www.djas.co.in
ISSN No-2321-1482

DJAS 3(II), 80-84, 2015

ORIGINAL ARTICLE

Dental JOURNAL
of Advance Studies

COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH RESIN FIBER POST AND STAINLESS STEEL POST: AN IN VITRO STUDY

Vijay Singh[1], Poonam Bogra[2], Saurabh Gupta[3], Navneet Kukreja[4], Neha Gupta[5]

[1]Professor & Head, Department of Conservative Dentistry & Endodontics, DAV(C) Dental College & Hospital, Haryana, India
[2]Professor, Department of Conservative Dentistry & Endodontics, DAV(C) Dental College & Hospital, Haryana, India
[3]Professor, Department of Conservative Dentistry & Endodontics, DAV(C) Dental College & Hospital, Haryana, India
[4]Professor, Department of Conservative Dentistry & Endodontics, MM College of Dental Science & Research, Haryana, India
[5]PG Student, Department of Conservative Dentistry & Endodontics, DAV(C) Dental College & Hospital, Haryana, India

ABSTRACT

Fracture resistance of endodontically treated teeth restored with post. **Aims:** This study aims to compare the fracture resistance of endodontically treated teeth restored with resin fiber and stainless steel post. Commercially available prefabricated resin fiber post (Dentsply Maillefer Easy Post), prefabricated stainless steel post (Coltene/Whaledent Parapost) were used. **Methods and Material:** Forty five maxillary central incisors were obturated and divided into 3 groups: Control Group (Group I) without any post (n = 15), Resin Fiber Post Group (Group II) (n = 15) and Stainless Steel Post Group (Group III) (n = 15). In all Groups except control group, post space was prepared; a post was cemented, and a core build-up was provided. All the specimens were subjected to compressive force under a universal testing machine until fracture. Statistical analysis used: The results were analyzed using the variable analysis test (ANOVA). **Results:** One-way analysis of variance revealed significant difference among test groups. The control group demonstrated highest fracture resistance (925.2183 N), followed by the resin fiber post group (486.7265 N) and stainless steel post group (423.539N). **Conclusion:** Teeth restored with resin fiber post showed higher fracture resistance values than prefabricated stainless steel post.

Keywords: Fiber Post, Parapost, Fracture Resistance

INTRODUCTION

To achieve optimum strength, aesthetics and function of root-filled teeth still remains a challenge. Pulpless teeth are considered to have a higher risk of fracture than vital teeth.[1] For restoring teeth with insufficient coronal tooth structure, a post and core is needed for the definitive restoration. The prognosis of an endodontically treated tooth depends on the quality of endodontic treatment, the amount of remained tooth structure and the amount of bone support. Teeth restored with post and core systems show lower fracture resistance compared to normal teeth. Therefore, post and core should only be used to provide suitable retentive and resistance forms for full coverage crowns.[2,3]

The type of post will also determine its fracture resistance, moreover the size and shape of the post and core, the final preparation design of the tooth and the type of luting agent used will influence tooth resistance to fracture.[4,5] The material from which the post is constructed plays a crucial role in the biomechanical performance of root canal treated teeth. The use of metal posts has been questioned because of their high modulus of elasticity, stiffness, and hardness, which may be associated with fractures of irreparable character.[6,7] This has resulted in popularity towards fiber reinforced posts. This focus of interest towards prefabricated fiber reinforced posts is because of similarity of elastic modulus to dentin and can therefore transmit occlusal forces in a uniform way. They also feature good aesthetic value, absence of corrosion, adhesive cementation and easy removal if needed.[8,9]

Corresponding Author:
Vijay Singh
E-mail:
drvijay.endo@gmail.com
Received: 3rd March, 2015
Accepted:29th July 2015
Online: 10th September 2015

Studies have provided conflicting results in relation to the adequacy of different types of cement to retain dental posts.[10-12] Sen and Bitter demonstrate in their study that resin cement increases the retention of fiber reinforced posts, improving their fracture resistance and that it is suitable for cementing metal posts.[13]

Ideally, the post material should have physical properties such as modulus of elasticity, compressive strength, and thermal expansion, as well as aesthetics similar to those of dentin and it should bond predictably to root dentin.[14] It has been advocated that the use of endodontic posts that can be bonded to both dentin and core material can improve the distribution of forces along the roots, thereby contributing to the reinforcement of the tooth.[15-17] Research regarding posts and cores is evolving towards the development of systems that are strong, corrosion resistant and biocompatible.[18]

Therefore, this study aims to evaluate and compare the fracture resistance under static loading of root canal treated maxillary central incisors restored with prefabricated resin fiber and stainless steel posts.

