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Original Article

Dentistry Section

Comparison of Resistance to Fracture of Endodontically Treated Teeth Reinforced with Various Posts: An In-vitro Study

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ABSTRACT

Introduction: Endodontically treated tooth reinforced with posts should restore its lost structural integrity, as well as withstand the various masticatory forces. Choosing the appropriate post, so that a durable prosthesis can be given, is often a challenge to a restorative dentist.

Aim: To compare the resistance to fracture, of endodontically treated teeth restored with the various posts when subjected to compressive loads, and analyse the different types of fractures and cracks which are visible under normal eye, microscope and radiograph.

Materials and Methods: An in-vitro study was conducted in the Department of Dentistry, Pondicherry Institute of Medical Sciences, Puducherry, India, from February 2019 to March 2020. Study was done with four types of posts namely cast post, stainless steel, fibre and titanium on seventy extracted teeth, which were randomly allocated into five groups with one group as control without any post. The teeth were subjected to increasing compressive loads with universal testing machine and the loads at which fracture occurred was recorded. The data was analysed statistically with one way Analysis of Variance (ANOVA) and the groups were compared with Tukey's Honestly Significant Difference (HSD) test. The types of fractures that occurred were also analysed.

Results: The loads at which the teeth reinforced with various posts fractured, showed significant difference (p-value <0.0001). The mean load at which fracture occurred for teeth restored without any posts was 711.6086 N and teeth with stainless steel post was highest at 1605.955 N. Those with titanium posts were found to have minimum microcracks (14.2%) when seen under dissection microscope. Maximum number of teeth with titanium posts had favourable fracture and withstood the load (64.29%), with fracture occurring only at root tip and no fracture elsewhere. Tukey's HSD test was done to compare the fracture resistance between the groups and there was no significant difference in the load at which fracture occurred between groups.

Conclusion: In the present study, of all different post and core materials, stainless steel post resisted highest load and titanium posts had favourable fractures.

Keywords: Compressive strength, Core, Fibre post, Titanium post

INTRODUCTION

Restoration of endodontically treated teeth which has minimal coronal structure and providing a durable prosthesis is often challenging to a restorative dentist. When there is considerable loss of tooth structure due to trauma, caries or as a consequence of endodontic treatment, the natural teeth will need reinforcement with a post and core to restore as well as retain an artificial crown [1,2]. The physical properties of the restorative material should be similar to the tooth structure so that maximum stress distribution is possible [3]. Any restorative treatment with posts should resist the impact of loads it is subjected to while chewing as well as from parafunctional habits [1,4].

The results of many studies done earlier are varied [5,6]. Some studies have shown that the post material should have a modulus of elasticity similar to the dentin, which can effectively transmit the stresses from the post to the root structure [7-9]. The ability of the post to sustain various loads also depends upon the direction of the forces they are subjected to, as well as the ability of them to bond to tooth structure [6].

The posts may be prefabricated or custom made and prefabricated posts are available in different materials as well as designs [9]. The forces to which the teeth are subjected to can cause visible fractures as well as internal cracks in the teeth which are often overlooked [10]. In many studies the more evident visible fractures are mostly considered [11,12]. In order to consider a post to be compatible and successful, the internal cracks caused by the loads also needs to be evaluated [13].

Thus, in the present in-vitro study, in addition to the visible fractures, the surface cracks as well as the internal fractures which occur when compressive load is impacted on teeth restored with four types of posts namely, cast post, fiber posts, stainless steel and titanium are evaluated. Considering the internal cracks which is often not studied would help in choosing a suitable post for restoration. This study also compares the cost factor involved in using the various posts and correlates it to the type of fractures.

The primary objective was to compare the fracture resistance of endodontically treated mandibular premolar teeth restored without posts, with those reinforced with various types of posts namely stainless steel, fiber post, custom cast post and titanium, when subjected to various loads. The secondary objective was to determine the various types of fractures which occurred as well as the cost factor on using different types of posts.

