Polyethylene ribbon fibers: a new alternative for restoring badly destroyed primary incisors

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Dentistry has advanced to the point where it is undesirable for children to be partially edentulous or to have unattractive anterior teeth. With the introduction of new materials and adhesive systems the use of polyethylene fibers as post and core offer a new reconstructive alternative for severely destroyed primary anterior teeth. These fibers offer root and coronal retention, stability and esthetics, and it is done chair side. The present study compared two different types of fibers and analyzed the fracture resistance between the two of them. Two groups were formed. Group I used non pre-impregnated resin fibers (glasSpan) and group II used pre-impregnated resin fibers (Splint-it). Both types of fibers have been used as post and core in the restoration of primary teeth and clinical studies have been published. Our results indicated that the mean fracture resistance for group I was 71.346 and for group II 97.952 (p=0.004). During the observation of the fractured samples, adhesive failures were noted for group I at the junction between the fiber and its core to the interior wall of the root canal. In group II, the fibers were dislodged out of the canal and the core part of the canal remained intact. It can be concluded that pre-impregnated fibers offer a better fracture resistance when used as post in endodontically treated primary anterior teeth.

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INTRODUCTION

The restoration of primary maxillary incisors severely destroyed by trauma or caries, is a challenge for the pediatric dentist. For the reconstruction of these primary anterior teeth, the dentist has had to seek a material that rebuilds the coronal part of the tooth making use of intracanal retention. Intracanal retention is necessary to achieve core retention and coronal stability for resisting the great occlusal forces to which children's teeth are exposed. It is also important to choose a material that is inexpensive, can be placed in one visit, and has the longevity to remain in place until just prior to the eruption of the succedaneous teeth without interfering with the normal eruption process.

The use of polyethylene ribbon fibers as root posts is a new reconstructive alternative that offers root and coronal retention, stability and esthetics, and is done without a laboratory phase. In 2001, Lopes and collaborators used polyethylene ribbon fibers (GlasSpan) in the reconstruction of extremely destroyed primary anterior teeth for retention in the root. One clinical case was monitored for a year showing excellent retention and stability results. These ribbons have the ability to fill the prepared root canal, while the remaining coronal part of the ribbon provides retention and stability to the crown to be constructed.[13,16,18]

GlasSpan (GlasSpan Inc., Exton, PA; 800/280-7726) is a braided glass fiber which can be used in the dental laboratory to fabricate fiber reinforced crowns, bridges, reinforced retainers, splints, and complete dentures. The restoration of a root canal treated tooth with a significant loss of structure is achieved with a post and core. The post may, however, generate stresses causing vertical root fracture and tooth loss.

The polyethylene ribbons are flexible, but have a strong fracture resistance without generating stress, therefore, can be used as root posts.[2,20] These fibers are inserted in the root canal space and a low viscosity composite is used to retain them. The fibers give a very good adaptation to the composite, because the fiber is not pre impregnated, so a low-viscosity resin can be applied to the fibers and then cured.[10] The bulk of these restorations are formed using a particulate filled resin, similar in structure to conventional composite resins. One of the potential draw-backs is that the clinician has to take into account that if the fibers become exposed

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intraorally, they can cause gingival inflammation and may attract plaque.[9]

On the other hand, studies have reported that the new pre- impregnated fibers have a better strength to withstand the occlusal forces because of the excellent integration of the fibers within the composite.[1,5] These results lead us to test these innovative fibers as post and core in severely destroyed primary anterior teeth. Splint-It[R] from Jeneric/Pentron have fibers pre-impregnated with resin, and as a consequence there is no need to prepare the rope before placement into the canal. They have been used in orthodontic appliances as bars to join teeth, as a space maintainer, and as a post-traumatic stabilization splint.[2,6]

Currently, the focus of maintaining the primary incisors revolves around function and esthetics, therefore, the characteristics of the polyethylene fibers make it a potentially new option in the reconstruction of destroyed primary anterior teeth. At present, we have several different options for restoring the crown of primary anterior teeth, which have been severely decayed. These procedures include: the use of stainless steel crowns, composite strip crowns, preformed ceramo-base metal crowns, and stainless steel crowns with composite facings.[5] All of these existing restorative options have considerable disadvantages.

