J Indian Prosthodont Soc (Apr-June 2014) 14(2):156–160
DOI 10.1007/s13191-013-0296-0

ORIGINAL ARTICLE

Influence of Smear Layer Treatment on Resistance to Root Fracture in Tooth Restored with Epoxy Fiber Post

Satheesh B. Haralur · Ali Hassan Al Faifi · Saed Saleh Al-Qahtani

Received: 31 August 2012 / Accepted: 10 June 2013 / Published online: 19 June 2013

Abstract To evaluate the influence of complete smear layer removal by EDTA on the resistance of root fracture of tooth restored with fiber post. Twenty single rooted premolars with average root length 16 ± 1 mm were randomly divided into two groups of ten each. All teeth were obturated with guttapercha after root canal preparation, sectioned 4 mm above the cement-enamel junction. In group I, teeth root canals were etched with 37 % phosphoric acid, fiber post cemented with self adhesive resin cement. In group II, teeth radicular dentin was treated with 17 % EDTA, followed by fiber post cementation with dual cure resin cement. Coronal part of the teeth reestablished with posterior composite and NiCr full veneer coping along with 2 mm circumferential ferrule. Restored teeth were loaded with incremental force at 30° to the long axis of the root until fracture occurred. The data obtained was evaluated with paired sample *T* test to compare the fracture resistance between the test groups. Group I had the mean failure load of 1,883.70 N while group II had 1,622.80 N mean failure load. Paired sample *T* test showed statistically significant (p value = 0.033) failure load difference between the groups tested. Within the limits of this study, it may be concluded that: the complete removal of smear layer by EDTA found to have reduced the fracture strength of tooth roots restored with an epoxy fiber post.

Keywords Smear layer · Ethylene diamine tetra acetic acid · Post and core technique

S. B. Haralur (✉) · A. H. Al Faifi
Department of Prosthodontics, College of Dentistry, King Khalid University, Abha, Kingdom of Saudi Arabia
e-mail: hb_satheesh@yahoo.com; sharlor@kku.edu.sa

S. S. Al-Qahtani
Department of Periodontology, College of Dentistry, King Khalid University, Abha, Kingdom of Saudi Arabia

Introduction

Preservation of endodontically treated fragile teeth is an integral part of restorative dentistry. Fragileness is due to deficient coronal tooth structure from previous caries, restorations and large access cavity. Endodontic posts are routinely involved in restoration of endodontically treated teeth with an inadequate coronal tooth structure [1–3]. Post contributes mainly in retention of core and helps final restoration to anchor the root [4]. Commercially available endodontic posts are manufactured from various materials ranging from metal to polymers. They are fabricated in different shapes to suit the variety of clinical conditions. Recently, in most part of the world fiber posts are preferred over the metal posts because of its less time consuming procedure, better esthetics and corrosion resistance. Fiber posts have a modulus of elasticity compatible with that of dentin, resulting in fewer probabilities of root fracture [5, 6].

Important criteria considered during post selection are its retention to prepared root canal and less prone for root fracture. The bond strength between radicular dentin and post is significantly influenced by smear layer, method of post space preparation and type of irrigant used during root canal treatment. The bond strength is also affected by luting cements used and compatibility of bonding agent with resin based material [7]. High surface free energy clean tooth surface, and its thorough wetting with bonding agents are a prerequisite for durable bonding. Hence, before the initiation of bonding procedures, radicular dentin should be thoroughly cleaned and pretreated.

Remnants of gutta-percha and sealer materials in the root canal treated radicular dentin also compromise the bonding strength. Smear layer is formed both during the instrumentation of tooth substrate for root canal treatment and post space preparation [8]. The resultant smear layer is known for its low surface energy. Bonding techniques usually have two basic strategies. Smear layer is modified according to the bonding techniques followed. One approach is the complete removal of smear layer by chelating agents or acid etch and rinse technique. Alternatively, smear layer is used as a substrate during cementation procedure by self -etching technique. Phosphoric acid and chelating agents are utilized for conditioning the radicular dentin during bonding procedure. Application of phosphoric acid results in discontinuous areas of deeply demineralized inter-tubular dentin [9, 10], while employment of chelating agents (EDTA) lead to complete removal of smear layer and opening of dentinal tubules [11, 12].