MATERIALS AND METHODS

An in-vitro study was done in the Department of Dentistry, Pondicherry Institute of Medical Sciences, Puducherry, India, from February 2019 to March 2020. The study was done on single rooted extracted mandibular premolar teeth of similar size and shape after obtaining the clearance from the Institutional Ethics Committee (IEC RC/18/34). The teeth which were extracted for orthodontic treatment as well as the mobile teeth extracted due to periodontal problems were collected for the study.

Inclusion criteria: Teeth without any caries, cracks or filling, root length of about 12 mm, for the purpose of standardisation, teeth with buccolingual and mesiodistal width about 7 mm and 6 mm

and no history of previous endodontic treatment were included in the study.

Exclusion criteria: Teeth with bifurcated roots, teeth with calcified canals and history of trauma or hypoplastic defects were excluded from the study.

Sample size calculation: Sample size was calculated based on Zhou L and Wang Q, study using STATA software at level of significance 0.05 and power 8 [12]. The sample size was 70 with 14 samples per group.

Root length was standardised at 12 mm measured from apex to cervical line in the buccal surface. The measurements were made with a digital caliper (Carbon fibre composites, Digital caliper resolution 0.01 mm). Thus the standardisation was done in selection of the teeth for the study.

Study Procedure

Preparation of samples: The selected teeth were cleaned and sterilised with 5.25% sodium hypochlorite and stored in normal saline solution at room temperature. The teeth were amputated off the coronal tooth structure above the cervical line buccally and lingually with airotor handpiece using diamond rotary bur with copious water irrigation. The teeth were numbered and randomly allocated into five groups of 14 each by computerised allocation.

Mounting of the teeth: Tooth was dipped in molten modelling wax from root apex to the cervical line to provide about 0.2-0.3 mm layer which is approximately equal to the width of the periodontal ligament. It was mounted on a cylindrical block made with self-cure acrylic material (DPR cold cure, India). The hollow cylinder was such that the tip of the root was exposed at the base. The modification was done based on a pilot study. When the specimen was completely encased in the acrylic mould, it was found that, as the load increased, the acrylic mould fractured. The brunt of the load thus was taken by the acrylic mould, leaving the tooth intact.

Hence a modification was done with an opening at the apex of the root. The load when applied now, was found to be impacting the tooth maximally. This was done in consultation with a mechanical engineer from Pondicherry Engineering College, Pondicherry, India. The wax spacer around the tooth was removed and light body polyvinyl siloxane silicone material was applied in the hollow cylinder and teeth were mounted back into the resin block [Table/Fig-1]. The wax spacer was replaced with polyvinyl silicone as it had a cushioning effect so that it simulated the periodontal ligament [14].

[Table/Fig-1]: Teeth with a polyvinyl siloxane lining on the root and mounted on acrylic cylinder mould prior to application of load.

Endodontic procedure and post space preparation: Working length was determined and endodontic treatment was performed with rotary files (Protaper, Dentsply, Switzerland) using the same set of files (Sx, S1, S2, F1, F2) and the canals were irrigated with 3% sodium hypochlorite (Prime dental product Thane, India) followed by normal saline irrigation and dried with paper points. The root canals were obturated with guttapercha (Diadent, 0.06 Taper, and Korea) using lateral condensation technique and using root canal sealer (Apexit Plus, Ivoclar Vivodent, Liechtenstein). The dowel space preparation was done on the next day of endodontic treatment after removing 8 mm of guttapercha using gates gliden drill. The post space preparation was done with gates gliden, peeso reamer and moser bur with sizes 1, 2 and 3 (Mani Medical India Pvt. Ltd.,) and the canals were prepared for accommodating post size 1 of different materials. Enlargement of dowel space was standardised by using the same set of enlargement instruments.

Group 1: Control group: In group I which was the control group, after the root canal was obturated, the excess gutta percha was removed from the pulp chamber and the access opening was filled with a composite resin material. An antirotational groove was placed on the inner walls of the buccal and lingual aspect of the 2 mm of ferrule for mechanical retention and a composite resin core (Paracore, Coltene) was built up. The guttapercha in the canals were not removed, as the control group did not have any reinforcement with posts.