Stainless steel crowns are strong, durable and easily adapted to a prepared tooth; however, they are not esthetically acceptable.[5] The celluloid strip crown is a molded plastic crown that is filled with composite material and light cured on the tooth. They are esthetically appealing and required removal of only a small amount of tooth structure because the retention is gained by bonding to the remaining enamel. However they can not be used for primary anterior teeth that are severely destroyed[14] or that have a minimal coronal stability. Preformed ceramo-base metal crowns are a superior restoration when significant tooth structure has been lost. They are manufactured in five sizes, and are contoured and finished by the practitioner. These crowns have excellent esthetics, strength and durability but they also have few shortcomings, namely, requiring extensive tooth reduction, time-consuming and expensive. Moreover, they are difficult to fit because they are hard and inflexible.[4] Stainless steel crowns with bonded facings combine the durability of the stainless steel with the esthetics of the composite. They can withstand occlusal forces and require a minimal amount of tooth reduction. However, there is a possibility that the bonded material may fracture, leaving only the stainless steel. They are also not as esthetic as composite strip crowns or preformed ceramo-base metal crowns, and require extra treatment time.[5]

Another alternative to repairing grossly decayed teeth is using complete endodontic therapy with the placement of a short post and composite build up. In primary teeth, intracanal retention can be achieved directly by placing a composite resin post into the root canal space prior to the build up of the resin.[7,15] However, composite resin loses retention due to resin polymerization contraction, enhancing micro leakage, and leading to possible fractures. Furthermore, all these methods need sufficient dental bulk to withstand occlusal forces and sufficient tooth structure for retention.[1,10]

In 1995, Rodrigues and others described the use of nickel-chromium (Ni-Cr) cast posts with macroretentive elements, to increase the resistance.[16] Some disadvantages were found in the use of these posts: They were easily bent or broken and because they are metallic, they potentially interfere with the final esthetics, requiring the use of opacifier materials.[22]

In 2000, Durante *et al,* used natural teeth that were prepared in a post shape for cementation in the root canal. The natural crowns offer outstanding anatomy and esthetics as well as preservation of natural tooth color. Secure methods of sterilization and storage are available to ensure the safety of a tooth. However, parents must accept and consent to the use of teeth from a bank.[8] This biological technique is a promising alternative; unfortunately there have not been enough cases to establish a baseline.

The present study compared the fracture resistance of two different types of polyethylene fibers. Pre-impregnated fibers with resin "Splint-It" versus non-pre impregnated fibers "GlasSpan". One clinical case was monitored for a year using GlasSpan fibers, in primary anterior teeth as post and core. The case showed excellent retention and stability. Studies have reported[11,16,17] that the new pre-impregnated fibers have better strength to withstand the occlusal forces because of the excellent integration of the fibers within the composite. These results lead us to test these innovative fibers as post and core in severely destroyed primary anterior teeth. The hypothesis is that resin pre-impregnated fibers functioning as a post will have a higher fracture resistance load compared to non-resin impregnated fibers used as a post in the reconstruction of primary anterior teeth.

METHODS AND MATERIALS

Sixty extracted non-restorable, maxillary, anterior primary teeth were used. These teeth were stored in physiological saline until pulpectomies were performed. Pulpectomies were done manually with Hedstrom endodontic files. The canals were cleaned with distilled water and properly dried with air and paper points. The teeth were subsequently obturated with zinc oxide-eugenol using rotary paste filler. The remaining coronal part of the anterior teeth were cut down leaving 1 mm of the crown portion above the cemento-enamel junction. Once the obturating paste had set, a number 4 round bur was used to remove the excess canal sealant, and a 1 mm post space in the obturated canals was created. Approximately 1-2 millimeters within the root is needed for adequate retention for all posts placed in primary teeth.[11,20] For the length of the fiber clinically, the alveolar crest as a stopping point or the cemento-enamel junction was used.