Subjects and Methods: Forty five freshly extracted human maxillary central incisors with completely formed apices were selected on the basis of similar root sizes and absence of caries, visible fracture lines or cracks. Teeth were then stored at 37°C in distilled water and divided into three groups.

Group I: Control group

Group II: Prefabricated resin fiber group (Dentsply Maillefer Easy Post, LOT no. 1101408)

Group III: Prefabricated Stainless Steel group (Coltene/Whaledent Parapost, LOT no. F37297)

The coronal portions of 15 incisors were sectioned perpendicular to the long axis at a level 5mm incisal to the labial cemento-enamel junction (CEJ) with the use of a water-cooled diamond rotary cutting instrument. These comprised the control group (Group I).

It comprised of teeth without any post space preparation and restoration of access openings done with composite resin 3M Z250 (ESPE, USA). The access cavities were etched for 15 seconds with 37.5% phosphoric acid gel and washed for 20 seconds. The 1 bottle adhesive Single Bond was then applied to the etched surfaces according to the manufacturer's instructions and light-cured for 10 seconds. The composite resin was packed into the cavity with a non-serrated amalgam plugger in 2-mm increments. All increments were cured for 40 seconds. The restoration was finished with diamond finishing burs.

In Group II and Group III the clinical crowns of the remaining 30 teeth were sectioned 2mm incisal to the labial CEJ. In each of the teeth, access to the root canal was made, working length was established 1.0 mm short of apical foramina and the root canals were prepared by using a step-back technique to a master apical file size of 60. Irrigation was performed by using 27-gauge irrigation needle, alternating 1.3% sodium hypochlorite and 17% ethylenediaminetetraacetic acid for 1 minute each between the use of each instrument. This was followed by a final rinse with distilled water before obturation with gutta-percha and AH Plus endodontic sealer by using the cold lateral compaction method.

A thin coat of polyvinylsiloxane was painted on root surfaces to within 1 mm of CEJ to simulate the effect of periodontal ligament. Samples were embedded vertically in acrylic resin blocks 3cm in height and 2cm in diameter to a level 2 mm apical to the CEJ to simulate bone. In these 30 teeth, post spaces 10 mm long were prepared with the drill supplied by the manufacturers of the resin fiber and stainless steel post using rubber stop as reference point for canal depth, leaving 4 mm of apical root filling intact. This resulted in minimal intra-radicular dentin removal. Each post was tried in the canal to ensure proper fit. Rely X was used according to the manufacturer's instructions and applied to the post space with lentulospiral and posts were coated with it. Afterwards, each post was seated inside each canal to full depth.

In Group II, teeth were restored with prefabricated resin fiber posts (cylindrical coronal portion with tapered apical part) (Figure 1A) and a core build up was

Figure 1A

done with composite resin followed by curing for 40 seconds from each direction with light curing device. The teeth were restored to a height of 5mm.

In Group III, teeth were restored with prefabricated stainless steel posts (cylindrical) (Figure 1b) and a core build up was done with composite as explained in Group II.

Figure 1B

All specimens of each test group were mounted on a specifically designed inclined test block made of steel and tested under universal testing machine. A compressive load was applied 2 mm cervical to the incisal edge on palatal aspect at an angle of 135° to the long axis of the tooth at a crosshead speed of 2.5mm/min (Figure 2). Failure threshold was defined as the point at which the loading force reached the maximum value to fracture the root, post or core.

Figure 2

RESULTS

Under static loading, the Control Group (Group I) exhibited the highest fracture resistance (925.2183 N), followed by the Prefabricated Resin Fiber Group (Group II) and further by the Prefabricated Stainless Steel Post Group (Group III) at 486.7265 N and 423.539 N, respectively Table 1. Direct comparisons between the groups revealed statistically significant discrepancies in the fracture resistance values among the 3 groups.

In order to determine the type of fracture of the specimens tested, radiographs were taken of each sample and subsequently analyzed with magnifying glasses.

Types of Fracture

After carrying out the compression tests, a radiograph of each specimen was completed and analyzed using a magnifying glass in order to ascertain the level at which the dental fracture occurred (coronal, middle, apical) and to characterize the type of fracture - horizontal, vertical, oblique. No vertical fractures were observed in all the samples.

