Original Research Paper Prosthodontics

THE EFFECT OF DIAMETER AND SURFACE TREATMENTS ON THE FRACTURE RESISTANCE OF NEW ESTHETIC POSTS

Dr. Julie George Alapatt	Associate Professor (C.A.P.). Dept. Of Prosthodontics., Govt. Dental College Thrissur
Dr. Noxy George Manjuran*	Reader. Dept. Of Prosthodontics. Pmscollege of Dental Science And Research, Golden Hills Vattappara, Trivandrum. Kerala *Corresponding Author
Dr. Jaini J. L.	Reader. Dept. of Prosthodontics, Amrita School of Dentistry. Amrita University. Kochi . Kerala.
Dr. T Sreelal	Professor & H.O.D. Dept. of Prosthodontics, Sree Mookambika Institue of Dental Science, Kulasekharam. Tamilnadu.

ABSTRACT The effect of diameter and surface treatment on prefabricated zirconium dioxide (diameter 1.4mm and 1.7mm) and glass fiber-reinforced (diameter 1.3mm and 1.6mm) endodontic posts were studied. The Zr posts were divided into groups A, B, and C, based on the surface treatment. Group A, the control group was given no surface treatment, group B was airborne particle abraded using 110 m alumina and group C roughened with a coarse grit diamond bur. FRC-posts without any surface treatment constituted Group D. The samples were tested for fracture resistance in an Instron Universal Testing Machine. One way ANOVA, small sample student t test, & Pearson correlation coefficient were the statistical tools employed to analyze the observations. Zirconium dioxide posts showed statistically significant higher fracture resistance when compared to glass FRC-posts. Surface treating the Zr posts with airborne particle abrasion further significantly improved the fracture resistance.

KEYWORDS : endodontic post, esthetic post, fracture resistance.

Introduction:

All ceramic restorations enjoy a premium status in the prosthetic rehabilitation of anterior maxillary region due to their superior natural appearance in comparison with metal ceramic restorations.[1] However, to strengthen weakened endodontically treated teeth against intra oral forces, posts are recommended. Posts distribute the torquing forces along the roots,[2] but it can create stress that may make these teeth more prone to root fracture.[3] Cast metal post and core foundations have a long history of successful use due to superior physical properties, but recently, prefabricated posts have gained popularity[4, 5].

The growing demand for aesthetics has led to the development of tooth coloured, metal-free post systems like carbon fiber posts, zirconia posts, glass fiber posts and woven fibers [polyethylene fibers] posts[6]. There is no universal post and core system accepted for all clinical situations. The present study is a sincere attempt to check the effect of different diameters and different surface treatments on the fracture resistance of aesthetic endodontic posts.

Methodology:

Freshly extracted intact maxillary central incisors having straight roots of comparable length (14mm), shape and diameter, were collected. After cleaning and disinfecting with 5.25% sodium hypochlorite solution, they were stored in normal saline. The selected teeth were decoronated, using an airotor handpiece (NSK) and 171 L diamond bur (Dentsply), at the level of 2mm from the cementoenamel junction, and endodontically treated. Root canals were manually instrumented to a length of 13mm, with K. files up to #60 master apical file, under simultaneous irrigation with 1% sodium hypochlorite. Final irrigation was done with 10ml of distilled water and dried thoroughly before obturation with gutta-percha points using lateral condensation technique and the pulp chambers were sealed with provisional cement. Specimens were immersed in distilled water at 37^{0}c for 72hrs. Thereafter with heated condensers 8mm of the filling material was removed to prepare post space, and measured using a plastic stop. After this canal space was enlarged and lengthened upto 10mm without any undercut, using appropriate sized reamers and drills supplied by the manufacture for each type of posts used for the study. Zirconium dioxide ceramic(Zr) post (Cosmopost Ivoclar Vivadent) 1.4mm and 1.7mm, and Glass fiber reinforced composite(FRC) post - (Twin Luscent Anchor-Dentatus USA) 1.3mm and 1.6mm were used. The post space was rinsed, dried thoroughly .

Total 24 prefabricated endodontic posts, including eighteen zirconium dioxide post and six FRCposts were used for the study. The Zr-posts were divided into three groups to receive 3 surface treatments. Group-A served as the control group and was given no surface treatment. Group-B was subjected to airborne particle abrasion using 110mm alumina. Group-C were roughened evenly with a coarse grit diamond bur mounted on a high-speed handpiece. No surface treatment was given to FRC-posts of Group D. In each of these four groups, three posts each will be with 1.4mm and 1.7mm diameter respectively.