Two mechanisms utilized to develop successful bonding between post and radicular dentin are micro-mechanical retention and chemical bonding. Micro-mechanical retention is resulted from formation of resin tags by impregnation of peri-tubular dentin. Vital chemical bonding is achieved by hybridization of inter-tubular dentin. Clean post space is critical for a clinician to utilize all important chemical bonding to intertubular dentin [13]. Simultaneously, while trying to improve the bonding between post and dentin, root fracture resistance should not be compromised. It is prudent for the clinician to know the effect of different bonding techniques on the fracture resistance to the root.

Therefore, this experimental study was planned with an objective of evaluating the effect of complete removal of smear layer in comparison with the substrate smear layer bonding techniques on the flexural strength of root.

Materials and Methods

Root Canal Treatment and Post Space Preparation

Twenty recently extracted single rooted maxillary premolar teeth were selected after evaluating them for similar root size and mean root length of 16 ± 1 mm. Selected teeth for the study were intact and free from caries. Root canals of all the teeth were enlarged up to 40 master apical file with stainless steel K-files using standardized biomechanical preparation. The specimen's root canals were obturated by gutta-percha through cold, lateral condensation technique. Post space preparation of eleven mm was performed by sequential use Gate's Glidden, peso reamers and calibrated drills. During post space preparation, due care was taken to maintain a minimum of 5 mm apical gutta-percha.

Mounting Teeth Samples in Acrylic Block

Coronal part of all the teeth was sectioned 4 mm above the cement-enamel junction with water cooled diamond bur (Fig. 1). Sectioned part of the tooth was smoothened with fine grit diamond bur. The entire root surface areas of teeth were covered by two layers of adhesive tape to provide uniform space for simulated periodontal ligament space. Twenty identical polymethyl methacrylate cylinders with 3 cm height and 2.5 cm diameters were fabricated to mount the teeth sample. Teeth were embedded vertically inside the self- cure polymethyl methacrylate acrylic block by fixing the teeth with calibrated file (inside the canal) to the dental surveyor (Fig. 2). Teeth were implanted by maintaining 3 mm of tooth structure above the acrylic resin block. They were withdrawn from the resin block when polymerization was in rubbery stage and subsequently adhesive tape over the root surface was removed.

Root Canal Conditioning and Post Cementation

Prepared teeth samples were randomly divided into two groups of ten samples each.

Group-I

Radicular dentin in this group was conditioned by application of 37 % phosphoric acid etchant (Total Etch, Ivoclar Vivadent AG, Liechtenstein) for 15 s, it was followed by copious distilled water rinsing and gentle air drying of the canal. Epoxy Fiber posts (Easy post, DENTSPLY International, York, USA) were cemented with self- adhesive resin cement (Rely X Unicem, 3 M ESPE, St. Paul, USA) following manufacturer's instructions. In this group smear layer was incorporated as a substrate.

