and CF 1.1: 32.93 (± 3.53). Group GF 1.1 was significantly greater than GF 1.5 and CF 1.1, similar to GC 1.5,

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and CF 1.1 showed a lower value statistically significant difference to CF 1.5.
Conclusion: The fibre posts used in this study have a negative effect on the fracture resistance of the resin composite material.
Clinical Implications: If the tooth has adequate sound structure, the use of prefabricated posts should be avoided.

RÉSUMÉ

Objectif : Déterminer la force de tension diamétrale d'un noyau de résine composite (Filtek Z250 - 3M) lié à des pivots en fibre de verre et en fibre de carbone de diamètre différent.
Matériel et méthodes : Partie I, des échantillons cylindriques de résine composite (C), mesurant 6 mm sur 3 mm, ont été fabriqués (*n* = 10). Deux autres groupes étaient composés de pivots de 1,5 mm en fibre de verre (Reforpost - Angelus) (GF 1,5) et de pivots de 1,5 mm en fibre de carbone (Reforpost - Angelus) (CF 1,5) liés à des disques en résine. Partie II, les spécimens ont été fabriqués en utilisant un pivot de 1,1 mm en fibre de verre (GP 1,1), et un pivot de 1,1 mm en fibre de carbone (CF 1,1). Les spécimens ont subi une photopolymérisation de 40 secondes de chaque côté, ont été conservés dans de l'eau distillée à 37 °C pendant 7 jours et soumis à un test de force de tension diamétrale dans une machine universelle (EMIC DL2000). Les données ont été enregistrées et analysées selon la méthode ANOVA et le test par paires a posteriori. Les résultats ont révélé une différence statistiquement significative (p <0,001) parmi les groupes.
Résultats : Partie I, la force moyenne (MPa) requise pour entraîner la rupture des spécimens de chaque groupe était : C: 52,33 (± 5,97), GF 1,5: 33,46 (± 4,35), CF 1,5: 35,74 (± 4,49). Le groupe témoin était significativement plus important que les groupes expérimentaux, mais il n'y avait pas de différence entres les deux groupes expérimentaux. Partie II, la force moyenne (MPa) pour chaque groupe était : GF 1,1: 37,81 (± 4,46), et CF 1,1: 32,93 (± 3,53). Le groupe GF 1,1 était significativement plus important que le groupe GF 1,5 et CF 1,1, semblable à GC 1,5, et CF 1,1 a démontré une différence statistiquement significative de valeur inférieure à CF 1,5.
Conclusion : Les pivots utilisés dans cette étude ont un effet négatif sur la résistance de rupture de la résine composite.
Conséquences cliniques : Si la dent a une structure solide, l'utilisation de pivots préfabriqués devrait être évitée.

Cast posts have been used in restorative dentistry for more than 100 years.[1] The main disadvantage of cast posts is the high modulus of elasticity of the metal, which exceeds by 8 to 15 times the modulus of elasticity of the dentin. This leads to a high incidence of fracture of the root due to a high stress concentration at the tooth-post interface.[2] Moreover, cast posts require more frequent clinical sessions, more extensive removal of dental structure, and may stain the adjacent root area.[3]

Prefabricated posts are now widely available and are made of carbon, glass, or quartz fibres. These posts have a modulus of elasticity similar to the dentin and allow the post to have the same flexion pattern as the tooth, thereby providing a homogeneous distribution of stress on the root and minimizing the incidence of root fractures.[4,5]

The advantages of prefabricated posts are: they involve less tooth removal, require less time to prepare, are easily removed, are more esthetic, are available in different diameters, and adhere better to the dental structure and the crown.[3,6]

When non-metallic prefabricated posts are used in the restoration of endodontically treated teeth, a crown restoration can be prepared at the same appointment as the resin core is being built and the two components can be bonded together to form a single unit.[7,8]

Fokkinga et al.[9] investigated the fracture resistance and failure mode of crowns fabricated with fibre posts bonded to a resin composite core. The types of posts used were: (1) prefabricated metallic posts, (2) prefabricated fibreglass posts (3) cast posts, and (4) no posts (disks of solid resin composite). A static load was applied until the fracture of the samples using a universal testing machine. Results were similar for fracture resistance and failure mode among the groups, which suggests that posts did not decrease the fracture resistance of the crowns.