Group II: Cast post and core: Group II had cast post and core. After the post space was prepared, a ferrule was incorporated and tooth was prepared with chamfer finish line. Ferrule which enhances the integrity of an endodontically treated teeth helps in countering the lever forces. Impression of the canal space was made by direct technique using inlay wax (Hiflex, PrevestDentpro) by incremental addition and the wax pattern was cast with cobalt chromium metal to make the post and core.

Group III (Stainless steel), Group IV (Fiber post), Group V (Titanium post): Group III, IV and V were restored with, stainless steel (Reforpost steel, Dental Avenue, India), fiber post (Angelus, Dental Avenue India, Andheri) and titanium (Dentsply, Switzerland). The posts were cemented in the root with resin luting cement (Paracore, Coltene, Switzerland) used according to the manufacturer's instructions. All cores were prepared with same resin material with a height of 4 mm from the cervical line.

The tooth preparation was done for metal ceramic crowns and the finish line was about 1 mm wide made with flat end tapered diamond bur. The crowns were luted with glass ionomer cement (Type 1 G C gold label, Japan) used according to the manufactures instructions. The crown length was standardised at 6 mm height from the cervical line to the highest cusp and crowns with similar mesiodistal, buccal, lingual and cervico-occlusal height and width was fabricated [Table/Fig-1]. All the procedures were done by the same operator inorder to avoid interoperator bias.

Application of compressive load: Each tooth was loaded with a universal testing machine (Instron 3382 100K UK) gradually subjecting to increase in compressive load at a speed of 0.5 mm/minute. The failure was considered to have occurred when the graph showed a sudden drop accompanied by an audible sound of fracture following which no further load could be applied [4]. The failure threshold was measured for all the teeth in each group. The parametres measured were the loads at which the fracture occurred as well as the types of fractures which occurred.

Types of fractures: The fractures were grouped as those which were visible under normal eye, those seen using microscope (Dissection microscope with a magnification of 20X) for surface cracks and those with internal fractures [Table/Fig-2] seen with a digital radiograph using vista scanner (Durr Dental). Each sample was examined for three outcomes namely visible fractures, cracks seen under microscope and internal fracture seen with radiograph. The fractures were classified as fracture at cervical region of crown, middle one third of root, apical root one third, root tip and vertical [Table/Fig-2].

[Table/Fig-2]: Types of fractures and the internal cracks examined with a digital radiograph.

Favourable fractures: Those with fractures at the root tip was considered to have withstood the load without any fracture elsewhere, making the tooth amenable to retreatment [15]. The root part sustained the impact and a core build up was still possible with a ferrule created with the available tooth structure above the cervical line. The fracture at cervical region was considered restorable as these fractures had adequate ferrule left intact for restoration [5]. Those teeth among the control group (teeth without posts) which fractured above the cervical line at a very less load were also considered restorable as the option of giving a post and reinforcing the tooth was possible [6].

Unfavourable fractures: The fracture at middle one third, at root one third and vertical fractures were considered as unfavourable fractures [7,9].

The cost of restoring with different types of posts were also analysed.

STATISTICAL ANALYSIS

The data collected was randomly checked by an independent observer to rule out errors and was statistically analysed using Statistical Package for the Social Sciences (SPSS) software version 20.0. The means of the loads at which fracture occurred was found for each group and one way Analysis of Variance (ANOVA) was done to know the statistical significance. The p-value less than 0.05 was considered as statistically significant. A Tukey's HSD test was done to compare between the groups. The percentage of the types of fractures which occurred in each group was also calculated.

RESULTS

The load at which complete fracture occurred for the teeth restored without posts and with different posts was evaluated. The mean load at which the fracture occurred for teeth without any post was 711.6086 N, and stainless steel post, 1605.955 N. Among prefabricated posts maximum load was sustained by stainless steel post. The p-value was 0.0001, which showed that there is a statistically significant difference in the mean load for fracture of various posts [Table/Fig-3].