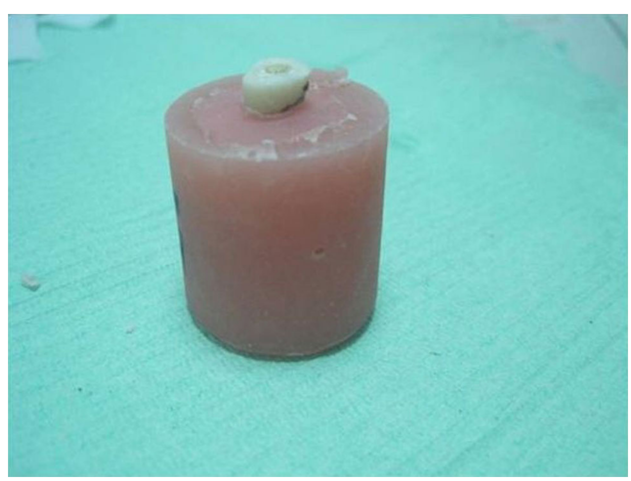

Fig. 1 Sectioned tooth 4 mm above CEJ

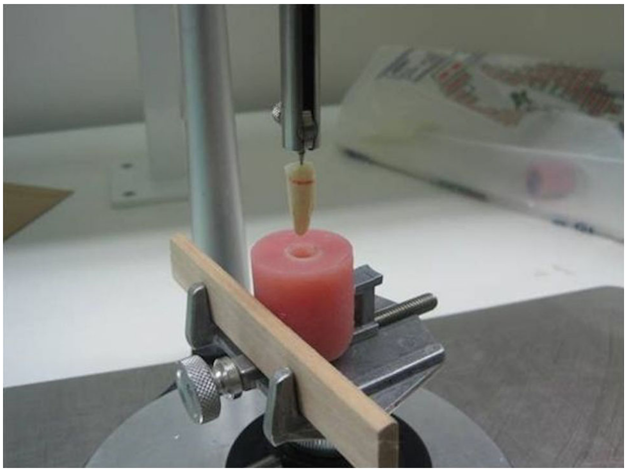

Fig. 2 Mounting of root canal treated teeth on acrylic block with surveyor

Group-II

Post spaces were treated with 2 ml of 17 % EDTA (File-Rite, Pulpdent Corporation, Watertown, USA) solution for 5 min, followed by thorough irrigation of the canal with 5 ml of distilled water. The root canal walls were subsequently conditioned with primer and adhesive (Tetric N, Ivoclar Vivadent AG, Liechtenstein) for 60 s and Dual cure resin luting cement was used to cement Epoxy fiber posts (Easy post, DENTSPLY International, York, USA) (Multilink, Ivoclar Vivadent AG, Liechtenstein) (Fig. 3).

Procedure for Testing Samples for Fracture Resistance

After cementation of fiber post, 5 mm coronal part of the tooth was re-restored with posterior composite (filtek p90, 3 M ESPE, St. Paul, USA.). All teeth samples were prepared to receive a full veneer metal coping with circumferential chamfer finish line and 2 mm ferrule. Core contours were standardized with the help of parallel milling machine with uniform height of 5 mm. Polycarbonate crown was used to prepare the additional silicone putty index mould. Analogous wax patterns were manufactured by injecting molten wax into a putty index mould. Nickel chrome metal copings were invested, wax eliminated, and cast as per standard dental casting procedure. Fabricated metal copings were cemented with type-I glass ionomer cement (Medicem, PROMEDICA Dental Material GmbH, Neumünster, Germany). The space gained by removing adhesive tape from the root surface in the acrylic block was relined with light body additional silicone impression material and teeth were remounted in the acrylic block. This provided the cushioning effect similar of periodontal ligament to the teeth sample. The Acrylic sample's bases were trimmed, so that compressive force applied was at 30° to the long axis of the tooth. For standardization of acrylic base trimming, one additional similar acrylic cylinder block (3 cm) was prepared. Mid sagittal line was drawn in the centre of the cylinder parallel to intended occlusal force direction. Following the line drawn, the acrylic cylinder was split into two half with diamond disc. Over the sectioned half 30° angulations was drawn at the base with the help of protractor. The length from the top of the cylinder to the marked 30° was measured. This length was used as the reference for all other samples for 30° angulations base trimming. Stainless steel band was used to encircle and bind the acrylic block during force application. Compressive force was applied on the palatal surface of the metal coping at 30° angulation with universal testing machine (ELE international Inc, Loveland, USA.) at the cross head speed of 0.5 mm/min until the failure (Fig. 4). Force at a failure point was recorded. The obtained failure loads were evaluated with paired samples *T* test to analyze the correlation between the groups.