The smear layer was removed by immersing in 5.25% sodium hypochlorite followed by 15% EDTA solution in an ultrasonic bath. The canal was then etched with 37% phosphoric acid gel (Total etch Ivoclar Vivadent) for 15 seconds and then rinsed thoroughly with distilled water and dried . Then Excite DSC (Ivoclar Vivadent) bonding agent was applied using self-activating microbrush and light cured. The Zr-posts were etched with 5% hydrofluoric acid (IPS ceramic etch) for 2 minutes. Then it was rinsed and air dried. Monobond S. silane coupling agent was applied onto the Zr-post for 15 seconds and allowed to air dry. Variolink II base and catalyst paste was mixed in a ratio 1:1 and applied in the canal using a lentulo spiral, also coated on the post and was inserted into the canal with a pumping action and light cured for 40s. After the cement had set, the specimens were embedded in acrylic resin blocks with the long axes oriented parallel to it.

The specimens were loaded in a Universal Testing Machine (Model 4206, Instron Corp.). The loading tip was aimed at an angle of 90^{0}, at a constant crosshead speed of 1 mm/min, and the fracture load was determined by a sudden drop in load magnitude. The tensile load necessary to cause failure of the post was recorded.

Results

The results of the test were statistically analyzed. One way Analysis of Variance ANOVA was used to find out variation among the different groups under study. Small sample student 't' test and

Pearson correlation co-efficient were the other statistical tools to analyze and interpret the data

Table – 1: Comparison of fracture resistance among larger diameter & smaller diameter posts viz. different surface treated Zr post and FRC post (TLA posts)

Group		MEAN	SD	N
Group A	larger diameter	428.50	15.09	3
	smaller diameter	384.3	29.4	3
Group B	larger diameter	659.97	33.28	3
	smaller diameter	509.6	16.9	3
Group C	larger diameter	482.80	18.25	3
	smaller diameter	398.7	17.6	3
Group D	larger diameter	209.33	21.01	3
	smaller diameter	191.5	20.2	3

Table – 2 : One-way analysis of Variance, ANOVA to compare the fracture resistance of larger diameter & smaller diameter groups

larger diameter	Sum of Squares	df	Mean Square	F	p value
Between Groups	310351.3	3	103450.4	196.145	0.000
Within Groups	4219.4	8	527.4		
Total	4219.4	11			
smaller diameter	**Sum of Squares**	**df**	**Mean Square**	**F**	**p value**
Between Groups	157145.3	3	52381.8	112.430	0.000
Within Groups	3727.3	8	465.9		
Total	160872.6	11			

In table (2), the ANOVA test for larger diameter groups gave an F value of 196.145 and the p value was highly significant ie. P=0.000; p<0.001. This shows that, there was a significant difference in fracture resistance among the groups. ANOVA test for smaller diameter groups gave an F value of 112.430 with a p value of 0.000 which was highly significant.

Table – 3: Pair wise comparison of fracture resistance for larger diameter & smaller diameter Zr posts & FRC post

3A larger diameter	Student 't'	p value
Group A Vs Group B	10.97***	0.000
Group A Vs Group C	3.97**	0.017
Group A Vs Group D	14.68***	0.000
Group B Vs Group C	8.08***	0.000
Group B Vs Group D	19.83***	0.000
Group C Vs Group D	17.02***	0.000
** : p<0.05, *** : p<0.001		

3B smaller diameter	Student 't'	p value
Group A Vs Group B	6.41***	0.000
Group A Vs Group C	0.73	0.620
Group A Vs Group D	9.37***	0.000
Group B Vs Group C	7.89***	0.000
Group B Vs Group D	20.97***	0.000
Group C Vs Group D	13.42***	0.000
*** : p<0.001		

Table (**3A**) showed that except for Group A with Group C comparison, where the p value had a difference but still significant at 5%level. P=0.017, all other combination of groups when compared, gave a significantly high value with a p value of 0.000 ie. P<0.001. In table **(3B**), the results for all combinations except one, were highly significant, to a level of p<0.001p=0.000. Group A and Group C did not show a significant increase in the fracture resistance. Whereas, the airborne particle abrasion markedly improved the fracture resistance of Zr posts. All the Zr posts was highly superior to FRC posts.