A Tukey's HSD test was done to compare the fracture resistance between the groups. Fracture resistance of teeth without post was found to be significant when compared with all the posts except cast post. The load at which fracture occurred in teeth with various posts did not show significant difference between the groups with different posts [Table/Fig-4].

On analysing the types of fractures, out of the total number of 70 specimens 5 (7.1%) had cervical fracture and all the 5 (100%) specimens were of those without posts. Maximum root tip fracture was seen on titanium 9 (45%). Visible vertical fracture was seen on one tooth with steel post. The visible fracture in the case of teeth without any post, maximum number was at the root one third 6 (42.9%). In the group restored with steel post 5 (35.7%) had fracture in the middle one third [Table/Fig-5]. On examination under dissection microscope minimum number of microcracks was seen in those with titanium post 6 (14.2%). No cracks were seen under microscope in 28 teeth (40%) [Table/Fig-5]. On examination for internal cracks, those without post had maximum crack in the middle one third of the root 5 (35.7%) and one had vertical root fracture among those without posts. Maximum number of internal fractures were seen in those without posts. Unfavourable fractures were seen least in titanium 5 (11.1%) and most in fibre post group 11 (24.4%) [Table/Fig-6].

Group	n	Mean	Standard deviation	p-value
Without post	14	711.6086	159.21950	0.0001
Cast post	14	1111.750	395.42441	
Stainless steel post	14	1605.955	665.74155	
Fibre post	14	1540.288	537.51457	
Titanium post	14	1552.718	554.57146	
Total	70	1304.464	592.62037	

[Table/Fig-3]: Loads in Newton at which the various posts fractured.
One way ANOVA test. p-value <0.05 was considered significant

Group	Type of post	Mean difference	p-value	95% Confidence interval lower bound
Without post	Cast post	-400.14214	0.215	-924.2907
	Stainless steel post	-894.34714*	<0.0001	-1418.4957
	Fibre post	-828.68000*	<0.0001	-1352.8286
	Titanium post	-841.11000*	<0.0001	-1365.2586
Cast post	Without post	400.14214	0.215	-124.0064
	Stainless steel post	-494.20500	0.074	-1018.3536
	Fibre post	-428.53786	0.160	-952.6864
	Titanium post	-440.96786	0.140	-965.1164
Stainless steel post	Without post	894.34714*	<0.0001	370.1986
	Cast post	494.20500	0.074	-29.9436
	Fibre post	65.66714	0.997	-458.4814
	Titanium post	53.23714	0.999	-470.9114
Fibre post	Without post	828.68000*	<0.0001	304.5314
	Cast post	428.53786	0.160	-95.6107
	Stainless steel post	-65.66714	0.997	-589.8157
	Titanium post	-12.43000	1.000	-536.5786
Titanium post	Without post	841.11000*	<0.0001	316.9614
	Cast post	440.96786	0.140	-83.1807
	Stainless steel post	-53.23714	0.999	-577.3857
	Fibre post	12.43000	1.000	-511.7186

[Table/Fig-4]: Comparisons between groups Tukey's HSD test.
*p-value <0.05 considered significant

Cervical n (%)		Mid root n (%)	Apical root 1/3rd n (%)	Root tip n (%)	Vertical n (%)	No fracture n (%)
Without post						
V	5 (35.7)	3 (21.4)	6 (42.9)	0	0	0
M	4 (28.6)	5 (35.7)	0	0	1 (7.1)	4 (28.6)
I	0	5 (35.7)	2 (14.3)	0	1 (7.1)	6 (42.9)
Cast post						
V	0	5 (35.7)	5 (35.5)	4 (28.6)	0	0
M	5 (35.7)	5 (35.7)	0	0	0	4 (28.6)
I	1 (7.1)	1 (7.1)	0	0	0	12 (85.7)
Steel post						
V	0	5 (35.7)	4 (28.6)	4 (28.6)	1 (7.1)	0
M	7 (50)	1 (7.1)	0	0	0	6 (42.9)
I	2 (14.3)	2 (14.3)	0	0	1 (7.1)	9 (64.3)