Heydecke et al.[10] studied the fracture strength and survival rate of endodontically treated crowned maxillary incisors with proximal class III cavities and different core build-ups including titanium posts, zirconia posts; hybrid composite filling partially the root canal, and access opening restored with resin composite. They found that the cementation of posts was comparable, but there was no evidence of advantageous fracture resistance when compared to the restoration of the endodontically treated tooth with composite alone.

The purpose of this study was to determine (1) the DTS of resin core material when bonded to prefabricated posts with different fibres, (2) the DTS of a resin core bonded to prefabricated posts with different diameters.

The null hypothesis is that there is no difference in DTS of the resin composite core material when bonded to glass fibre or carbon fibre prefabricated posts, or to posts with different diameters when compared to the resin core material alone.

Materials and Methods

Part I – Effect of Type of Fibre

Two commercial, fibre-reinforced, composite posts were tested. Materials used are listed in Table 1.

Thirty disc specimens were fabricated with a resin composite material (Filtek Z250 – 3M/ESPE) using a two-part, stainless steel dye. The inferior portion, measuring 80 mm in diameter with a central perforation of 2 × 1 mm, was used to position the pre-fabricated posts (Figure 1). The superior portion, measuring 70 mm in diameter, had a central perforation of 6 mm in diameter and 3 mm in depth. The central perforation of the inferior portion allows the positioning of a prefabricated post into the center of the specimen that is formed in the superior portion.[5] Three groups of resin composite core specimens were prepared with this device, each consisting of 10 specimens. Resin composite discs without posts served as control group (Group C). The remaining specimens were made using either glass or carbon-reinforced post and resin composite core combinations as follows: Reforpost (Glass Fibre) 1.5 mm diameter glass fibre post (Group GF 1.5) and Reforpost (Carbon Fibre) 1.5 mm diameter carbon fibre posts (Group CF 1.5).

Group C specimens were fabricated by inserting the resin composite (Filtek Z250 – 3M ESPE) into the stainless steel dye using a spatula and then the resin was light-cured for 40 seconds (Optilight Plus QTH unit – Gnatus – 540mW/cm2). The samples were removed from the dye, light-cured on the opposite surface for another 40 seconds and then stored in 37ºC distilled water for seven days.

Figure 1. Metallic matrix.

Figure 2. Light-curing a sample.

Group CF 1.5 and Group GF 1.5 specimens were prepared using an additional step. Prior to their insertion into the lower portion of the dye, the posts were cleaned with 97% ethyl alcohol in accordance with the manufacturer's instructions to prevent contamination. Silane (Silane Agent – 3M/ESPE) was applied to the cleaned posts for 60 seconds, air-dried and a layer of adhesive (Single Bond 2 – 3M/ESPE) was applied and gently air-dried to facilitate solvent evaporation and light-cured for 40 seconds (20 seconds in each side of the post). The fibre post was then placed into the central perforation of the inferior part of the dye and a resin composite was fabricated similar to Group C and light-cured for 40 seconds (Figure 2). The resin disc with the fibre post was removed from the mould, the bottom surface was light-cured for another 40 seconds and then stored in 37ºC distilled water for 7 days.

After seven days of distilled water storage, specimens were subjected to compressive loading in a universal testing machine (EMIC DL2000) with a load cell of 2.000 kg at 1 mm/min of crosshead speed. Each sample was oriented horizontally on the platform of the machine and a DTS test was performed. Load was applied until failure of the resin core specimen occurred. The force (N) needed to fracture the sample disc was converted into megapascal (MPa).

A one-way analysis of variance (ANOVA) was used to determine whether there was any difference among the three groups means (C, GF 1.5, and CF 1.5). The Tukey-Kramer test was used for pair-wise comparisons. A p value <.05 was considered to be statistically significant and a 25% difference in effect size was considered to be clinically significant.

Part II – Effect of Diameter of Fibre

In part II, new specimens were made, using 1.1 mm diameter glass fibre post and resin composite core (Group GF 1.1), and using 1.1 mm diameter carbon fibre post and resin composite core (Group CF 1.1) following the same procedures described above.