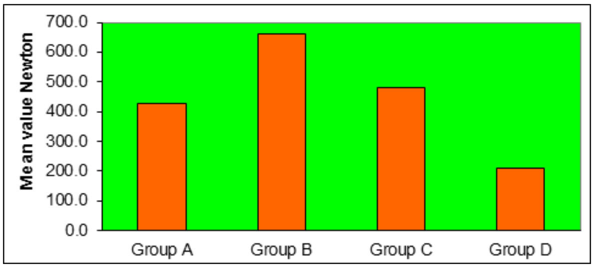
Table – 4 Relationship between diameter of the post and fracture resistance

	r	p value
Pearson correlation coefficient	0.980***	0.000

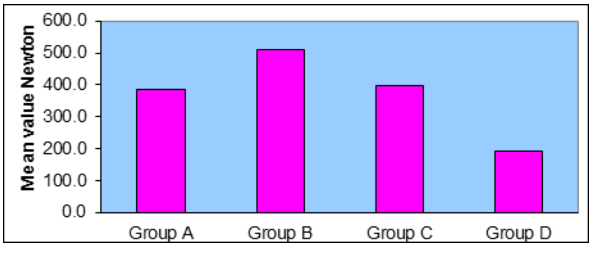
*** : p<0.001

A definite increase in fracture resistance was there when the diameter of the posts increased. The p value was highly significant p=0.000 P<0.001

GRAPH NO-1 Bar diagram showing fracture resistance for larger diameter posts among the different groups under study



GRAPH NO-2 Bar diagram showing fracture resistance for smaller diameter posts among the different groups under study



Discussion:

Endodontic treatment of an otherwise intact tooth reduces its resistance to fracture by 5%, whereas MOD restorations reduces the resistance to fracture by 69%[1]. A post and core system is often required to provide retension and support for the restoration of teeth lacking coronal tooth structure[7].The factors influencing post selection are root length, tooth anatomy, root width, canal configuration, amount of coronal tooth structure, torquing force, stressess, development of hydrostatic pressure, post design, post material, material compatibility, bonding capability, core retension, retrievability, esthetics and crown material.[8,9]

Lloyd and Palik categorizes the post diameter selection into three. i.e conservationist, preservationist and proportionists[10]. ***Stern*** and ***Hirshfield*** suggested that post width should not be greater than 1/3[rd] of the root width at its narrowest dimension (Proportionist). Other investigators propose that post should be surrounded by a minimum of 1mm of sound dentin (Perservationist). Others including ***Pilo*** and ***Tamse*** advocated minimal canal preparation and maintaining as much residual dentin as possible (Conservationist). Tooth restored with larger diameter posts is reported to provide the least resistance to fracture with a decrease in the width of the remaining dentin.

Traditional cast metal post-and-core systems have high risk of root fracture since they transfer the stress to the less rigid tooth substance.[11] Likewise, the metallic posts can fracture due to corrosion. Dissimilar alloys may result in galvanic reaction, and the volume changes due to the by-products of the reaction may result in root fracture. Additionally, metals used may cause allergic or toxic reactions within adjacent soft or hard tissues[12]. Opaque metal post-cores impart a grayish colour to all-ceramic crowns influencing the aesthetic outcome of the restoration.[11] Consequently, during the past decade, use of non-metallic post-cores have increased.

In the later 1980s Christel et al developed zirconia posts with good optical and biological properties compatible with all ceramic crown[6]. ***Meyenberg*** et al and ***Heydecke*** et al demonstrated that the fracture strength of these systems is comparable to the established post-core systems based on titanium or high precious alloys[4,13,14] In Zirconium based ceramics predominant phase at room temperature is monoclinic, which is stable upto 1170°C, after-which it transforms into the tetragonal phase. Pure Zirconia material shows a polymorphic phase transformation accompanied by a high volume change when cooling down after sintering, which makes the sintered body unstable. Therefore, 3 to 6 wt% of Y_2O_3 is added to stabilize the Zr-ceramic in tetragonal phase that is usually not stable at room temperature.[15,16]

The Yttria – partially stabilized tetragonal zirconia polycrystalline ceramics (Y – TZP) have an elastic modulus of approximately 200 Mpa, and a flexural strength of 820 Mpa. Zr posts demonstrate high fracture resistance due to high flexural strengths, which is comparable to that of cast gold post-cores or titanium posts. Zr posts are advocated for use, with heat-pressed glass ceramic or composite resin core materials. Bonding to zirconium oxide ceramics require different pre-treatment procedures like grinding, airborne particle abrasion, etc. that increase the mean flexural strength of zirconia based ceramics[17], which is still a controversy. Severe grinding may introduce deep structural flaws that act as stress concentrators and decrease the mean flexural strength.