Fibre post						
V	0	7 (50)	4 (28.6)	3 (21.4)	0	0
M	4 (28.6)	2 (14.3)	0	0	2 (14.3)	6 (42.9)
I	0	2 (14.3)	0	0	2 (14.3)	10 (71.4)
Titanium						
V	0	2 (14.3)	3 (21.4)	9 (64.2)	0	0
M	4 (28.6)	2 (14.3)	0	0	0	8 (57.1)
I	0	2 (14.3)	0	0	2 (14.3)	10 (71.4)
Total						
V	5 (7.1)	22 (31.4)	22 (31.4)	20 (28.6)	1 (1.4)	0
M	24 (34.3)	15 (21.4)	0	0	3 (43)	28 (40)
I	3 (4.3)	12 (17.1)	0	0	6 (8.6)	47 (67.1)

[Table/Fig-5]: Types of fractures in teeth restored with different types of posts. Each sample was examined for three outcomes namely visible fractures, cracks seen under microscope and internal fracture seen with radiograph
V: Visible fractures I: Internal fracture/cracks
M: Cracks seen under microscope

Type of post	Favourable fracture n (%)	Unfavourable fracture n (%)	p-value
Without post	5 (35.71%)	9 (64.29)	0.145
Cast post	4 (28.57%)	10 (71.43)	0.029
Stainless steel	4 (28.57%)	10 (71.43)	0.029
Fibre	3 (21.43%)	11 (78.57)	0.002
Titanium	9 (64.29%)	5 (35.71)	0.145

[Table/Fig-6]: Favourable and unfavourable fractures observed with different posts. p-value <0.05 considered significant

The cost of using various posts namely cast post, steel post, fibre post and titanium post was approximately 400, 450, 460, 800 Indian Rupees, respectively. Titanium post, though was more expensive, was found to have more favourable fractures compared to other groups [Table/Fig-6].

DISCUSSION

Post and core reinforces and salvages a fractured tooth and enable it to perform masticatory functions. In the present study, teeth without posts were found to be least resistant to the applied load and fractured easily. This showed that it is imperative to restore the teeth with compromised coronal structure with post and core.

Stainless steel post was found to withstand maximum load followed by titanium and fibre post. It is considered that posts with modulus of elasticity similar to dentin will have lesser stress concentration and lead to lesser root fractures [16]. The modulus of elasticity of stainless steel is higher than all the other materials used as post in the study and only compressive load was applied in the present study [17]. The physical properties of materials used as posts will have an effect on the stress distribution when load is applied. Modulus of elasticity is the comparative stiffness of the material and a stiffer material will have higher elastic modulus and they change their shape slightly under load [18]. The effect of application of different types of loads needs to be studied further.

In the case of teeth restored without any posts, cervical fracture was seen at a very lower load compared to the teeth restored with posts. Cervical fracture though it is a favorable fracture, fracturing at a very less load cannot be considered as an advantage. This is to draw attention to the need of reinforcing teeth with posts whatever the material may be [19]. In the present study prefabricated posts were found to have better fracture resistance than cast posts.

Kivanc BH et al., compared fracture resistance of thin walled tooth with various posts [4]. According to them metal cast post had the highest fracture strength which is contradictory to the present study. Cast metal dowel procedure is time consuming and needs greater number of sessions. The cast post does not have any advantage of bonding to the tooth structure as well as there is chance for corrosion and its modulus of elasticity is different from tooth structure [20,21].

A prefabricated post is a preferable option if the fracture resistance is similar or better than cast posts. Fiber reinforced post had more fracture resistance than cast post in a study by Haralur SB et al., [22]. Soundar SIJ et al., also evaluated fracture resistance of teeth restored with different post and core systems namely cast post, stainless steel and fiber post [23]. The results were similar to the present study. Similar studies from the literature have been compared in [Table/Fig-7] [2,5-7,9,16,17,20,24,25].

