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Original Research Article

A Comparative Evaluation of Fracture Resistance of Maxillary Central Incisors Restored with Three Prefabricated Post and Core Systems -An in Vitro Study

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Abstract:
In this study, the fracture strength and nature of fracture, in extracted maxillary central incisors, restored by various post and core techniques, was investigated. Root posts of different types were placed in 60 endodontically treated maxillary central incisors. These incisors were divided into 3 Groups (n =20), based on various Post and Core techniques: Stainless steel post, Glass fibre posts, Carbon fiber posts. Posts were luted with dual cure resin cement and buildup of the coronal portion of the posts were done withcomposite resin. Metal crowns were cemented on the posts. Then all the specimens were subjected to flexural loading in a universal testing machine. Fracture strength values and nature of fracture for each group were compared and evaluated.

Conclusion: Fracture resistance of the Para post system was found to be having more resistance to fracture in comparison to glass fibre and carbon fibre posts.

Keywords: Post and core, fracture strength, composite resin.

Introduction

Preservation of the tooth structure is the prime objective of dental treatment. Various preventive, curative, restorative measures, techniques and materials have been evolved, evaluated and practiced to fulfill this objective[1].

Dental caries is the most common cause which makes the patient visit the dental clinic. Dental caries causes mutilation of the teeth. Endodontic therapy is the established solution to retain these types of mutilated teeth. In the past 50 years, the standardization of endodontic instruments, the biomechanical preparation of the canal and recent pharmacological agents have led to a success rate of 95% for all endodontic procedures [2]. The high success rate of modernday endodontics has resulted in an increased demand for clinically convenient post and core systems to help restore the lost tooth structure[3].

The survival of pulpless tooth is directly related to the quantity and quality of the remaining dental tissue. The extent of tooth structure loss due to caries, trauma and certain aspects of endodontic therapy have important implications in the restoration of the involved teeth [3]. In the instance of minimal remaining tooth structure, a foundation (core) is required to retain the crown, often with the placement of a dowel to provide retention for the core [4].

Last few decades have made tremendous studies in dental research and various designs of post which are used today. These posts are either custom made or prefabricated. Custom made cast post and core have been widely used to reestablish the dental structure lost during endodontic treatment. Due to the two-step clinical procedure and technique sensitivity with custom made post and core system, prefabricated posts are more routinely used [5]. Prefabricated posts can be made from different materials such as carbon fibers, stainless steel, brass and titanium. They come in different designs and shapes. In recent years the use of prefabricated post has gained importance but various materials and designs available today pose a challenge for the clinician to select a suitable post for the case [5,6].

Various studies have been done in the previous years that compared the effectiveness of different post systems e.g. custom-made cast post and various designs and materials of prefabricated posts. The present study was planned to compare the fracture strength and mode of fracture of three commonly used post systems.

Materials and Method

A total of sixty freshly extracted vital maxillary central incisors were collected from the Department of Dentistry, MAMC, Agroha, Hisar, Haryana. The

BMP of all the teeth was done with conventional step back technique with K- Files with an apical enlargement upto size 60. After Biomechanical Preparation each canal was Obturated bylateral condensation technique with Gutta Percha (Dentsply, India) using AH 26 root canal sealer (Dentsply, India).

These teeth were then equally divided into 3 groups of20 each. One type of post system was used for each group (Fig 1a):

Group I Carbon fibre posts (Carbonite, Nordin-Int.)

Group II Glass fibre post (Glassix, NordinInt.)

Group III Stainless steel posts (Parapost, ColteneWhaledent Int.)

The fracture strength testing was performed using a custom-made stainless-steel mounting block (zig). Block consisted of right angled triangular shaped piece of stainless steel (Fig 1b). A 1 cm deep hole having 16 mm diameter was made on the long arm (hypotenuse) of the triangle. A long hollow rod of same diameter (16 mm) and 3 cm length was welded into the hole so that 1 cm of length is into the hole and 2 cm is outside the hole. An analog of round hollow rod of 16 mm diameter and 2 cm length was made and sectioned into 2 equal halves vertically. For orientation purpose, a vertical slot was made in the inner aspect of the hollow rod of the analog that corresponds with the hollow rod of the zig. For retention purpose, two screws were placed horizontally on the hollow rod of the zig that gets tightened to hold the sample in place.

All the teeth were mounted vertically in methyl methacrylate acrylic resin. Specimens were mounted in the analog after application of separating media on the walls of the analog. After the material was set, block was retrieved from the analog and placed into the zig and screws were tightened so as to have precise fitting of the sample into the zig. The crowns of the teeth were then removed at CEJ. (Fig 1c).

Post space was prepared with the post drills supplied with the system to the depth of 10 mm under full water irrigation. Posts were tried in and shortened with diamond disc to a height of 5 mm above the CEJ i.e., the total post length of 14 mm. Canal spaces were dried with absorbant paper points. After that posts were inserted and luted with dual cure resin cement (paracore) (Fig 1d). Over this, core build up was done with dual cure composite resin. Core was prepared with contra angled air rotor hand piece and flat end tapered diamond bur. Wax patterns were made and metal crowns were fabricated. Metal crowns were cemented with GIC over the prepared core (Fig 2a).

