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RESEARCH ARTICLE

EFFECT OF DIFFERENT REINFORCEMENT TECHNIQUES ON FRACTURE RESISTANCE OF OVERLY FLARED ENDODONTICALLY TREATED TEETH WITH EXTENSIVE CORONAL TOOTH STRUCTURE LOSS – AN IN VITRO STUDY

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ABSTRACT

Introduction Despite newer technological advances in dentistry in recent years, there still exist major challenges for the restoration of excessively flared endodontically treated teeth with extensive coronal tooth structure loss. The aim of this study is to evaluate and compare the fracture resistance of excessively flared endodontically treated teeth with extensive coronal tooth structure loss with different reinforcement techniques.

Method: Standardized MOD cavities were prepared on single rooted premolars followed by root canal preparation. Samples were randomly divided into 3groups(n=10). Group I-Apically snugly fitting Fiber post was luted using Rely X. Group II-Both fiber post and Ribbond were placed in the post space. Group III-Fiber post along with accessory post were luted in the canal. Remaining access cavity was filled with packable composite in increments in all the groups. The specimens were subjected to thermocycling. Universal Testing Machine was used to evaluate the fracture resistance. Statistical analysis of data was done using ANOVA and Bonferroni's test.

Results: Highest mean fracture resistance was recorded in group II followed by group III, and Group I. There was no statistical significant difference between groups. Group II showed 100% favourable fracture pattern.

Conclusion: Overly flared structurally compromised teeth restored with combination of fiber post and Ribbond showed higher mean fracture resistance with favourable fracture pattern.

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INTRODUCTION

Despite newer technological advances in dentistry in recent years, there still exist major challenges for the restoration of excessively flared endodontically treated teeth with extensive coronal tooth structure loss. Root filled teeth with significant coronal tooth structure loss require an intraradicular reinforcement (Erkut, 2008). Prefabricated posts following resin reinforcement of root dentine has been used to increase the fracture resistance of flared canals (Saupe, 1996). Nevertheless, till todate there is still no consensus regarding the most suitable material and technique for restoring an overly flared endodontically treated teeth. Glass-fiber resin post systems are composed of fibers arranged unidirectionally along the long axis of the post, allow better light transmission, curing and uniform stress distribution along the length of the post (Kalkan, 2006).

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Fiber posts are luted in the post space with the help of a dual-cure resin cement. It is a known fact that, the resin cement thickness adversly affects the outcome of the final restoration (D'Arcangelo, 2007 and Faria-e-Silva, 2009). Hence, a thinner resin cement layer resulting in minimal volumetric shrinkage which further reduces the stresses at the resin/dentin interface is preferred. This is very difficult to achieve in an overly flared root canal. Luting a smaller diameter fiber post that fitted snugly at the apical half of root canal without any post space preparation, would result in more of resin luting cement in the coronal half causing higher volumetric polymerisation shrinkage leading to debonding of the post and fracture of the roots (Luijl, 1992; Grandini, 2003; Eick, 1997; Grandini, 2005). Further, choosing a larger diameter fibre post that fitted well at the coronal half of the flared canal, result in a wider post space preparation at the apical half of the root which decreased the remaining radicular dentin thickness(RDT) resulting in fracture of the root (Lassila, 2004). To overcome the above problem, polyethylene woven fiber- Ribbond can be used in overly flared canals with dual-cure resin cement. It has

an added advantage that it can be compacted in any given post space confirming to the root canal anatomy and do not require further tooth preparation (Ganesh and Shobha Tandon, 2006). Hence, considering the advantages of fiber post and Ribbond material, a combination technique incorporating polyethylene fibers besides the apically snugly fitting DT light post has been tried by Vajihesadat Mortazavi *et al* to maximize the benefits and minimize the limitations of the above mentioned post systems (Vajihesadat Mortazavi, 2012). Recently another alternative technique of using a combination of snugly apicaly fitting fibre post with accessory fiber posts has been tried. It was thought to reinforce the overly flared canal by increasing the surface area of bonding, at the sametime decreasing the resin cement thickness-thereby the volumetric shrinkage in accordance to the study done by Rodivan Braz (Rodivan Braz, 2015). Numerous above mentioned techniques have been tried to reinforce the excessively flared endodontically treated teeth with varying results and it is still inconclusive as to which technique is the best. So, the aim of the present study was to evaluate the effect of different reinforcement techniques on the fracture resistance of excessively flared root canal treated teeth with excessive coronal tooth structure loss.