Author's name and year	Place of study	Sample size	Posts compared	Parameters assessed	Conclusion
Civeleki A et al., 2007 [5]	Istanbul	40 maxillary canines	Cast post, fibre post	Fracture resistance	Cast post higher fracture resistance 2103 N
Torabi K and Fattahi F, 2009 [20]	Iran	50 mandibular premolars	Fibre post	Fracture resistance, mode of failure	Cast posts higher failure threshold
Giovanni AR et al., 2019 [6]	Brazil	60 maxillary canines	Glass fibre, metal	Fracture resistance	Glass fibre better resistance
Padmanabhan P, 2010 [9]	Bangalore	30 maxillary central incisors	Stainless steel, carbon fibre, ceramic	Fracture resistance, mode of failure	Stainless steel highest fracture resistance, carbon fibre favourable fracture
Perumal P et al., 2011 [7]	Nagpur	40 maxillary incisors	Cast post, stainless steel, glass fibre, ceramic	Fracture resistance, mode of failure	Stainless steel highest fracture resistance, glass fibre favourable fracture
Abduljabbar T et al., 2011 [24]	Saudi	40 mandibular premolars	Cast metal, zirconia, glass fibre	Compressive strength	Zirconia highest, Fibre more than cast post
Vachhani KA and Asnani MM, 2014 [16]	Gujarat	40 maxillary central incisors	Glass fibre, metal post	Fracture strength	Metal highest fracture strength, favourable failure glass fibre
Singala K et al., 2015 [25]	Punjab	60 central Incisors	Stainless steel, cast post, glass fibre, carbon fibre	Flexural strength, nature of fracture	Carbon fibre highest, glass fibre least
Vadavadagi SV et al., 2017 [2]	Karnataka	45 central Incisors	Glass, quartz, carbon fibre	Compressive strength	Everstick fibre highest fracture resistance, followed by fibre
Baharom M et al., 2021 [17]	Malaysia	32 central incisors	Stainless steel fibre	Fatigue strength, type of fracture	Unfavourable fracture in stainless steel
Present study, 2023	Pondicherry	70 mandibular premolars	Without post, stainless steel, cast post, fibre post, titanium	Fracture resistance, types of failure-visible, under microscope surface cracks, internal fracture, cost factor	Stainless steel resisted highest load, titanium post favourable fracture, least microcracks in titanium post, prefabricated post better than cast post in strength and cost, titanium durable though expensive.

[Table/Fig-7]: Similar studies from the literature [2,5-7,9,16,17,20,24,25].

In the present study none of the teeth restored with various posts had any fracture at cervical one third except those without any posts. This was similar to the observation made by Baharom M et al., [17]. According to a study done by Vachhani KA and Asnani MM, the unfavourable fractures were seen most in those with metal posts, which was concurrent with our observation where 71.4% of fractures in the cast post was seen in middle one third and apical one third [16]. In the case of stainless steel post, 35.7% of fractures were found in the middle one third.

On examination under dissection microscope vertical fractures were seen in those with fiber post as well as in control group. This observation was similar to the study done by Rathke A et al., where fibre reinforced posts showed highest incidents of defects mainly vertical cracks [26]. Surface cracks at various levels were seen least in titanium posts. Internal cracks were seen most in those teeth without any posts. Fractures in the mid root as well as root one third were considered to be unfavourable fractures. Kurthukodi AJ et al., had classified fractures as favourable and catastrophic on similar lines when seen under stereo microscope and had found 90% favourable fractures in fibre reinforced posts and Santana FR et al., found metal posts to have catastrophic results [27,28]. The specimens with fracture at the root tip was considered to be those which withstood maximum load without any fracture elsewhere and maximum number of teeth with titanium posts was found to have only root tip fracture.

The cost of titanium post is almost twice the cost of the rest. Schwendicke F and Stolpe M, found that though preformed metal posts were cheaper, the survival rate of fibre post was better and cost effective [29]. Hence, clinical decision making should not only consider the initial cost of treatment but also the cost for management of future complications. Similarly titanium post though costlier may be considered a more prudent choice as it had more number of favourable fractures when compared to the rest of the groups. It is also evident that, irrespective of the type, the use of a post is an absolute necessity in teeth fractured at cervical one third.

