Original Article

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A COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF MAXILLARY CENTRAL INCISORS RESTORED WITH THREE PREFABRICATED POST AND CORE SYSTEMS

Kapil Singla[1], Manmeet Gulati[2], Pratik[3], Inderpreet Kaur[4]
1.Reader, Deptt Of Prosthodontics, Desh Bhagal Dental College, Muktsar
2.Professor, Deptt Of Prosthodontics, Desh Bhagat Dental College, Muktsar
3.Sr Lecturer, Deptt Of Prosthodontics, Desh Bhagat Dental College, Muktsar
4.Reader, Deptt Of Prosthodontics, Adesh Dental College, Bathinda

ABSTRACT:

Statement Of Problem: The published information is equivocal regarding the fracture resistance of endodontically treated teeth restored with different post and core systems. Additionally, little is known about the biomechanical performance of metallic, carbon fiber and glass fibre posts.

Purpose: This in vitro study investigated the amount of strength required to fracture the different post and core systems and also the nature of fracture with the different post and core systems used in the study.

Materials And Methods: Sixty recently extracted maxillary central incisors were selected for use. Teeth were subjected to conventional endodontic treatment and grouped into 3 groups viz group I, II and III consisting of 20 samples in each group. Specimens of group I were restoed with Stainless steel posts, group II with Glass fibre posts and group III with Carbon fibre posts.Over this, core build up with light cure composite and metal crowns were fabricated and cemented over the prepared core. Flexural fracture strength testing was performed by application of compressive loading in a universal testing machine. Root fractures below the simulated bone level 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 load and mode of fracture of each specimen were noted. One way ANOVA, Post Hoc test, Student's t test and Chi Square tests were used for statistical analysis.

Results: There were significant differences among the three groups studied. The highest fracture strength was recorded with specimens of group I (1074.2 N). A p-value of less than 0.05 was considered as significant. P value was highly significant between group I and II versus group I and III . P value was non significant between group II and III.

Conclusion: On evaluation of fracture resistance the Stainless steel posts were found to be having more resistance to fracture in comparison to glass fibre and carbon fibre posts.Fracture was more favourable with glass fibre and carbon fibre when compared with stainless steel posts. It is recommended to use post 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.

Keywords: post, core, prefabricated, fracture resistance

INTRODUCTION:

*Corresponding Author Address: Dr. Kapil Singla Email: drkapilsingla82@gmail.com

Restoration of endodontically treated teeth is a challenging endeavour. They are more prone to fracture due to loss of moisture supplied by vital pulp. Extensive structural defects due to decay, trauma and prior restoration provides a need for post and core restoration. Last few decades have made tremendous studies and research in designing the posts. 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.[1]

Prefabricated posts can be made from different materials such as carbon fibers, stainless steel, brass and titanium. Prefabricated posts come in different designs and shapes. To suit various clinical situations they may be smooth, serrated, threaded or vented, parallel or tapered [1].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. Research for post & core aims to develop systems that are biocompatible, preserve root dentin, minimize stress and maintain the integrity of root form.

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.The objectives of the study were to determine the amount of strength required to fracture the different post & core systems used in the study and to determine the nature of fracture with the different post and core systems used in the study.

MATERIALS AND METHODS

Collection of samples:

A total of sixty human extracted maxillary central incisors were collected. Teeth with any cracks, caries, and fractures were excluded from the study. Teeth were stored in a solution of neutral buffered formalin for less than three months at room temperature.

Root canal treatment of samples:

Teeth with similar root length were selected. The biomechanical preparation of all the teeth was done with conventional step back technique with K-Files and sodium hypochlorite solution irrigation. After Biomechanical Preparation each canal was Obturated by manual lateral condensation technique with gutta percha (Dentsply) [2] using AH 26 root canal sealer (Dentsply).

Experimental design:

The teeth were equally divided into 3 groups (20 teeth in each group). Group I was restored with stainless steel posts, group II with glass fibre posts and group III with carbon fibre posts. (Table I).

Description of the mold

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 1). 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.

Mounting of the specimens

All the teeth were mounted vertically to a depth of 2 mm apically from CEJ in methyl methacrylate acrylic resin[2]. 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 a level 1 mm coronal to the CEJ with a diamond disc with a full water spray coolant.[2]

Preparation of the specimens

Post space was prepared with the post drills (Parapost, Coltene Whaledent Int.) 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. The prepared post holes were cleaned with 17% ethylene diamino tetra acetic acid (EDTA), followed by 5.25% solution of sodium hypochlorite for 30 seconds.[2] Canal spaces were dried with absorbant paper points. After that posts were inserted and luted with dual cure resin cement (Paracore, Coltene Whaledent Int.). Over this, core build up was done with dual cure composite resin and cured with light cure gun. 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 and finished and polished with standardised metal finishing kit. Metal crowns were cemented with glass ionomer cement over the prepared core.