After cutting the coronal tooth structure and creating the space in the root, each tooth was embedded in an acrylic cylinder mounted to a metallic ring. In the 1 mm space created at the entrance of the root, 37% phosphoric acid etchant was placed in the internal walls of the canal and the remaining tooth structure for 15 seconds, washed for 30 seconds, and dried with air jet. One coat of adhesive (UNO[R]) was placed into the canal wall. Lightly air-dried for 3 seconds and then light cured. Two groups were formed to test the polyethylene fibers.

Group I. Thirty teeth were restored using GlasSpan[R] small diameter (fiber not pre-impregnated with resin) as a post and core using a total length of 3mm. The same bonding agent that was placed in the walls of the root was impregnated on the piece of the ribbon and then light cured. After that, the fibers were measured by a ruler and then cut by the scissors that the manufacture recommended. The piece of ribbon was then inserted in the 1 mm space of the canal with cotton pliers. A one increment of flowable composite (Tetric Flow[R]) was inserted into the interior of the canal impregnating the fiber and all the walls of the root canal, followed by light polymerization (Figure 1). The coronal part of the ribbon (2mm) was covered with the same flowable composite, making a core, followed by light polymerization.

Group II. Thirty teeth were restored using Splint-It[R] 1 mm braided from Jeneric/Pentron (fiber pre-impregnated with resin). A 3 mm fiber length was cut. After the adhesive was placed into the canal, flowable composite was injected into the canal and the fiber was condensed immediately, and then light cured. The excess of Splint-It rope fiber extended at least 2 mm beyond the canal for optimal retention of the core build-up material. Flowable composite was placed around the fiber (Figure 2).

All the samples were fabricated as post and core. The crown reconstruction was not done in the study because we were just studying the fracture resistance of the fibers used as post and core, not the behavior in the composite crown system.

All teeth were stored in physiological saline at room temperature for 72 hours after which the teeth were ready for testing fracture load resistance on a testing machine (Instron[R] universal machine). Each tooth in the acrylic cylinder was fitted to the metallic ring and mounted on the test machine (Figure 4). The test knife was placed perpendicular to the sample (Figure 3), on the lingual side of the composite core,

Figure 1. Fiber placed inside the root canal.

Figure 2. Post and core.

2 to 3 mm away from the tooth margins as Sharaf recommends in his *in vitro* study.[20] A cross head speed of 0.5mm/min was used and the fracture load was recorded in N. The statistical analysis was performed using the program SPSS 8.0 for Windows. Means were compared using the student t-test.[(17)] A P value of less than 0.05 was considered statistically significant.

All samples pieces of both groups were analyzed after they were dislodged. The type of fracture was recorded.

RESULTS

There was significant difference between the two groups. Statistical analysis of five variables was considered: Load at maximum, displacement at maximum, stress at maximum, percentage of strain and load at yield. Significant differences between load at maximum and stress at maximum were observed between the uses of different fibers. Means and standard deviation was also analyzed. The mean fracture resistance for group I (glasSpan), at 71.34 ± 5.72 N, was lower than that of group II (Splint-It) 97.95 ± 6.80 N (Table I).

Figure 3. Knife perpendicular to the sample.

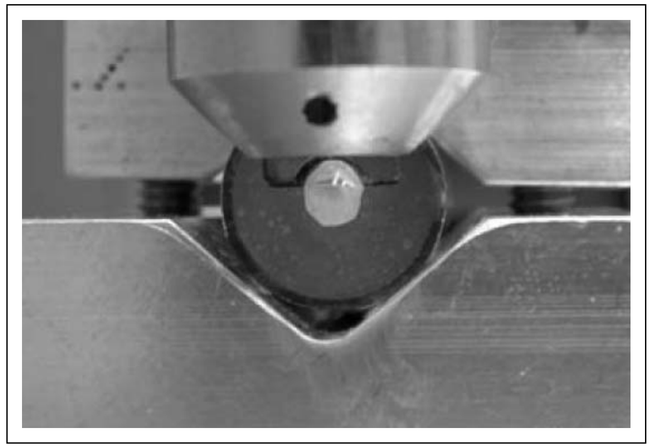

Figure 4. Test knife placement.