MATERIALS AND METHODS

Freshly extracted 30 intact single rooted human premolars were collected and stored in distilled water at room temperature. Teeth with caries, pre-existing restorations and fractures or cracks, endodontic treatment were excluded from the study.

Standard mesio-occluso-distal [MOD] tooth preparation was done using straight fissure diamond abrasive and 3mm of buccolingual width of the cavity was maintained. Gingival extent of preparation was kept 1mm above CEJ. Working length was determined using 15 size k-file. Biomechanical tooth preparation was done upto F3 Protaper file [Dentsply] using 17% EDTA [RC Prep] and 2.5% Sodium hypochlorite irrigant. 30 size paper points were used to dry the canals followed by Sectional oburation in apical 5mm of root canal with Protaper F3 cone using AH Plus sealer, maintaining a uniform post length of 8mm. Following this, no.4, 3 and 2 Gates Glidden drills were used consequtively to flare the coronal orifice, progressing 2mm deeper till the middle third of the root. To standardize and confirm 1mm of remaining dentine thickness around the post space at CEJ (RDT decreases as it progresses apically), after preflaring with GGs, one of the tooth specimen was subjected to CBCT, measured and taken as standard. After preflaring the specimens following the CBCT guidelines, RDT was further confirmed using radiovisiography. Thirty fiber posts fitting snugly at the apical area were severed at 10mm length and kept aside for later use. Samples were then divided into 3 groups (n=10) as follows

Group 1: Post space was irrigated with saline and dried with paper points. By using self-adhesive resin cement[RelyX Unicem,3M ESPE], an apically snugly fitting glass fiber post [no.13,Coltene/Whaledent] was luted in the canal extending 2-3mm above the CEJ for core retention. Excess material was removed and light cured for 40seconds. MOD cavity was etched with 37% phosphoric acid for 15seconds [Ultradent], rinsed for 10seconds and air dried gently. Followed by application of bonding agent in 2 coats (Swiss tec SL-Coltene Whaledent) with an applicator tip and light cured for 20seconds. The MOD cavity was restored with Packable composite (Filtek Z350xt) following incremental technique and each increment was cured for 40seconds.

Group 2: 2mm wide Ribbond fiber was saturated with bonding agent. Apically snugly fitting fiber post was luted with Rely X resin cement and placed inside the canal.

Table 1. Comparison of mean Fracture resistance between different study groups using one-way ANOVA test followed by Bonferroni's Post hoc analysis Test

Groups	N	Mean	SD	Std. Error	95% CI for Mean		Min	Max	P-Value
					Lower	Upper			
Group 1	10	430.82	90.24	28.54	366.27	495.37	209.4	529.0	<0.001*
Group 2	10	551.77	171.95	54.38	428.76	674.78	229.1	711.5	
Group 3	10	547.15	172.32	54.49	423.88	670.42	225.0	816.4	

Table 2. Multiple comparison using Bonferroni Post hoc analysis

(I) Group	(J) Group	Mean Difference (I-J)	95% CI of the Diff		P-Value
			Lower	Upper	
Group 1	Group 2	-121.0	-284.8	42.9	0.35
	Group 3	-116.3	-280.2	47.5	0.42
Group 2	Group 1	121.0	-42.9	284.8	0.35
	Group 3	4.6	-159.2	168.5	1.00
Group 3	Group 1	116.3	-47.5	280.2	0.42
	Group 2	-4.6	-168.5	159.2	1.00

Table 3. Favourable and unfavourable fractures in each group

Groups	Favourable fracture	Unfavourable fracture
Group 1	7(70%)	3 (30%)
Group 2	10 (100%)	0 (0%)
Group 3	7(70%)	3 (30%)

The Ribbond fiber is compacted along side the fiber post in the empty space (coronal third of canal) using the hand plugger ensuring atleast 2mm for retention of the core and cured for 40seconds and the rest of the cavity was filled as in group 1.

Group 3: Post space was irrigated with saline and dried with paper points. An apically snugly fitting glass fiber post [no.13, Coltene/Whaledent] was luted in the canal with self-adhesive resin cement [RelyX Unicem, 3M ESPE], extended 2-3mm above the CEJ for retaining the core. The accessory fiber posts

(Reforpin; Angelus) were placed in empty space around the main glass fiber post, excess material was removed and light cured for 40 seconds. Rest of the access cavity was filled as in group 1.

