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Fracture resistance of endodontically treated and thermocycled premolars restored with two different post and core systems using two commercially available luting agents - A comparative invitro study.

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Abstract

Statement of problem: A permanent restoration cannot be placed on a tooth that has severe structural loss. To strengthen the retention and resistance of permanent restorations in such teeth with limited remaining coronal tooth structure, further fortification is required. Pre-fabricated posts and cast custom posts are the most often used post and core designs available. It is unclear about the superiority of these post systems and the influence of resin luting agents that are in use today, on the fracture resistance of such debilitated tooth.

Purpose: The purpose of the current study is to compared the fracture resistance of endodontically treated and thermocycled premolar teeth which were

reinforced using custom posts and fiber posts, luted with two commercially available self-adhesive cement.

Materials & Methods: 40 human mandibular premolar teeth were prepared endodontically to receive custom and fiber posts. The samples were grouped as Group I – intact teeth group (n= 10), Group II – fiber post group (n=20), Group- III custom post group (n=20). Each group was divided into 2 sub-groups of 10 samples each, posts of sub group-A were luted with rely X U200 and sub group-B with Ivoclarspeedcem resin cement. The samples were thermocycled and static load was applied perpendicular to the long axis of tooth to evaluate their fracture resistance. Descriptive statistics, one way analysis of variance, Tukey's post hoc test, and independent samples t tests was done to analyze the study data.

Results: The samples reinforced with cast custom post and core showed statistically significant fracture resistance values when compared with those of fiber post and intact teeth group. There exists a statistically insignificant difference on the type of luting agent used to lute the posts.

Conclusion: Within the limitations of the study, custom posts showed more fracture resistance and the type of resin cement has insignificant effect on the fracture resistance of samples.

Clinical implications: The results of this in vitro study suggest that Cast custom post and cores have highest fracture resistance than the fiber posts with composite cores. There existed an insignificant relation between the effect of resin luting agents used on the post systems.

Keywords: Custom post and core, fiber post, endo dontically treated teeth, fracture resistance, resin cement.

Introduction

In dental practice, the task of restoring endodontically treated teeth is encountered almost daily. In fixed prosthodontic treatment, many abutment teeth, such as, severely attrited teeth with reduced crown structure in full mouth rehabilitation cases, for severely tilted abutment teeth which require more tooth preparation to obtain a straight path of insertion, and of course, severely decayed teeth with not more than two walls to be intact may require post and core treatment[1].

In the clinical scenarios, the coronal structure will be severely compromised, which necessitates the placement of post into the radicular portion to supports the core part. Trope et.al, (1985) suggested that a post is typically used to promote the retention of core[2], thereby improving retention of crown.

Pre-fabricated posts and cast custom posts are the most often used post and core designs available[3]. These prefabricated posts are advised in teeth with significant dentin loss; the core might be formed of materials that bind to dental tissues[4,5]. Glass fiber and carbon-fiber materials have recently become available for prosthodontic applications as post materials.

Cast custom post and cores are frequently recommended for teeth with minimal residual coronal structure or for uniadicular teeth with low coronal volume. In such cases, an alloy with a high gold content is preferable in terms of strength and corrosion resistance. A Study done by Eskitascioglu[6,] reported higher fracture resistance for cast custom post than that of fiber post. Carlos Torres Sánchez et al[7,] done a study in which he reported that the fracture resistance of tooth restored with fiber posts is greater than those with cast custom posts.

Controversial results have been reported from in vitro research that compared prefabricated and individually cast posts and cores. Moreover, in terms of sealing ability of post and core restorations to lute dentinal walls, resin cements have surpassed traditional luting agents such as zinc phosphate cement, polycarboxylate

cements, and glass ionomer cement. Resin cements are used in Monoblock theory, in which the dentin, post, and core work together as one cohesive unit[8].

Various in vitro studies compared fracture resistance between prefabricated fiber post and custom cast posts and cores simulating the oral conditions in a laboratory set up. Some studies had supported fiber posts and some to the cast custom posts about fracture resistance. The superiority between these posts in terms of fracture resistance is still uncertain.

Hence, the present study aimed to evaluate fracture resistance of endodontically treated premolar teeth which were restored using glass fiber and cast custom posts wherein they were cemented using two commercially available self-adhesive resin cements thereby comparing the effect of luting agents regarding fracture resistance.

The null hypothesis was that there will be no significant difference in the fracture resistance of endodontically treated teeth reinforced using cast custom post and fiber post.

Materials and methods

Fifty intact human, mandibular premolar teeth were collected and stored in normal saline. The samples collected were divided into three groups. Group I consist of 10 samples that were intact. Group II & III represents endodontically treated teeth that were reinforced with glass fiber and cast custom posts respectively. Each group was divided into two subgroups, i.e., subgroups a & b with 10 samples each, based on the type of luting agent used viz., rely X U 200, and Ivoclar speed cem self-adhesive luting agents respectively (table-1). All the endodontic therapies were done by single person in crown down technique using Protaper gold rotary system.