Table I. T-test

Test	Sample Number	Mean	Std. Deviation	Std. Error Mean	P Value
Load at max GlasSpan	30	71.3460	28.6132	5.7226	.004
(N) Splint-It	30	97.9524	34.0212	6.8042	
Displacement GlasSpan	30	.6563	.2813	5.625E-02	.094
(mm) Splint-It	30	.5173	.2936	5.872E-02	
Stress GlasSpan	30	16.0399	6.4327	1.2865	.004
(MPa) Splint-It	30	22.0214	7.6485	1.5297	
% Strain GlasSpan	30	13.1251	5.6247	1.1249	.094
(%) Splint-It	30	10.3467	5.8714	1.1743	
Load at Yield GlasSpan	30	5.952E-02	3.114E-02	6.229E-03	.236
(kN) Splint-It	30	7.300E-02	4.527E-02	9.651E-03	

DISCUSSION

Children with severe carious destruction of primary incisors present a difficult challenge. The ideal complete root-coronal restoration would be retentive, fracture-proof, look like a natural tooth, and last close to the exfoliation time. The stainless steel crown, the most reliable and durable restoration, is unattractive and sometimes rejected by the parents and/or child. A post and core system can be placed in these teeth using a stress-relieving post (polyethylene fibers).[17] This system has the capacity to fill the prepared root canal, while the remaining coronal part of the fiber provides retention and stability to the crown to be constructed. The fiber posts are placed to a depth of 1 to 2mm or at the level of the alveolar crest seen in the radiograph. Therefore, posts placed in young children must be treatment planned appropriately. Roots must be long enough to support the placement of a post. Children 5 years or older would not have sufficient longevity and would not be candidates for this technique. However, radiographs need to be taken every four to six months to monitor the development and distance of the permanent teeth.[20] The coronal rehabilitation can be made of composite resin, aided by celluloid crowns.

This technique shows an innovative way of treating severely destroyed primary incisors. The use of fiber core post together with flowable composite and the bonding agent offers an alternative where all components are bonded together to form a firmly attached restoration unit. The design as well as the material of the post can affect the fracture resistance of the post-core and crown restoration. This technique uses the coronal portion of the root, which is the strongest part of the root to transmit any functional stresses and may add to success.

The present study simulated a realistic clinical condition that pediatric dentists encounter often in their practices, i.e., reduced amount of tooth structure or no crown present due to caries destruction, leaving the options of extraction or reconstruction with a post and core system and crown reconstruction. The intent of this study was to compare the resistance to fracture and

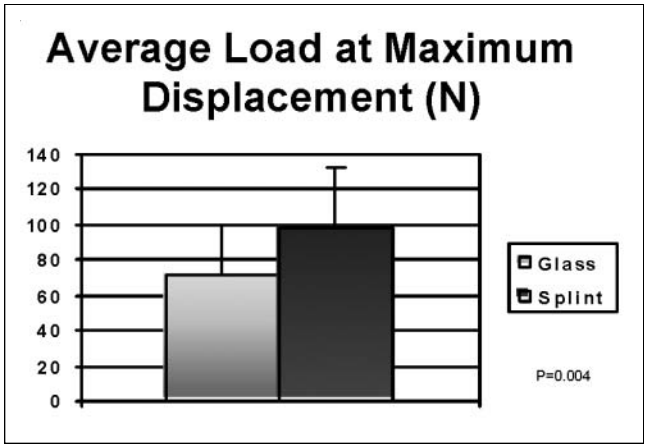

Figure 5. Figure 5 represents the average load at maximum displacement using the Instron Universal Machine. Error bars represent one standard deviation. Student T Test demonstrated a P=0.004.