FRC-post systems introduced in 1992, are composed of unidirectional glass fibres embedded in a resin matrix that strengthen posts without compromising the modulus of elasticity. Fractures of teeth restored with Zr-posts are often unrestorable, whereas invitro studies on the fracture strength of FRC-posts showed less catastrophic failures. FRC-posts have modulus of elasticity values which are close to that of dentin.[18,19] Moreover, if a root fracture occurs in the presence of a fiber post, it is usually located more coronally and easily retrievable, as compared to other posts.[20] Compared to metal, composite resin absorbs and distributes forces in a more uniform manner, and increases resistance to fracture[5]. These tooth colored FRC posts are light transmitting and highly esthetic, and do not impart a grey color to the remaining teeth. They are relatively inexpensive The most common mode of failure with bonded fiber posts is by debonding, at the interface between the dentin and resin cement, and degradation due to repeated mechanical loading and moisture contamination..

The mean values of fracture loads, for the larger diameter posts were, 428.50 ± 15.09N, 659.97 ± 33.28N, 428.80 ±18.25N and 209.33 ± 21.01N for Group A, Group B Group C and Group D respectively. There was a marked difference for the air borne particle abraded group of Zr-posts. For smaller diameter posts, the mean values of fracture load were 384.3 ± 29.4N, 509.6 ± 16.9N, 398.7 ±17.6 N, and 191.5±20.2N; for Group A, Group B, Group C and Group D respectively. In both larger and smaller diameter groups, Group B(110mm alumina abraded Zr-post) was found to have superior fracture resistance, whereas Group D (FRC) was considerably inferior.

Pair wise comparison of fracture resistance for larger diameter posts, showed that, the fracture resistance of Group B was markedly increased after surface treatment, when compared with Group A, and Group C with a highly significant p value ie p 0.000; <0.001. The surface treatment given in Group C also increased the fracture resistance significantly as compared to the control Group A. The p value was significant ($p < 0.05$, $p= 0.017$).

All the groups of Zr-post were having a marked superiority over the FRC-posts under study regarding fracture resistance of the posts. For smaller diameter groups also, the observation was similar to that of larger diameter posts, except that, Group A and Group C did not show any significant improvement over the other. When compared with each other, all the other groups showed highly significant difference with a p value of 0.000 for all comparisons ($p < 0.001$).

From the statistical analysis and observations, the present study comes to the conclusion that, airborne particle abrasion with 110mm alumina of Zr-posts significantly improved their fracture resistance. Like wise, diamond bur roughening also helped to improve the fracture resistance to a significant level. The FRC posts were far inferior to the Zr-posts in case of fracture strength. The finding of the present study are confirmed by the studies conducted by ***Kosmac T., Oblak C*** et al[1,21].

Pearson correlation coefficient was done to analyze the relationship between post diameter and fracture resistance of the posts. The values obtained were highly significant p=0.000 ie $p < 0.001$. It should be noted that, the greater the post diameter the greater the fracture resistance.

Pfeiffler and ***Nergis*** compared Zr-posts and FRC-posts of different diameters and reported that, with an increase in diameter the fracture loads also increased, in a linear fashion[22,8]. But it has been pointed out that in an attempt to increase the fracture resistance of posts, the post diameter should not be increased in a non-judicious way, resulting in weakening of the remaining structure and root fracture.

In the present study, the effects of thermal cycling and long term storage were not evaluated and are considered limitations of this study. Moreover, controlled clinical trials are needed before clinical recommendations can be provided.

Conclusion:

All groups of zirconium dioxide post were found to be the best regarding the fracture resistance when compared to glass fiber posts. Airborne – particle abrasion with 110mm alumina, as well as surface roughening with coarse diamond bur on the zirconium dioxide post, significantly improved its fracture resistance. Irrespective of the type of post considered, it was observed that the greater the diameter the greater the resistance. Clinical implications of the study is that, in high esthetics demanding situations, zirconium dioxide ceramic post after air borne particle abrasion with 110 mm alumina is a promising restoration; provided the individual is not a bruxer or engaged in sports where there is a risk of tooth fracture. The glass fiber reinforced composite is also another reliable option, which is relatively inexpensive too, but not as strong as Zirconium dioxide ceramic post.