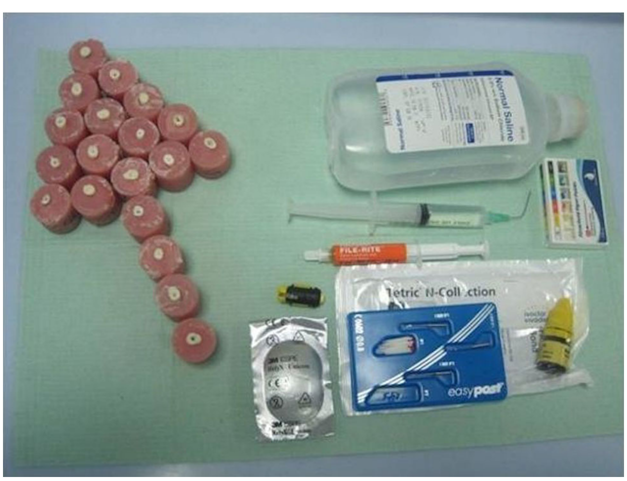

Fig. 3 Photo showing adhesive systems, EDTA, used for the study

Results

The failure load for group I was ranged from 1,402 to 2,215 N. Group II had the maximum failure load of 1,931 and 1,180 N was the minimum failure load. Group I had a mean failure load 1,883.70 N while group II had 1,622.80 N (Table 1). Among the tested samples group-I exhibited the higher fracture resistance compared to group-II, which showed the lower fracture resistance. At the failure load, all the specimens exhibited the root fracture. In group I, Out of ten samples seven had the oblique fracture line initiated from palatal cervical finish line to a labial surface inside the acrylic block. Remaining two had the vertical fracture, and one had fractured initiated from buccal cervical finish line to the palatal surface. Failures in group II included, eight specimens with inclined fracture

Fig. 4 Testing of the sample on universal testing machine

Table 1 Paired samples statistics

		Mean	*N*	Std. deviation	Std. error mean
Pair 1	Group I	1,883.70	10	259.875	82.180
	Group II	1,622.80	10	244.319	77.260

Table 2 Paired samples correlations

		N	Correlation	Sig.
Pair 1	Group I and group II	10	0.673	0.033

from palatal cervical finish line to a buccal surface of the root embedded inside an acrylic block, while two samples had the fracture in opposite direction. *T* test statistical analysis was performed for comparative evaluation of mean fracture resistance between the experimental groups. Paired Student *T* test showed the failure load for group II was significantly lower than group I with *p* value 0.033 (Table 2 and 3).

Discussion

Teeth which are exposed to trauma, extensive caries, and endodontic treatment invariably will have deficient coronal tooth structure. To regain their function and esthetics, these teeth need to be restored to their previous anatomical form with sufficient strength to sustain masticatory forces. Mutilated teeth cannot be salvaged by root canal therapy alone, it should be complemented with post and core to reinforce the coronal part. Root filled teeth with inadequate coronal structure are successfully restored with post and core treatment. Good retention between post and radicular dentin along with reduced incidence of root fracture are two key elements for success of post and core treatment. So the treatment methods used always try to address these two concerns.

Cast metal posts were used more frequently in previous decades. Their utility is on the continuous decline due to more clinical time involved and higher incidence of no salvageable root fractures.

Metallic post and core are not favorable in all ceramic restorations due to its "Shine through" effect. There is increased trend towards the tooth colored Epoxy resin post due to simple clinical procedure, better esthetics, and reduced incidence of root fracture.

Many studies have been conducted to improve the bond strength between the radicular dentin and posts. Researchers advocated different surface treatments for post and radicular dentin to improve the bonding strength. Various researchers also evaluated the effect of post insertion in the root canal on the flexural strength of the root [14, 15]. In the present in vitro study, group-I samples were treated with 37 % phosphoric acid and 7th generation bonding system. The samples incorporated the smear layer as a substrate and mean failure load for group-I was 1,883.70 N.

Group-II samples were treated with EDTA to completely remove the smear layer. The mean failure load for the root for the group II was 1,622.80 N. As per the results obtained, group I teeth flexural root strength was higher than the group-II samples. Complete removal of smear

Table 3 Paired samples test

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95 % Confidence interval of the difference				
					Lower	Upper			
Pair 1	Group I–group II	260.900	204.226	64.582	114.805	406.995	4.040	9	0.003

layer resulted in substantial reduction of flexural strength compared to the partial smear layer removal. The comparative analysis of fracture resistance between partial (group-I) and complete removal (group-II) of smear layer was evaluated with paired *T* test. Paired *T* test analysis showed statistically significant difference between the groups with p value 0.033. The reduction of root flexural strength can be attributed to the application of chelating agents during post space conditioning. Use of EDTA reported to have deleterious effect on the micro hardness value of dentin, although this softening effect helps in faster preparation of canal [16, 17].