Results

The results of the DTS test are presented in Table 2. In part I, Group C (control group) displayed the highest mean DTS value, while Groups CF 1.5 and Group GF 1.5 presented similar, but showed lower fracture resistance values. The fracture resistance of Group CF 1.5 was slightly greater than that of Group GF 1.5. The amount of

Table 1. Materials Used

Brand	Composition	Manufacturer
REFORPOST	Fibreglass post (1.5 mm and 1.1 mm)	Angellus
REFORPOST	Carbon fibre post (1.5 mm and 1.1 mm)	Angellus
Filtek Z250	Composite resin – Type II	3M ESPE
Single Bond	Bonding agent	3M ESPE
Silane	Silane	3M ESPE

force required to fracture the resin disc was 31.7% less for Group CF 1.5 and 36% less for Group GF 1.5 when compared to Group C.

The ANOVA indicated that the mean force required to fracture the resin disc was statistically significant among the groups (p <.001). Post hoc, pairwise comparisons using the Tukey-Kramer test revealed a statistically significant difference in mean fracture resistance of both Group CF 1.5 and Group GF 1.5 compared to the control group (p <.05). The difference in mean fracture resistance between Group CF 1.5 and Group GF 1.5 was not statistically significant (p >.05). All assumptions respecting ANOVA were satisfied.

In part II, the reduction of the glass fibre post diameter increased the fracture resistance of the resin core, while the reduction of the carbon fibre post diameter decreased the final strength of the core.

The amount of force required to fracture the resin disc was 27.7% less for Group GF 1.1 and 37.9% less for Group CF 1.1 when compared to Group C. These differences were deemed to be statistically significant.

Post hoc, pairwise comparisons using the Tukey-Kramer test revealed that the fracture resistance of Group GF 1.1 was significantly greater than that of Group GF 1.5 and CF 1.1 (p >.05). The comparison of the mean fracture resistance between Group CF 1.1 and Group CF 1.5 showed a statistically significant difference (p <.05). There were no statistical difference between Groups GF 1.1 and CF 1.5.

The SEM image of the surface of a fragment of a specimen made with glass fibre post at 500× magnification showed a cohesive failure of the post occurred, thus exposing the fibres (Figure 3). All of the specimens bonded to a post and fractured at the same point within the post material adjacent to the bond between the post and the resin core.

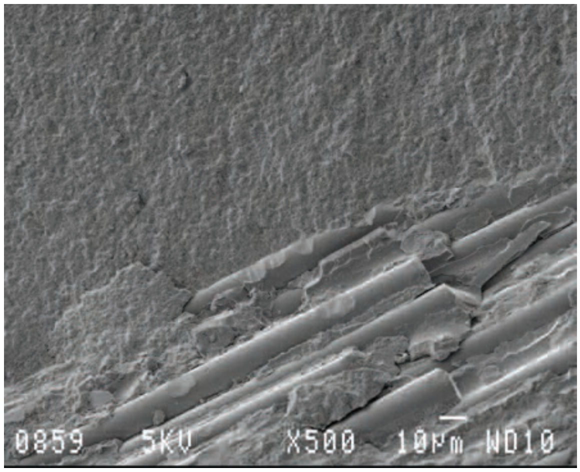

Figure 3. Fibre Post – 500 x original magnification showing post and resin composite.

The scanning electron microscope (SEM) image of a fragment of a specimen made with carbon fibre post at 500× magnification displays cohesive failure also occurred with this type of post as evidenced by a peeling of the surface layer of the post occurred upon fracture (Figure 4). This image shows that the carbon fibres are relatively smaller in diameter when compared to the glass fibres.

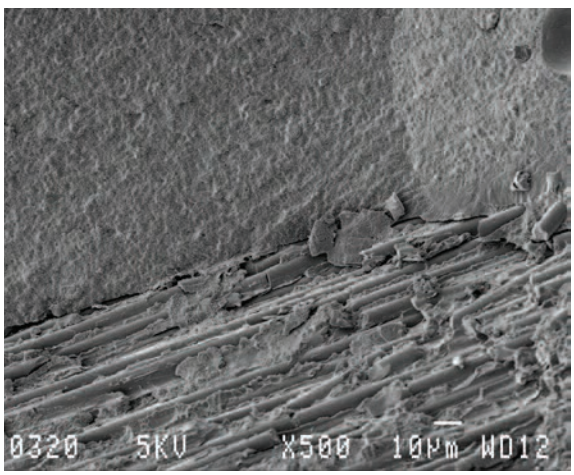

Figure 4. Carbon Post – 500x original magnification showing post and resin composite.