After endodontic therapy, post space is prepared for the teeth of group II, and III which were reinforced with their respective post systems. Posts of Sub group-a in both the groups were luted using Rely X U 200 self-adhesive luting agent, and those of sub group-b with Ivoclarspeedcem self-adhesive resin cement. The samples were subjected to thermal cycling and static load was applied along the long axis of the teeth to evaluate the fracture resistance of the samples.

Sample preparation

The root surface of the samples were coated with light body poly vinyl siloxane and mounted into auto polymerizing acrylic resin blocks of 5x5x2 cm to simulate the housing of teeth with periodontal ligament. All the samples were embedded vertically into the mold to a level 2mm apical to the CEJ (figure 1). Conventional MOD cavities were prepared down to the level of canal orifice using high speed Ai rotor hand piece with coolant. Later, root canal treatment was done for the samples in group II and III in Crown down technique using Protaper gold system. The obturated canals were prepared to receive posts using peesoreamers. For the samples in group II the post space was reinforced with fiber posts and core build up was done with composite resin. In group II, the fiber posts of sub group IIA and sub group IIB were luted with rely X U 200 and Ivoclarspeedcem self-adhesive resin cements respectively. For the samples in group III, post space was recorded using pattern resin with plastic wed gets and custom posts were fabricated in indirect method (figure 2). Core build up was made with hard inlay wax and later, the post and core was invested and casting was done. Custom posts of sub group IIIA and sub group IIIB were luted using rely X U 200 and Ivoclar speed cemself-adhesive resin cements.

Sample testing All the samples were then thermocycled between 350 C (28s), 150 C (2s), 350 C (28s), 450 C (2s) was applied with an intermediate pause of 12 seconds. Then, a static load was applied on the specimens till they fracture (figure 3,4,5), in a universal testing machine at a crosshead speed of 0.5 mm/min; loads were applied perpendicular to the long axis of the teeth at the occlusal surface. Fracture loads (N) were recorded.

Results

Statistical analysis was performed using SPSS version 2.0 software (IBM SPSS, IBM, Armonk, NY, USA). Descriptive statistics, one way analysis of variance with Tukey's post hoc tests, and independent samples t tests were done to analyze the study data. One way analysis of variance showed that there were significant differences in fracture resistance between the study groups. Highest fracture resistance was observed for group III (3365N±457.72N) followed by group II (2387 N ± 663.55 N).

Group I demonstrated the least fracture resistance (1470N ± 239.49 N) which was represented in table 2, with statistical significance ($p < 0.001$). Similar findings were noted in graph 1. Independent samples t test showed statistically insignificant (p value= 0.9) correlation between the luting agents and the post systems used in the study, which was demonstrated in table 3.

Discussion

Carious lesions and periodontal diseases are the leading causes that weaken the tooth and compromise its functions. In such conditions, the teeth should be treated endodontically. In dental practice, the task of restoring endodontically treated teeth is encountered almost daily. In fixed prosthodontic treatment, many abutment teeth, such as, severely attrited teeth with reduced crown structure in full mouth rehabilitation cases, for severely tilted abutment teeth which require more tooth preparation in order to obtain a straight path of insertion, and of course, severely decayed teeth with not more than two walls to be intact may require endodontic treatment. It is estimated that an apparent loss of 9% of moisture content occurs in coronal structure of endodontically treated teeth.

This loss of moisture, when accompanied with compromised coronal structure of endodontically treated teeth, will offer a poor foundation for the definitive coronal restoration9,10. Therefore, post and core restorations should be done in such cases to provide a strong foundation on which definitive restoration will be planned.

In the present study, Human teeth were used for the in vitro testing of post and core restorations. The usage of extracted human teeth is common for invitro testing of fracture resistance of various post systems. The results obtained by selecting human teeth as sample, can almost be generalized to the clinical situation in restorative dentistry. Within the human teeth, posterior teeth will take up maximum amount of occlusal load and are more susceptible for caries as they offer larger and critical surface areas for the microbes to lodge on. In the posterior teeth, Premolars have lesser tooth structure and smaller pulp chambers11. Premolars are the most commonly extracted teeth for orthodontic purpose and their tooth structure remains intact at the time of extraction. These therapeutically extracted teeth are most often unaffected with caries, as they are exposed to the oral environment for a short period of time. All these factors will satisfy the inclusion criteria of this study, which made the premolars suitable as a study sample for this study.

In the present study, the collected teeth samples were stored in normal saline. When the teeth were stored in saline, the calcium content in the dentin remains unaltered, thereby helping the tooth in maintaining its mineral content and strength[12].