Flexural fracture strength testing

Flexural fracture strength testing was performed after 24 hours of the fabrication of specimens (during this period, specimens were kept in saline solution), by application of compressive loading in a universal testing machine Machine (model 1114, Instron Corp., Canton, Mass.) (fig 2), applied on the palatal aspect of specimen at 135° 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. 3). 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.[3]

Statistical analysis

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) and student's t test. 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.

RESULT:

Samples were evaluated for fracture resistance using Instron, Universal Testing Machine. Failure threshold was defined as the point at which the loading force reached a maximum value by fracturing the root, bending the post, or fracture of the post. The findings of all the three groups were recorded, tabulated and statistically analyzed. The Mean, Range, Standard Deviation and Standard Error was measured. One way ANOVA, Post Hoc test, Student's t test and Chi Square tests were used for statistical analysis. A p-value of less than 0.05 was considered as significant.

One Way ANOVA test (Table II) for Group I, II and III shows the Mean, Std. Deviation, Std. Error and 95 % Confidence Interval for the three groups. Mean fracture load for group I was highest (1074.2). P value was less than 0.05 that shows the significance between the groups.

Post Hoc Test (Table III) for Group I, II and III shows the significance between the three groups. P value is highly significant between group I & II and between group I & III. P value is non significant between group II and group III.

Student's t test between Group I and Group II shows that Mean for group I was 1074.185 and for group II was 656.075. As p value was less than 0.05, there was a statistically significant difference between the two groups.

Student's t test between Group I and Group III shows that Mean for group I was 1074.185 and for group III was 656.075. As p value was less than 0.05, there was a statistically significant difference between the two groups.

Student's t test between Group II and Group III shows that Mean for group II was 656.075 and for group II) was 549.145. As p value was more than 0.05, there was no statistically significant difference between the two groups.

Mode of failure of specimens (Table IV) for group I, II and III was calculated using chi- square test. p value was less than 0.05 between group I and group II, and between group I and group III. That shows there was statistically significant difference between the groups. P value was more than 0.05 between group II and group III. That shows than there was no statistically significant difference between the two groups.

DISCUSSION:

Prosthodontists are presented with a daunting task when required to manage endodontically treated teeth. Previously, custom made cast post and cores were used to reestablish the dental structure lost during endodontic treatment but it has some disadvantages like two step clinical procedure and technique sensitivity that may jeopardize the long term success. To overcome this disadvantage, prefabricated posts were introduced. A recent nation wide survey of dentists indicated that 40 % of general dentists used prefabricated posts most of the time, and the most popular prefabricated post was the parallel sided serrated post [1]. Parallel-sided prefabricated post systems exhibit maximal retention but threads in parallel posts have been reported to be capable of creating excessive stress levels at the dentinal-thread interface.[4]

It has already been proven that tapered and threaded post increase root fracture 20 times in comparison to parallel post. This has lead to an increased use of parallel post because they provide better retention, cause less incidence of root fracture and are passively fitting.[5] Prefabricated posts can be made from different materials such as metals, fibers and ceramic. The present study was intended to compare the three designs of parallel post.

The extracted teeth were selected carefully of similar lengths so as to minimize variations in length of the roots. Length was measured with digital vernier caliper that was accurate to 0.01 mm. Root canal treatment of all the specimens was done. Specimens were mounted vertically to a depth of 2 mm apically from CEJ in methyl methacrylate acrylic resin. The crowns of the teeth were then removed at a level 1 mm coronal to the CEJ with a diamond disc as in study done by **Akkayan B. et al** [6, 7] Post space was prepared with the post drills supplied with the system to the depth of 10 mm. Canals were then irrigated with EDTA. EDTA is being used as a chelating agent and it also softens the dentin thus making the instrumentation easier [8]. To ensure a proper apical seal care was taken that a minimum of 4 to 5 mm of Gutta Percha was retained after the post space preparation[3]. The post length remained standard for the three Groups.

The primary retentive factors of a Post and core are its design and fabrication, providing an accurate fit between the dowel and canal walls. Lloyd and Palik summarized these factors into 3 categories- conservationist, preservationist and proportionist [9,10]. Consequently, the selection of a luting agent is secondary to the design and fabrication of a passively fitting post and core. In all Groups the post were cemented using dual cure resin cement (paracore). It is superior to other luting cements such as Zinc Phosphate and Glass Ionomer cement because it is insoluble in oral fluids and maximum strength is reached immediately unlike other cements in which maximum strength is reached after 24 hours [1,9,11,12].