In the emphasis to improve the retention, one should not compromise on other important criteria of resistance for root fracture. Root fracture invariably leads to extraction of the tooth, while debonded post provides another chance for a clinician to restore the tooth properly. Hence less susceptibility to root fracture is a very important advantage. Though debonding of post is also a failure, but it can be considered as a favorable failure compared to root fracture.

The results from the study indicate the complete removal of smear layer by EDTA leads to reduction of flexural strength of root. Further studies are indicated to establish the effect of complete smear layer removal on the flexural strength of the tooth restored with metal, zirconia and ceramic post.

Conclusion

Within the limitation of the study, it can be concluded that; complete removal of smear layer by EDTA to improve the bonding between radicular dentin and post is shown to have deleterious effect on the flexural strength of root.

It is not advisable to treat the radicular dentin with EDTA during biomechanical preparation, if the tooth needs to be restored with post in the future. Application of EDTA though helps in faster preparation of canal, but it results in considerable reduction in flexural strength of root.

Acknowledgments We thank for support on this research by King Khalid University, Kingdom of Saudi Arabia.

Conflict of interest There is no perceived or actual conflict of interest from the study.

References

1. Hunter AJ, Flood AM (1989) The restoration of endodontically treated teeth. Part 2. Posts. Aust Dent J 34(1):5–12
2. DeSort KD (1983) The prosthodontic use of endodontically treated teeth: theory and biomechanics of post preparation. J Prosthet Dent 49(2):203–206
3. do Valle AL, Pereira JR, Shiratori FK, Pegoraro LF, Bonfante G (2007) Comparison of the fracture resistance of endodontically treated teeth restored with prefabricated posts and composite resin cores with different post lengths. J Appl Oral Sci 15(1):29–32
4. Cohen BI, Musikant BL, Deutsch AS (1992) Comparison of retentive properties of four post systems. J Prosthet Dent 68(2):264–268
5. Milot P, Stein RS (1992) Root fracture in endodontically treated teeth related to post selection and crown design. J Prosthet Dent 68(3):428–435
6. Akkayan B, Gulmez T (2002) Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 87(4):431–437
7. Boone KJ et al (2001) Post retention: the effect of sequence of post-space preparation, cementation time, and different sealers. J Endod 27(12):768–771
8. Serafino C et al (2004) Surface debris of canal walls after post space preparation in endodontically treated teeth: a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 97(3):381–387
9. Prabhu SG, Rahim NS, Bhat KS (2003) Comparison of removal of endodontic smear layer using Naocl, EDTA, and different concentration of maleic acid—A SEM study. Endodontology 15:20–25
10. Goldman LB, Goldman M, Kronman JH, Lin PS (1981) The efficacy of several irrigating solutions for endodontics: a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol 52(2):197–204
11. Guerisoli DM et al (2002) Evaluation of smear layer removal by EDTAC and sodium hypochlorite with ultrasonic agitation. Int Endod J 35(5):418–421
12. Pashley DH, Michelich V, Kehl T (1981) Dentin permeability: effects of smear layer removal. J Prosthet Dent 46(5):531–537
13. Gwinnett AJ (1993) Quantitative contribution of resin infiltration/hybridization to dentin bonding. Am J Dent 6(1):7–9
14. Ari H, Erdemir A, Belli S (2004) Evaluation of the effect of endodontic irrigation solutions on the microhardness and the roughness of root canal dentin. J Endod 30(11):792–795
15. Saleh AA, Ettman WM (1999) Effect of endodontic irrigation solutions on microhardness of root canal dentine. J Dent 27(1):43–46
16. Martinez-Insua A et al (1998) Comparison of the fracture resistances of pulpless teeth restored with a cast post and core or carbon-fiber post with a composite core. J Prosthet Dent 80(5):527–532
17. Pierrisnard L et al (2002) Corono-radicular reconstruction of pulpless teeth: a mechanical study using finite element analysis. J Prosthet Dent 88(4):442–448