The mounting procedure done in the present study will resemble the lodging of tooth into bone[13]. The cavity preparations were done, to simulate the carious destruction that necessitates post placement for the teeth. Studies have shown that the endodontically treated teeth with an extensive MOD preparation will represent the worst-case scenario of carious destruction[14]. The teeth with the prepared cavities were then subjected to undergo endodontic preparation using Protaper system in crown down technique, as it offers several advantages like less canal transportation, less post treatment pain, and less crack pro pagation in instruments15.

After a proper biomechanical preparation, the prepared canals were obturated with 6% taper Gutta Percha cones using a resin sealer. Epoxy resin-based sealers have been shown by stereomicroscopy to have moderate sealing capacity, but superior to ZOE-based sealers. ZOE sealers demonstrate more micro leakage than AH Plus21.

The post space preparation to receive fiber posts and custom posts were done using peesoreamers. The fiber post system used in the present study was Hi-rem Endodontic posts. These posts are composed of high-strength glass fibers embedded in an epoxy resin matrix. A study done by Tariq Abdul-Jabbar on fracture resistance of fiber post reported a mean fracture resistance of 561.4+/-37.2N7. Another Study done by Roshan Uthappa on fracture resistance of fiber post reported thet restorations retained by fiber posts has less chance of failure than that of metal post. Study done by Maroulakos et.al16, had reported a mean fracture resistance of custom post to be 117+/- 19.3 N. These values were comparable with the fracture resistance of cast custom post that were obtained in the present study. Another post system that was evaluated for the fracture resistance in the present study was cast custom post and core. For the custom post fabrication, a plastic wedge with pattern resin was used to record the prepared post space17. Study done by Oliver Pontius showed a mean fracture resistance for cast custom post as 1270+/-312.5 N. Study done by Heydecke reported a mean fracture resistance for custom post to be 408N1.

Study done by Eskitascioglu6, reported a fracture resistance of 370+/-172 N for the cast custom post. In his study, the post space was recorded with silicone impression material. Study done by Tariq Abdulijabbar7 reported a mean fracture resistance for cast post and core as 541.2+/-36.9 N. Study done by Maroulakos et.al16, had reported a mean fracture resistance of custom post to be 174+/- 51 N.

These values were comparable with the fracture resistance of cast custom post that were obtained in the present study. The posts were cemented using self-adhesive resin cements. Self-adhesive resin cement was selected for its higher push-out bond strength than conventional dualpolymerizing resin cements17. The presence of resin cement with fiber posts created a unique system called a Monoblock system where the resin cement can bond to the dentin and fiber posts18. Study done by Arzu et.al[19], reported that the custom posts luted with rely X showed the highest fracture resistance when compared with that of glass fiber post. The values obtained in study done by Arzu et.al, were comparable with the present study. The oral cavity is quite dynamic with respect to the thermal changes. So, it is necessary to simulate this condition in the invitro study thereby evaluating the effect of temperature changes on fracture resistance of the teeth.

Thermocycling was done following Gale and Darwell20 protocol 35 0C (28s), 15 0 C (2s), 35 0C (28s), 45 0C (2s) as these are the thermal changes that a human oral cavity will encounter most often.

Study done by K. Bitter21 had evaluated the effect of thermal cycling on the bond strength of luting agents to dentin. The thermal cycle of 5000 cycles with a temperature in between 5 0 and 55 0 c showed bond strength of Rely X more than that of Ivoclarvariolink, Pana via F, clear fill core. This result showed a significant adhesion capacity of Rely X self-adhesive resin, which can also be seen in the current study. The present study had also shown a significant adhesion capacity of rely X cement, despite of thermal changes. Fracture resistance for the samples was evaluated using universal testing machine.

The load was applied perpendicular to the long axis of the sample with a cross head speed of 0.5mm/min. and the peak load was measured in Newtons. This angulation of the sphere head was placed to approximate the compressive masticatory load from the opposing teeth19. The present study was done in a way having mere resemblance with the intra oral conditions. To approximate the compressive masticatory load from opposing teeth, a static load was applied on the sample's perpendicular to their long axis. The dynamic thermal conditions of the mouth were replicated using thermocycling, with the temperatures like that of intraoral temperatures. Though the study has mere resemblance with the intra oral conditions, it also had some limitations like, in corpora ting the static loading on the sample teeth. Within the oral cavity, the load applied on the tooth will be dynamic in nature. The modes of fracture failure,

whether it was catastrophic or favourable was not determined in the study. Therefore, within the limitations, the present study concludes that the fracture resistance of the teeth treated endodontically and reinforced with cast custom post was higher than the fracture resistance of an intact tooth.