Limitation(s)

The load used in the study was unidirectional and it is not similar to the normal real time oral physiologic processes, where teeth may be subjected to forces in different directions, during functional as well as parafunctional activities. In the present study, only compressive load is studied and the effect of other types of loads namely shearing and tensile, also needs to be considered to know the real impact of forces.

CONCLUSION(S)

Posts are absolutely needed for restoration of endodontically treated teeth with compromised tooth structure, to retain the restoration and resist the functional as well as parafunctional loads. The prefabricated posts were found to have better fracture resistance compared to cast posts. Among the prefabricated posts though the stainless steel post resisted maximum compressive load, there was no significant difference in comparison with other materials. Teeth with titanium posts was seen to have endured the load, with fracture only at the tip and it may be considered a durable choice for posts as it is also known to be non corrosive. Titanium posts may be slightly expensive but it may be considered as an option as it is a non ferritic metal and is Magnetic Resonance Imaging (MRI) compatible too. In addition to visible fractures, internal fractures also need to be evaluated when considering the type of fractures. The effect of multidirectional forces needs to be evaluated and long-term studies need to be done to correlate the results with clinical scenario. The cost factor involved in the various procedures are not often factored in research and it is advisable to include this parameter also in future research.

REFERENCES

[1] Maroulakos G, Nagy WW, Kontogiorgos ED. Fracture resistance of compromised endodontically treated teeth restored with bonded post and cores- An in-vitro study. J Prosthet Dent. 2015;114(3):390-97.
[2] Vadavadagi SV, Dhananjaya KM, Yadahalli RP, Lahari M, Shetty SR, Bhavana BI, et al. Comparison of different post systems for fracture resistance-An invitro study. J Contemp Dent Pract. 2017;18(3):205-08.
[3] Al-Shibri SA, Elguindy J. Fracture resistance of endodontically treated teeth restored with lithium disilicate crown retained with fibre post compared to lithium disilicate and cerasmart endocrown-An in-vitro study. Dentistry. 2007;7(12):01-09.
[4] Kivanc BH, Alacass T, Ulusoy OIA, Genc O, Gorgul G. Fracture resistance of thin walled roots restored with different post systems. Int Endod J. 2009;42(11):997-1003.
[5] Civeleki A, Kaptan F, Iseri U, Duger O, Kazazoglu E. Fracture resistance of endodontically treated teeth restored with fibre or cast posts. Balk J Stom. 2007;11:196-200.
[6] Giovanni AR, Vansan LP, Neto MDS, Pailino SM. Invitro fracture resistance of glass fibre and cast metal posts with different lengths. J Prosthet Dent. 2009;101(3):183-88.
[7] Perumal P, Chander GN, Anitha KV, Reddy JR, Muthukumar B, Makade CS, et al. A comparative evaluation of fracture resistance of endodontically treated teeth restored with different post core systems-an in-vitro study. J Adv. Prosthdont. 2011;3(2):90-95.
[8] Tammineedi S, Kakellu S, Tota MM, Basam RC, Basam LC, Vemuri SJ, et al. Comparison of the effect of sodium hypochlorite, EDTA, and etidronic acid on wettability of root canal sealers using contact angle goniometer: An in vitro study. Conserv Dent. 2020;23(6):589-92.
[9] Padmanabhan P. A comparative evaluation of the fracture resistance of three different prefabricated posts in endodontically treated teeth. An in-vitro study. J Conserve Dent. 2010;13(3);124-28.
[10] Mamoun JS, Napoletano D. Cracked tooth diagnosis and treatment. An alternative Paradigm. Eur J Dent. 2015;9(2):293-303.
[11] Lins do Velle A, Pereira JR, Shiraton FK, Pegoraro LF, Bonfante G. Comparison of fracture resistance of endodontically treated teeth restored with prefabricated post and composite resin cores with different post length. J Appl Oral Sci. 2007;15(1):29-32.