Table 2. Mean force (MPa) required to fracture core specimen, by group

Group	Mean	SD	SE	% Difference from Control	HG
Group (C)	52.33	5.97	1.88		a
GF 1.1	37.81	4.46	1.41	-27.75%	b
CF 1.5	35.74	4.49	1.42	-31.70%	bc
GF 1.5	33.46	4.35	1.37	-36.10%	cd
CF 1.1	32.93	3.53	1.11	-37.08%	d

HG = Homogeneous Groups – Different letters means statistic difference among groups.

Discussion

Different mechanical tests have been used to evaluate the bond strength of fibre posts when bonded to a resin composite build-up core.[11] The DTS is an evidence-based testing method because of its simplicity, uniformity and reproducibility. It is considered an important assay for simulating in-vitro, the tensile stress to which dental restorations are subjected in the oral cavity.[11,12]

Thermocycling was not applied to the specimens. According to Purton et al. thermocycling should be given less emphasis in tests for the retention of root canal posts cemented with resin cements.[13]

In another study investigating the effects of pre-treatment on bond strength between resin cements and various posts including prefabricated glass fibre posts and Interpenetrating Polymer Post (IPN post, Stick Tech), it was found that thermocycling had no significant influence.[14]

Cho et al.[15] verified the DTS of two resin composites (XRV Herculite and Prodigy) for core build-up. They tested samples with the same diameter as the specimens evaluated in this study (6 mm × 3 mm) and reported average DTS values of 51 MPa and 55 MPa, respectively. Santos Jr. et al.[5] also investigated a resin composite core build-up material (Tetric-Ceram) and reported mean values of DTS of 54 MPa. Those results are similar to our study where the average DTS value for the resin composite core (Z250) was 52.3 MPa.

In this study, the use of glass fibre and carbon fibre posts decreased the fracture resistance of the core build-up material by 31.7% for CF 1.5 and 36.1% for GF1.5 respectively. Results demonstrated that the resin composite core material provides higher fracture resistance when used as a solid block.

The use of carbon fibres or glass fibres to prepare the posts did not result in any difference of strength of the samples, although there was difference in width of the fibreglass fibres compared to the carbon fibres.

The reduction of the post diameter to 1.1 mm (GF 1.1) increased the DTS values when compared to the 1.5 mm glass fibre posts (GF 1.5). This may be explained due to the increasing on the final volume of the core material.

The behaviour of Groups CF 1.5 and CF 1.1 which results demonstrated that the bigger the diameter the higher the DTS (statistically significant) probably can be explained because of the relatively smaller diameter of the carbon fibres compared to glass fibres and the higher number of the fibres per volume.

All resin composite samples with bonded fibre posts demonstrated cohesive failure. The failure occurs predominantly within the fibre-reinforced post along the interface between the resin matrix and the post. This finding suggests that the bond between the composite core material and the post surface was stronger than the bond between the internal fibres and the resin matrix of the post.

This study showed a decrease in fracture resistance of resin composite core build up material when used in conjunction with these particular glass and carbon fibre prefabricated posts. This finding indicates that the glass fibre or carbon fibre posts used in this study do not strengthen resin composite core build-up materials. Thus, if the tooth has adequate sound structure, the use of prefabricated posts should be questioned.

Conclusion

The use of carbon fibre and glass fibre prefabricated posts utilized in this study, bonded to resin composite core build-up material decreased the fracture resistance of resin core material by about one third. Both carbon fibre and glass fibre posts with 1.5 mm diameter displayed similar behaviour to compressive forces but differs when 1.1 mm fibre posts where used.

The increasing on the diameter of the glass fibre post decreases the fracture resistance of samples.

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Disclosure

The authors declare no competing financial interest.

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