Flexural fracture strength testing

Flexural fracture strength testing was performed after 24 hours of the fabrication of specimensby application of compressive loading in a universal testing machine (Fig 2b), applied on the palatal aspect of specimen at 135^{o} angulations along the long axis of tooth with a crosshead speed of 5 mm per minute. For all the specimens, fracture resistance was recorded at the point of sudden drop in stress strain curve (Fig 2c). The point of application was standardized for all specimens by measuring in the midline of the palatal slope from a point 5 mm from the incisal edge. Root fractures below the simulated bone level (edge of acrylic resin block) were regarded as unfavorable. Fractures at or above the simulated bone level, as well failures in the coronal portion of the post, and displacement of the crown and or post were considered as favorable fractures. The fracture strength values were submitted to statistical analysis. The mean and standard deviation estimated from the specimens was statistically analysed. Mean values were compared by one way analysis of variance (ANOVA). Post Hoc test was used to compare the three groups. A non-parametric Chi Square test was used to measure the favourable and unfavourable fractures. In the present study, p-value less than 0.05 was considered as the level of significance.

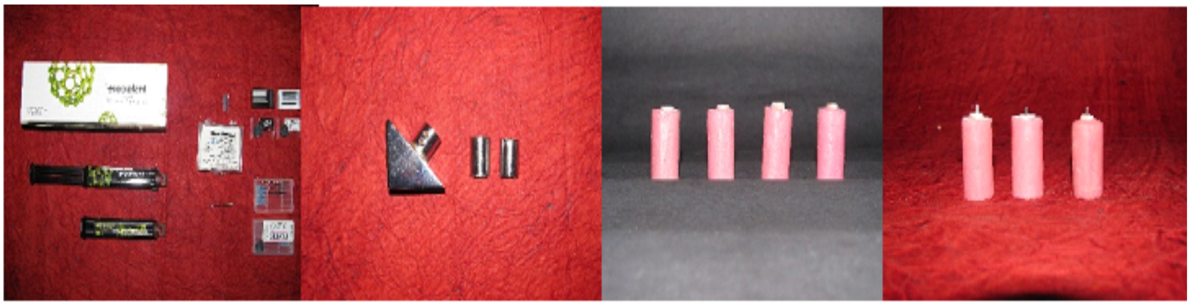

Figure 1: (a) Post system used in the study, (b) Stainless steel mold and Analog used to mount the specimens and fracture strength testing, (c) Samples mounted in Methyl methacrylate Resin andcut with the Diamond disc, (d) Posts placed in samples

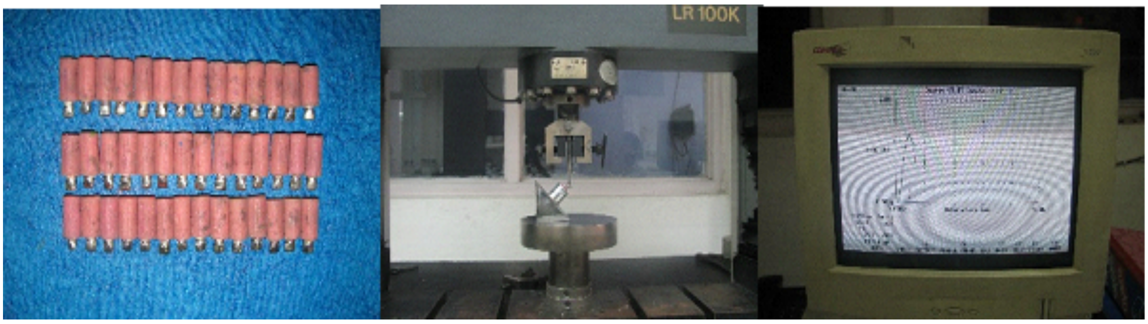

Figure 2: (a) Final samples ready for testing procedure, (b) Samples testing in UTM, (c) Stress strain graph

Results

Table 1: Fracture Resistance of each sample in Group I, II and III in Newtons

Sample no.	Group 1 (Stainless steel post)	Group 2 (Glass fibre post)	Group 3 (Carbon fibre post)
1	1119.0	783.8	701.7
2	1054.0	667.5	407.0
3	1359.0	956.0	872.9
4	1252.6	651.7	874.8
5	849.8	585.1	358.2
6	875.2	557.1	447.0
7	990.3	618.4	482.4
8	778.4	560.6	497.0
9	1527.0	608.2	352.6
10	1050.0	868.6	569.4
11	855.4	898.3	352.8
12	1348.0	615.0	406.7
13	972.0	435.4	400.1
14	1360.0	418.0	873.6
15	799.6	782.5	702.6
16	1209.6	836.9	401.6
17	936.5	418.1	565.3
18	1408.6	315.2	608.1
19	536.9	943.5	402.7
20	1201.8	601.6	706.4