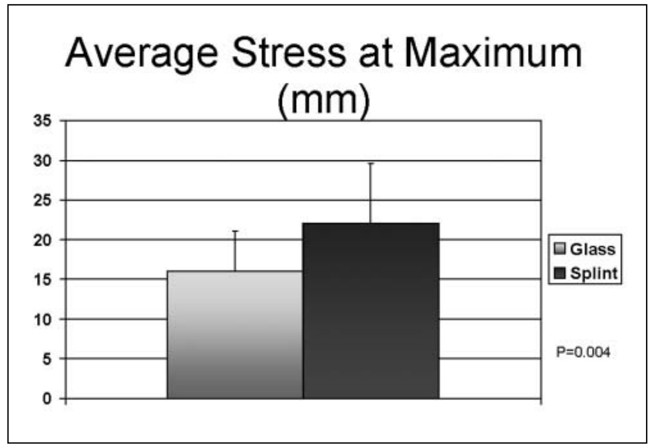

Figure 6. Figure 6 represents the average stress at maximum dislodgement using the Instron Universal Machine. Error bars represent one standard deviation. Student T Test demonstrated a P=0.004.

Figure 7. GlasSpan dislodgement with flowable composite.

Figure 8. Splint- it fiber deattached to the core system.

the mode of failure of two different fibers used as post and core for restoring primary anterior teeth. Many articles in the literature described techniques and methods of the different uses of polyethylene fibers. Lopes Vieira and collaborators[16] presented one clinical case, where it was possible to reconstruct all upper anterior primary teeth using the polyethylene ribbon fibers (glasSpan), checking the success of this material as root retention after approximately 1 year of the reconstruction of the crowns. Sharaf[20] introduced fiber core posts (Jeneric/Pentron, USA) into the root canals of primary incisors for a distance of 2 to 3 mm. After a follow up period of one year, only two teeth out of thirty had to be extracted. The failure in this study was attributed to failure in pulpal therapy rather than failure in the restorations.

In the current study, the results demonstrated statistical differences in fracture resistance between the two fibers used as post and core. Meaning that the pre-impregnated fibers offer a greater fracture resistance when compared to the not pre-impregnated fibers. Lopes Vieira *et al.*[20] used non pre-impregnated fibers (glasSpan) and reported a one-year success follow up. With the new pre-impreganted fibers we can expect better results including, longevity and improved fracture resistance when used in primary anterior teeth.

Also an interesting finding was noticed during the dislodgement or mode of failure. Adhesives failures were noted for group I at the junction between the fiber and core to the interior wall of the root canal (ten samples). In other words, the fiber covered by the flowable composite, was displaced out of the canal (Figure 7).

For group II after the compression force was applied, the fiber was displaced out of the canal and the flowable composite inside the root canal did not come out (seven samples). The fiber core post portion remained intact (Figure 8) whereas in group I the fracture resulted in the separation of the flowable composite with the fiber post.

For all specimens, the dislodgment was noticed at the entrance of the canal. This finding indicates that the pre-impregnated fibers (splint-It) used in group II did not attach to the flowable composite injected in the interior on the canal, never-the-less, these fibers offered a better fracture resistance when compared to the non pre-impregnated fibers (glasSpan). The evaluation of the mode of fracture of the post and core system is important to improve the performance of the system. Even though the study found that pre-impregnated fibers offer the greater fracture resistance, the fibers did not perform as a post and core system or unit, as in group II. Future research is needed to find a better bond system to the pre-impregnated fibers when used as post.

CONCLUSIONS

1. Pre-impregnated resin fibers offer a better fracture resistance when used as post and core in primary anterior teeth.
2. The mode of dislodgement after the force was applied was different for both groups. The non pre-impregnated fibers were dislodged with the composite unit that was inside the root canal as well as the coronal part of the core (ten samples). The resin-impregnated fibers were dislodged leaving the composite core unit inside the canal, but attached to the coronal part of the core (seven samples).

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