[12] Zhou L, Wang Q. Comparison of fracture resistance between cast posts and fibre posts. A meta-analysis of literature. Endod. 2013;39(1):11-15.
[13] Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod. 1989;15:512-16.
[14] Khiavi HA, Habibzadeh S, Safaeian S, Eftekhar M. Fracture strength of endodontically treated maxillary central incisors restored with nickel chromium and non-precious gold alloy casting post and cores. J Contemp Dent Pract. 2018;19(5):560-67.
[15] Karhade Ishani, Gulve M. Management of horizontal root fracture in the middle one third via intraradicular splinting using a fibre post. Case Rep Dent. 2016;2016:9684035. Doi: 10.1155/2016/9684035. Epub 2016 Jan 24. PMID: 26904313; PMCID: PMC4745925.
[16] Vachhani KA, Asnani MM. Evaluation of fracture strength of teeth restored with different types of posts luted with different luting cements– An invitro study. Niger J Clin Pract. 2015;18(3):411-15.
[17] Baharom M, Muttlib NAA, Ariffin Z, Husein A. Fracture resistance and fracture pattern of maxillary anterior teeth restored with metallic and non-metallic posts, World Journal of Dentistry. 2021;12(3):194-99.
[18] Mortazavi V, Fathi MH, Katiraei N, Shahnaseri S, Badrian H, Khalighinajad N, et al. Fracture resistance of structurally compromised and normal endodontically treated teeth restored with different post systems. An in-vitro study. Dent Res J. 2012;9(2):185-91.
[19] Singh N. Assessment of fracture strength of two different post and core systems. International Journal of Research in Health and Allied Sciences. 2020;6(6):86-89.
[20] Torabi K, Fattahi F. Fracture resistance of endodontically treated teeth restored by different FRC posts: An in-vitro study. Indian J Dent Res. 2009;20 (3):282-87.
[21] Pasqualin FH, Giovanni AR, Nato MD, Paulino SM, Vansan LP. Invitro fracture resistance of glass fibre and cast metal posts with different designs. Rev Odonto cienc. 2012;27(1):11-18.
[22] Haralur SB, Al Ahmari M, Al Qami SA, Althobati MK. The effect of intra radicular multiple fibre and cast posts on the fracture resistance of endodontically treated teeth with wide root canals. Biomed Res Int. 2018;8:01-07.
[23] Soundar SIJ, Suneetha TJ, Angelo MC, Kovoor LC. Analysis of fracture resistance of endodontically treated teeth restored with different post and core system of variable diameter. An in-vitro study. J Ind Prostho Soc. 2014;14(2):144-50.
[24] Abduljabbar T, Sherfudhin H, AlSaleh SA, Al-Helal AA, Al-Orini SS, Al-Aql NA. Fracture resistance of three post and core systems in endodontically treated teeth restored with all-ceramic crowns. King Saud University Journal of Dental Sciences. 2012;3(1):33-38.
[25] Singala K, Gulati M, Pratik, Kaur I. A comparative evaluation of fracture resistance of maxillary central incisors restored with three prefabricated post and core systems. Int J of Dental and Health Sciences. 2015;2(4):738-48.
[26] Rathke A, Frehse H, Hrusa. Vertical root fracture resistance and crack formation of root canal treated teeth restored with different post luting systems. Odontology. 2022;110:719-25.
[27] Kurthukodi AJ, Paul J, Gandhi K, Rao DJ. Fracture resistance of endodontically treated permanent anterior teeth restored with three different esthetic post systems-an invitro study. Journal of Indian Society of Paedodontics and Preventive Dentistry. 2015;33(4):296-301.

[28] Santana FR, Castro CG, Simamoto J, Soares PV, Quagliatto PS Estreta C, et al. Influence of post systems and remaining coronal tooth tissue on biomechanical behaviour of root filled molar tooth. International Endodontic Journal. 2011;44:386-94.

[29] Schwendicke F, Stolpe M. Cost effectiveness of different post retained restorations Endod. 2017;43(5):709-14.

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