Table 2: One Way ANOVA test for Group I, II and III

Descriptive Fracture Strength								
	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
Stainless Steel post	20	1074.185	256.486	57.352	954.145	1194.224	536.90	1527.00
Glass Fibre post	20	656.075	185.255	41.424	569.372	742.777	315.20	956.00
Carbon Fibre Post	20	549.145	181.950	40.685	463.989	634.300	352.60	874.80
Total	60	759.801	308.370	39.810	680.141	839.462	315.20	1527.00

Shows the Mean, Std. Deviation, Std. Error and 95 % Confidence Interval for the three groups. Mean for the stainless-steel group post was the highest. P value was less than 0.05 that shows the significance between the groups.

Mean fracture load for group I was 1074.18 256.47.

Mean fracture load for group II was 656.07 185.25.

Mean fracture load for group III was 759.80 308.37.

Table 3: Post Hoc Test for Group I, II and III

Multiple Comparisons Dependent Variable: Fracture Strength				
(I) GROUP	**(J) GROUP**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Stainless Steel post	Glass Fibre post	418.11000(*)	66.63604	.001**
	Carbon Fibre Post	525.04000(*)	66.63604	.001**
Glass Fibre post	Stainless Steel post	-418.11000(*)	66.63604	.001**
	Carbon Fibre Post	106.93000	66.63604	.342
Carbon Fibre Post	Stainless Steel post	-525.04000(*)	66.63604	.001**
	Glass Fibre post	-106.93000	66.63604	.342
* The mean difference is significant at the .05 level.				

Shows the significance between the three groups. P value is HS (highly significant) between stainless steel group and carbon fibre group; and between the stainless steel group and the glass fibre group. P value is NS (non significant) between glass fibre group and carbon fibre group.

Table 4: Mode of failure of specimens for group I, II and III

Group	**Restoration type**	**Favourable fracture**	**Unfavourable fractures**
1	Stainless steel post	6	14
2	Glass fibre post	14	6
3	Carbon fibre post	15	5

P value between groups I and II - 0.011 HS
P value between groups I and III - 0.004 HS
P value between groups II and II - 0.723 NS

Discussion

Endodontically treated teeth usually present with undermining of coronal portion. The tooth in function is subjected to interrelated factors that include tooth morphologic features, position in the arch, and occlusal forces[5]. Post and core are often needed to retain a complete crown for these teeth. Numerous methods and techniques are available for post and core planning. The techniques vary from a conventional single unit custom made cast post and core to commercially available prefabricated systems, but till now no system has been satisfactory [6].

Previously, custom made cast post and cores have been widely used to reestablish the dental structure lost during endodontic treatment, but it has some disadvantages like two step clinical procedure and technique sensitivity. To overcome this disadvantage, prefabricated posts were introduced. Prefabricated posts can be made from different materials such as metals, fibers and ceramic [7]. The present study was intended to compare the three designs of parallel post.

Carbon fibre posts were introduced in 1990 by Duret and Renaud [8] and became commercially available in Sweden in 1992. These were based on carbon fibre reinforcement principle. Carbon fibres, by exerting uniform tension on the filaments, impart high strength to the posts [9]. These are composed of unidirectional carbon fibres that are 8 micrometers in diameter embedded in a resin matrix [3].

Glass fibre posts were introduced soon after the introduction of carbon fibre posts. These posts were introduced to counteract the black color of carbon fibre posts, so as to provide esthetically sound restorations. All these fibre posts have similar mechanical properties [10].
Fibre posts have some advantages than stainless steel posts. Retreivability of fibre posts is easier, less risk of iatrogenic damage because the post material can be drilled out by direct removal [8,10,11]. Resistance to corrosion is another advantage of fibre posts when compared with metallic posts. Due to these advantages, fibre posts are becoming more popular now days [12].

To determine the fracture resistance an Instron, Universal Testing Machine was used13. In a study by Guzy and Nicholls [13], a loading angle of 130 degrees was chosen to simulate a contact angle found in class I occlusion between maxillary and mandibular anterior teeth. Thus, force was applied at an angle of 45 degrees to the long axis of the tooth. The crosshead speed was (0.5 cm/min) using a load cell of 5 kilo Newton [14]. For all specimen's peak load at failure (Fracture Resistance) were recorded, which was determined by sudden drop in stress strain graph.

After comparing and analyzing the results of our study it can be stated that purpose of a post is to retain a core which is used to retain the definitive prosthesis. Posts do not reinforce endodontically treated teeth and are not necessary when substantial tooth structure is present after teeth have been prepared.

Conclusion

The following conclusions are drawn:
On evaluation of fracture resistance, the Para post system was found to be having more resistance to fracture in comparison to glass fibre and carbon fibre posts

1. Fracture is more favourable with glass fibre and carbon fibre when compared with stainless steel posts.

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