Reference:

1. Oblak C, Jevnikar P, Kosmac T, Funduk N, Marion L. Fracture resistance and reliability of new zirconia posts. J Prosthet Dent. 2004;91(4):342–8.
2. Fraga RC, Chaves BT, Mello GS, Siqueira J F J, Siqueira JF. Fracture resistance of endodontically treated roots after restoration. J Oral Rehabil [Internet]. 1998;25(11):809–13.
3. Newman MP, Yaman P, Dennison J, Rafter M, Billy E. Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent. 2003;89(4):360–7.
4. Nothdurft FP, Pospiech PR. Clinical evaluation of pulpless teeth restored with conventionally cemented zirconia posts: A pilot study. J Prosthet Dent. 2006;95(4):311–4.
5. Goncalves LA d A, Vansan LP, Paulino SM, Sousa Neto MD. Fracture resistance of weakened roots restored with a transilluminating post and adhesive restorative materials. J Prosthet Dent. 2006;96(5):339–44
6. Shetty T, Bhat GS, Shetty P. Aesthetic postmaterials. 2005;5(3):122–5.
7. Carter JM, Sorensen SE, Johnson RR, Teitelbaum RL, Levine MS. Punch shear testing of extracted vital and endodontically treated teeth. J Biomech. 1983;16(10):841–8.
8. Fernandes AS, Shetty S, Coutinho I. Factors determining post selection: A literature review. Vol. 90, Journal of Prosthetic Dentistry. 2003. p. 556–62.
9. Gutmann JL. The dentin-root complex: anatomic and biologic considerations in restoring endodontically treated teeth. J Prosthet Dent. 1992;67(4):458–67.
10. Lloyd PM, Palik JF. The philosophies of dowel diameter preparation: A literature review. Vol. 69, The Journal of Prosthetic Dentistry. 1993. p. 32–6.
11. Hedlund S-O, Johansson NG, Sjögren G. Retention of prefabricated and individually cast root canal posts in vitro. Br Dent J. 2003;195(3):155–158; discussion 147.
12. Toksavul S, Türkün M, Toman M. Esthetic enhancement of ceramic crowns with zirconia dowels and cores: A clinical report. J Prosthet Dent. 2004;92(2):116–9.
13. Heydecke G, Butz F. Fracture strength and survival rate of endodontically treated maxillary incisors with approximal cavities after restoration with different post and core systems : an in-vitro study. 2001;29:427–33.
14. Heydecke G, Butz F, Hussein A, Strub JR. Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and-core systems. J Prosthet Dent. 2002;87(4):438–45.
15. Bitter K, Priehn K, Martus P, Kielbassa AM. In vitro evaluation of push-out bond strengths of various luting agents to tooth-colored posts. J Prosthet Dent.

2006;95(4):302–10.
16. Kakehashi Y, Lüthy H, Naef R, Wohlwend A, Schärer P. A new all-ceramic post and core system: clinical, technical, and in vitro results. Int J Periodontics Restorative Dent. 1998;18(6):586–93.
17. Xible AA, De Jesus Tavarez RR, De Araujo CDRP, Bonachela WC. Effect of silica coating and silanization on flexural and composite-resin bond strengths of zirconia posts: An in vitro study. J Prosthet Dent. 2006;95(3):224–9.
18. Santos GC, El-Mowafy O, Rubo JH. Diametral tensile strength of a resin composite core with nonmetallic prefabricated posts: An in vitro study. J Prosthet Dent. 2004;91(4):335–41.
19. Lassila LVJ, Tanner J, Le Bell A-M, Narva K, Vallittu PK. Flexural properties of fiber reinforced root canal posts. Dent Mater [Internet]. 2004;20(1):29–36.
20. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: a 2-year prospective study. Int J Prosthodont [Internet]. 2003;16(6):593–6.
21. Ernst CP, Cohnen U, Stender E, Willershausen B. In vitro retentive strength of zirconium oxide ceramic crowns using different luting agents. J Prosthet Dent. 2005;93(6):551–8.
22. Pfeiffer P, Schulz A, Nergiz I, Schmage P. Yield strength of zirconia and glass fibre-reinforced posts. 2006;19–23.