Fracture resistance of endodontically treated teeth reinforced with cast custom post showed significant values when compared to that of prefabricated glass fiber posts. Within the custom post group and fiber post group, the effect of luting agents on the fracture resistance of either of the posts seemed to be insignificant, suggesting that the luting agents used in the study did not affect the posts in terms of their fracture resistance.

Conclusion

Within the limitations, the study concludes that

- The fracture resistance of the teeth reinforced using cast custom post was greater than intact teeth group.
- There exists an insignificant difference among the fracture resistance of fiber posts luted with rely X U200 and Ivoclarspeedcem plus resin cements
- There exists an insignificant difference among the fracture resistance of cast custom posts luted with rely X U200 and Ivoclarspeedcem plus resin cements
- The fracture resistance of the teeth reinforced using cast custom post was greater than the fiber post group.

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Tables

Table 1: Sample distribution

Group I	Group II	Group III
control group (n=10)	Endodontically treated teeth restored with fiber posts (n=20)	endodontically treated teeth restored with custom cast post and core (n=20)
	Sub group IIA: Fiber posts cemented with Rely X U 200 cement (n=10)	Sub group IIIA: custom posts cemented with Rely X U 200 cement (n=10)
	Sub group IIB: Fiber posts cemented with Ivoclar speed cem cement (n=10)	Sub group IIIB: custom posts cemented with Ivoclar Speed Cem cement (n=10)

Table 2: Comparison of fracture resistance between the study groups.

Group	N	Mean	Std. Deviation	Std. Error	F value	P value
Intact teeth	10	1470	239.490	75.733	46.36	<0.001*
Fiber posts	20	2387	663.556	148.376		
Custom posts	20	3365	457.723	102.350		

Table 3: Comparison of fracture resistance in fiber posts and custom posts based on the luting agent used.

Group	Luting agent	N	Mean	Std. Deviation	Std. Error Mean	t value	P value
Fiber Post	Rely X	10	2390.00	642.374	203.137	0.02	0.985
	Ivoclar	10	2384.00	718.937	227.348		
Custom Post	Rely X	10	3378.00	373.387	118.075	0.124	0.903
	Ivoclar	10	3352.00	550.006	173.927		

Graph 1: Whisker box plot to Compare fracture resistance between the study groups.

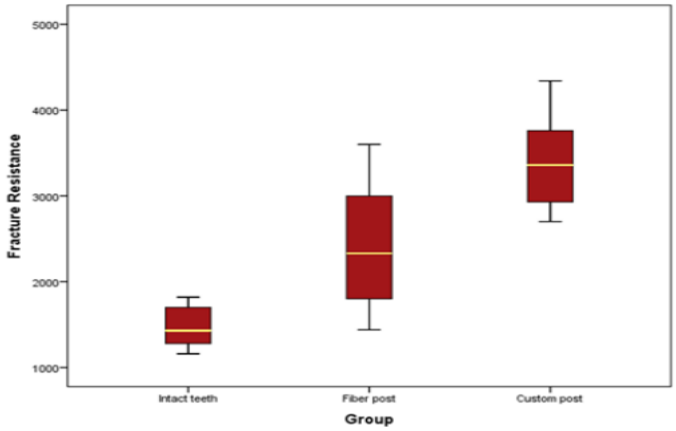

Figure legends

Figure 1: Mounting of tooth and MOD cavity preparation.

Figure 2: Indirect method of post space recording with pattern resin.

Figure 3: Sample testing under universal testing machine.

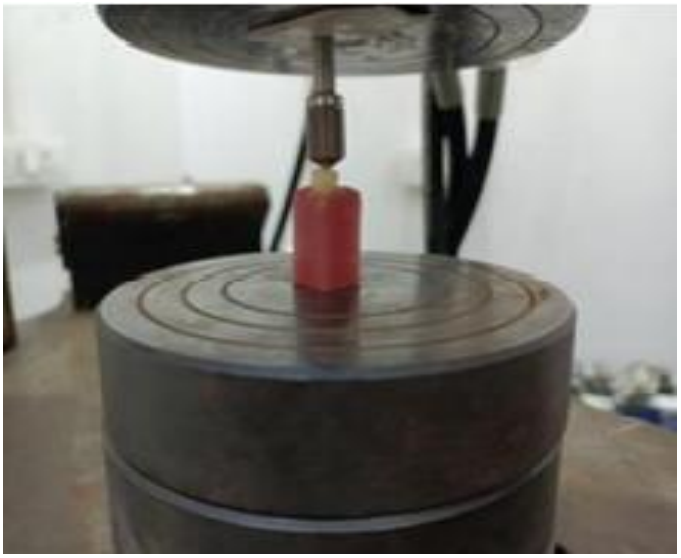

Figure 4: Fractured tooth with fiber post.

Figure 5: Fractured tooth with cast custom post