After the post cementation, core build up was done with dual cure composite resin. Dual cure composite resin core build up material is found to be better than other core buildup materials like silver amalgam and glass ionomer based core materials because it bonds better with the fibre posts [1]. Wax patterns of all the samples were made and all metal crowns were fabricated to cement onto the specimens.

To determine the fracture resistance an Instron, Universal Testing Machine (model 1114, Instron Corp., Canton, Mass.) was used [3,7,13,14,15,16]. Testing conditions were adjusted to simulate the invivo situation. In a study by Guzy and Nicholls[6], a loading angle of 130° 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° to the long axis of the tooth (simulating the angle of occlusion of the incisal edge of apposing mandibular central incisor). The crosshead speed was (0.5 cm/min) using a load cell of 5 kilo Newton [4]. For all specimens peak load at failure (Fracture Resistance) were recorded, which was determined by sudden drop in stress strain graph (Fig. 3). To simulate the 45° angle, custom made zig was used that consisted of triangular shaped piece of stainless steel. Specimens were mounted on the long arm (hypotenuse) of the zig so as to produce an angle of 45° to the long axis of the tooth.

The mean fracture load for stainless steel post group was significantly higher (1074.18) when compared with glass fibre post group (656.07) and carbon fibre group (549.14). This shows that stainless steel posts have more fracture resistance than glass fibre or carbon fibre group. This is attributed to the fact that stainless steel posts are more rigid than fibre posts [17].

Range for Stainless Steel group was 536.90-1527.0, mean was 1074.18 and standard deviation was ± 256.48. For Glass Fibre group, range was 315.20-956.0, mean was 656.07 and standard deviation was ± 185.25. For Carbon Fibre group, range was 352.60-874.80, mean was 549.14 and standard deviation was ± 181.95. This range may be because of variation in canal anatomy and in remaining root structure of the tooth.

Regarding the favourability of fractures, only 6 fractures were favourable out of 20 for group I, whereas in group II and III, 14 and 15 fractures were favourable. That shows there were more favourable fracture in glass fibre post group and carbon fibre post group as compared to stainless steel post group. Literature indicates that the failure mode of fibre posts is more favourable than the metallic posts[3], as observed in the present study. This is attributed to the fact that fibre posts have young's modulus of elasticity similar to dentine that results in the decreased stress transfer to the dentine on loading of the post, thus reducing the risk of root fracture.[18]

Carbon fibre posts were introduced in 1990 by Duret and Renaud [1], 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 [11]. These are composed of unidirectional carbon fibres that are 8μm in diameter embedded in a resin matrix [1]. 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 [18].

Fibre posts have some advantages over stainless steel posts. Retreivability of fibre posts is easier than a metallic post. It is easier to remove a fibre post as compared to metal post, and less risk of iatrogenic damage because the post material can be drilled out by direct removal [9,11,18]. Resistance to corrosion is another advantage of fibre posts when compared with metallic posts [19]. Due to these advantages, fibre posts are becoming more popular now days.

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 were drawn from this study:

1. 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
2. Fracture is more favourable with glass fibre and carbon fibre when compared with stainless steel posts.
3. It is recommended to use post 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.

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TABLES:

Table I: Experimental groups

Groups	Material of Post	Manufacturers
I	Stainless steel posts	Parapost, Coltene Whaledent Int.
II	Glass fibre posts	Glassix, Nordin Int.
III	Carbon fibre posts	Carbonite, Nordin Int.

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

Descriptives
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

Table III: 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.

Table IV: 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

FIGURES:

FIG.1 –MOULD

FIG.2 -UNIVERSAL TESTING MACHINE

FIG.3 A –SAMPLE TESTING

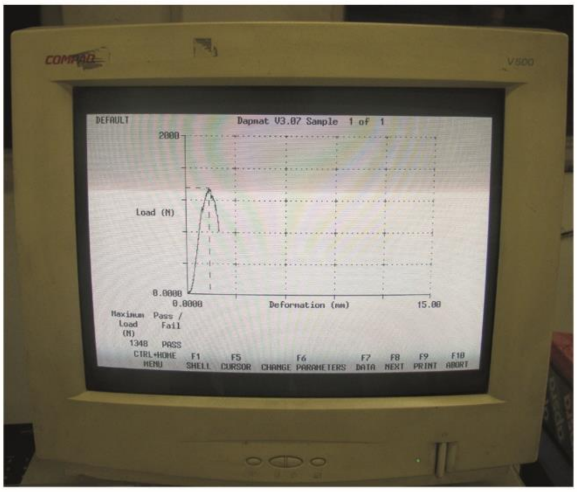

FIG.3 B- STRESS STRAIN CURVE