On the basis of the radiographs taken, the fracture lines were outlined for each group:

Group I (Control group): Figure 3

13 oblique fractures in coronal third

2 oblique fractures in the middle third of the teeth

Figure 3

Group II (Prefabricated resin fiber group): Figure 4

4 Horizontal fractures in middle third of the teeth

4 Horizontal fractures in the core

4 Oblique fractures in the middle third of the teeth

3 Oblique fractures in the coronal third extending to the core of the teeth

Figure 4

Group III (Prefabricated stainless steel group): Figure 5

11 Horizontal fractures in apical third at the apical end of the post

2 Horizontal fractures at junction of middle and coronal third

2 Horizontal fractures in coronal third of the teeth

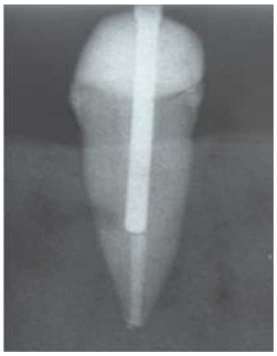

Figure 5

DISCUSSION

Endodontically treated teeth with great loss of dental structure often require posts and cores to secure retention for a fixed restoration. Loss of retention of posts or root fractures of endodontically treated teeth restored with posts are common.[19] It is therefore important to use post and core techniques that minimize these risks.

In this study, intact natural central incisors were selected to simulate clinical situations for endodontically treated teeth. Previous studies have reported their use as an acceptable way to research post systems.[23] The use of a rigid material (acrylic resin) to embed extracted teeth may lead to distorted load values and possibly affect the mode of failure of the specimens. Therefore an attempt was made to simulate the periodontal ligament and surrounding anatomical structures by coating the roots with a polyvinyl-siloxane and embedding the roots in acrylic resin.[22]

Two different post systems of different material were selected for the study. The posts used in this study were resin fiber posts, which have a cylindrical coronal portion and a conical apical portion and stainless steel post which have cylindrical shape. Studies have shown that materials with a modulus of elasticity similar to that of dentin (18.2GPa) seem to increase physical resistance of restored teeth to fracture.[24] Dual-cure self-adhesive universal resin cement (Rely X) was used in the study because it allows a single-step luting process, thereby eliminating any procedural technique sensitivity,[27] moreover the modulus of elasticity of Rely X is 18.6GPa which is similar to that of dentin (18.2GPa). Since, the placement of a crown during endodontic restoration testing may obscure the effects of different build-up techniques.[21] None of the teeth were restored with an artificial crown and ferrule. As described by Asif et al, the complete crown with a 2mm ferrule on sound tooth structure changed the distribution of forces to the root and the post and core complex. In this study, the test loads were applied directly on the cores, not to artificial crowns. If complete crowns with 2mm ferrules were included, the results of this study may have been different.[20] Hence, cores were not restored with crowns to exclude any external strengthening influence on the post and core foundations. However, since the clinical situation cannot be simulated without the use of crowns; hence this might be a limitation of the study.

The mean failure load value of the control group was more than the experimental groups. This is because the remaining dentin thickness plays a critical role in the resistance of the dentin/root restorative complex during function[1], moreover endodontically treated teeth are more susceptible to permanent deformation because of loss of tooth structure and flaws introduced during access preparation.[25] In the present study, resin fiber post group specimens fractured at mean load values of 486.7265 N under static loading as compared to 423.539N for stainless steel post. The lower load required to fracture the stainless steel post may be because of the difference of modulus of elasticity of post is 207GPa as compared to dentin with modulus of elasticity of 18.2GPa, whereas the modulus of elasticity of resin fiber post is 21GPa which is almost similar to dentin. This difference might create stresses at different interfaces and the possibility of post separation and failure.[26] The resin fiber post group failed at higher load values than the stainless steel group because resin fiber posts are still able to achieve a biomechanically homogeneous unit more consistently than stainless steel because of comparatively similar modulus of elasticity to dentin.[28] It is believed that the creation of a monoblock dentin post core system through the dentinal bonding would allow better distribution of forces along the root. The similarity in elasticity of a resin fiber post to root dentin may allow post flexion to mimic tooth flexion so that the post acts as a shock absorber, transmitting only a fraction of the stresses placed on the tooth to the dentinal walls. Therefore if excessive loads are applied to the tooth, the post will be able to absorb stresses, reducing the possibility of root fracture. The new generation of post systems is designed to be biocompatible, corrosion resistant, able to bond to tooth structure, aesthetic, and allow retrievability when the post and core system fails. Therefore, the use of these fiber resin post systems is promising; however, controlled clinical studies showing their performance in a long term situation are required. Within the limitations of this study, it can be concluded that teeth restored with resin fiber posts exhibited higher fracture resistance than those restored with stainless steel posts under static loading.