Fracture testing: The samples were subjected to thermocycling (6000 cycles at 5-55 ^{o}C, dwell 30s, transfer time 5s) and were stored in sterile water for 10 days. In order to simulate the human periodontium the external root surface of the teeth were covered with 0.2-0.3 mm thick layer of polyvinyl siloxane impression material (Aquasil Soft Putty, Dentsply), teeth were mounted in cold cure acrylic blocks approximately 1mm below CEJ and were placed in the custom made metal jig mounted at an angle of 45^{o} to the long axis of the upper loading jig. This was subjected to static loading with a cross head speed of 0.5mm-1 using a universal testing machine onto the middle of the central fissure of premolar till the tooth fractured. The load at the time of failure was recorded. Data was analysed by ANOVA and multiple comparisons (post-hoc test) using Bonferroni test.

RESULTS

The mean fracture resistance and its comparison between groups are presented in the tables 1 & 2 and the fracture pattern in table 3. Group 2 showed highest mean fracture resistance followed by Group 3 and Group 1 respectively. It was observed that there was no statistically significant difference between the groups. Group 2 showed 100% favourabe fracture patterns, whereas group 1 and group 3 showed 70% of favourable fracture pattern.

DISCUSSION

Reconstruction of overly flared endodontically treated teeth with extensive coronal tooth structure loss is a greatest challenge in restorative dentistry. Teeth with more than half of the coronal tooth structure loss and less remaining root dentin require an intraradicular post system to provide support to the core material (Kimmel, 2000; Trope, 1985; Mitsui, 2004). Numerous techniques have been tried for the same with varying results and it is still not very clear, as to which reinforcement technique holds best. Aware of the newer materials and techniques, this study was intended to evaluate the effect of different reinforcement techniques on fracture resistance of excessively flared endodontically treated teeth with extensive coronal tooth structure loss. Premolars are used in the present study, as they are the ones more prone to fracture following endodontic treatment (Mohammadi, 2009; Yamada, 2004; Tamse, 1999). They bear the combination of shear, tensile and compressive forces during mastication compared to other teeth (Robbins, 2002) and has been reported to show the highest incidence of flared oval canals with delicate root morphology (Strassler, 1995), less amount of anatomic crown structure left following endodontic access cavity and crown preparation owing to the cervical constriction of the tooth. The proximal surfaces of premolars are usually more prone for caries due to their contact relation and would require an MOD preparation that usually resulted in 63% reduction in relative cuspal rigidity (Reeh E S *et al*. 1989). Panitvisai & Messer (1995) reported that, even the cuspal deflection increased following endodontic access preparation leading to fracture of the tooth (Panitvisai, 1995). Hence, MOD cavities were prepared in this study to mimic the extensive tooth preparation required in grossly decayed teeth clinically. In a study done by Prashanth Monga *et al*, it was seen that composite resin core provided better fracture resistance to endodontically treated with MOD preparation as compared to other core materials (Prashanth Monga, 2009). However there are studies which showed that hybrid composites resulted in more of cuspal deflection due to polymerization shrinkage stresses. However, this was thought to be less in case of nanohybrid composites due to smaller particle size of nanofillers (5-75nm) and nanoclusters present in it. Their particle size was very less, resulting in increased filler loading that reduced the polymerization shrinkage and increased the mechanical properties, tensile strength and compressive strength (Braga, 2005). Hence, we have used packable Nanohybrid composite resin-Filtek Z350 as permanent access cavity restorative material. Periodontal ligament and supporting structures were simulated by coating a thin layer of polyvinyl siloxane on the root surface before embedding it in acrylic resin.