REFERENCES

1. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. J Prosthet Dent 1984;51:780–4.
2. Nandini VV, Venkatesh V. Current concepts in the restoration of endodontically treated teeth. J Ind Prosth Soc 2006;6(2):63-7.
3. Assif D, Gorfil C. Biomechanical considerations in restoring endodontically treated teeth. J Prosth Dent. 1994;71(6):565-7.
4. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of Fixed Prosthodontics. 3rd ed. Chicago: Quintessence. 1998.
5. Caputo AA, Standlee JP. Restoration of endodontically involved teeth. In: Caputo AA, Standlee JP, editors. Biomechanics in Clinical Dentistry. Chicago: Quintessence 1987;185–203.
6. Qualtrough AJE, Mannocci F. Tooth-colored post systems: a review. Oper Dent 2003;28:86–91.
7. Maccari P., Conceiçao E., Nunes M. Fracture resistance of endodontically treated teeth restored with three different prefabricated esthetic posts. Journal of Esthetic and Restorative Dentistry 2003;15(1):25-31.
8. Butz F., Lennon A. Survival Rate and Fracture Strength of Endodontically Treated Maxillary Incisors with Moderate Defects Restored with Different Post-and-Core Systems: An in Vitro Study. International Journal of Prosthodontics 2001;14: 58-64.
9. Raygo C., Chai J. Fracture resistance and primary failure mode of endodontically treated teeth restored with a Carbon Fiber-Reinforced Resin post system in vitro. International Journal of Prosthodontics 2001;14: 141-45.
10. Turner C. The retention of dental posts. J Dent 1982;10: 154–65.
11. Hansen E, Caputo A. Cementing mediums and retentive characteristics of dowels. J Prosthet Dent.1974;32:551–7.
12. Chapman K, Worley J, von Fraunhofer J. Retention of prefabricated posts by cements and resins. J Prosthet Dent. 1985; 54:649–52.
13. Newman M. Fracture resistance of endodontically treated teeth restored with composite posts. Journal of Prosthetic Dentistry 2003; 89(4):306-7.
14. Cheung W. A review of the management of endodontically treated teeth: post, core and the final restoration. J Am Dent Assoc 2005;136:611-9.
15. Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin bonded preformed post. J Prosthet Dent. 1997;78:10-14.
16. Hornbrook DS, Hastings JH. Use of a bondable reinforcement fiber for post and core build up in an endodontically treated teeth: maximizing strength and aesthetics. Pract Periodontics Aesthet Dent 1995; 7:33-42.
17. Craig RG, Peyton FA. Elastic and mechanical properties of human dentin. J Dent Res 1958;37:710-18.
18. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275-78.
19. Bergman B, Lundquist P, Sjogren U, Sundquist G. Restorative and endodontic results after treatment with cast posts and cores. J Prosthet Dent 1989;61:10–15.
20. Assif D, Bitenski A, Pilo R, Oren E. Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent 1993; 69:36-40.
21. Libman WJ, Nicholls JI. Load fatigue of teeth restored with cast posts and cores and complete crowns. Int J Prosthodont 1995;8:155–61.
22. Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin bonded preformed post. J Prosthet Dent 1997; 78:10-4.
23. Martinez Insua A, da Silva L, Rilo B, Santana U. 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 1998;80:527-32.
24. Joshi S, Mukherjee A, Kheur M, Mehta A. Mechanical performance of endodontically treated teeth. Finite elements in analysis and design 2001; 37:587–601.
25. Kinney JH, Marshall SJ, Marshall GW. The mechanical properties of human dentin: a critical review and re-evaluation of the dental literature. Crit Rev Oral Biol Med 2003;14:13–29.
26. Artopoulou II, O'Keefe KL, Powers JM. Effect of core diameter and surface treatment on the retention of resin composite cores to prefabricated endodontic posts. J Prosthodont 2006;15:172–9.
27. Ceballos L, Garrido MA, Fuentes Vl. Mechanical characterization of resin cements used for luting fiber posts by nanoindentation. Dent Mater 2007;23:100–5.
28. Naumann M, Preuss A, Frankenberger R. Reinforcement effect of adhesively luted fiber reinforced composite versus titanium posts. Dent Mater 2007; 23:138–44.

Source of Support: Nil, Conflict of Interest: None Declared