This is to maintain the fact that rigid reinforcement of the root may alter the fracture strength and pattern of failure (Sonthi Sirimai, 1999). The fracture resistance of the root canal treated tooth will be affected by remaining coronal and radicular dentin following root canal treatment and post space preparation (Teixeira, 2009). Radicular dentine thickness below 1mm requires intracanal rehabilitation to increase the fracture strength (Anthony, 1985). In order to simulate the overly flared root canals, we have enlarged the root canal orifices of specimens using no.2, no.3 and 4 Gates Glidden drills leaving pical 5mm of GP. On evaluating the results of our study, Group 2 (Fiber post and Ribbond combination) showed highest fracture resistance (mean load at fracture - 551.77), followed by Group 3(fibrepost-accessory fiber post) and group 1 (Fiber post- 430.82).On comparing Group 1 and Group 2 (Fibre post 430.82 < Combination 551.77), Group 2 showed better fracture resistance as compared to Group 1 but was not statistically significant. This could be due to the added advantage of placing an apically snugly fitting rigid fibre post along with the ribbond fibres in empty space present in the coronal half of the canal. The fibre post would have provided uniform stress distribution along the length of the post and rigidity (Boksman, 2011), while the Ribbond fibres around the fibre post would have decreased the amount of resin luting cement thereby decreasing the volumetric shrinkage. This technique, also eliminated the need to do a wider post space preparation which is required to cement a large diameter fibre post in a coronally flared canal which would reduce the remaining root dentine thickness (Ganesh and Shobha Tandon, 2006).

The Ribbond fibres even provided an increased surface area of bonding at the tooth interface-thereby reinforcing the weakened flared tooth (Jose, 2002). Further comparing the fracture pattern between Group 1 and 2, it was seen that although the mean fracture resistance was not statistically significant between them, Group 2 showed 100% favourable fracture pattern as compared to Group 1 (70%). Ribbond fibers could have acted as stress breakers and elastic buffers which is not seen in case of only fiber post and luting cement (Van Meerbeek *et al*., 1993 and Sema Belli & Gurcan Eskitascioglu, 2008). Similar results were seen in the study done by Vajihesadat Mortazavi *et al*. in which Fiber post and Ribbond combination showed 100% favourable fracture pattern in flared root canal compared to only Fiber post (Vajihesadat Mortazavi, 2013). Further on comparing Group 1 and 3 (fiber post along with accessory fiber post 547.15 > fiber post group 430.82), it was seen that mean fracture resistance value of fiber post along

with accessory fiber posts was higher than only fiber post group, but was not statistically significant. Both the groups showed similar favourable fracture pattern. On comparing group 2 and 3 (fiber post and Ribbond 551.77 > fiber post along with accessory fiber post 547.15), group 2 showed a marginal increase in mean fracture resistance but was not statistically significant. A possible explanation could be, group 3 required more of resin cement to coat each accessory fiber posts during cementation. Insertion of apically tapering accessory fiber posts which are wider coronally would have resulted in thicker resin cement layer and larger lacunae or bubbles apically, reducing the cohesive strength of the resin cement (Grandini, 2005). In addition, this large volume of cement in the root canal, induced high stresses at the adhesive interfaces leading to debonding of post from each other and the root dentin wall. This adhesive failure might have reduced the stress distribution along the root canal wall and may have played an important role in the fracture strength and failure mode of the flared roots (Braga, 2006). To sum up, It can be concluded that the teeth with some form of corono-radicular reinforcement was better than without any reinforcement in overly flared grossy destroyed teeth. Fiber post-Ribbond combination as reinforcement showed highest fracture resistance followed by fiber post- accessory post combination, Fiber post group. There was not much of a statistically significant difference in the mean fracture resistance between Fibre post/Ribbond, Fibre Post/ fiber post and fiber post – accessory posts. However, the fracture resistance of both the Combination groups was better than the fiber post alone. Further on evaluating the fracture pattern in different groups, it was observed that almost all the specimens with some form of reinforcement showed favourable fracture pattern located above CEJ, group 2 – 100%, group 1 and 3 – 70%.

Conclusion

This invitro study was intended to evaluate the effect of different reinforcement techniques on fracture resistance of overly flared endodontically treated teeth with extensive coronal tooth structure loss. Following conclusions were drawn :

- Combination of Fiber post and Ribbond group showed higher mean fracture resistance followed by Group 3 (fiber post along with accessory fiber post) and group 1 (Fiber post- 430.82).
- There was no statistically significant difference in the mean fracture resistance values between the three groups. But more favourable fracture pattern was seen with the combination of fiber post + Ribbond (group 2 – 100%) as compared to fiber post (group 1 – 70%) and fiber post- accessory fiber post groups (group 3 – 70%). Hence, amongst the Combination techniques, fiber post-Ribbond faired better than fiber post-accessory fiber posts for restoring grossly decayed/overly flared endodontically treated teeth holds promise both in terms of increasing the fracture strength of weakened tooth and also resulting in favourable fracture pattern that are easily restorable.

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