Journal of Medical Sciences

ISSN 1682-4474

science alert

ANSInet
an open access publisher
http://ansinet.com

Research Paper

J. Med. Sci., 9 (3): 140-145
1st April, 2009

Fracture Strength in Teeth Restored with Three Dowel Core Systems Before and after Load Cycling: An *in vitro* Study

N. Asadzadeh, J. Ghanbarzadeh and A.R. Mohajeri

The aim of this *in vitro* study was to compare the fracture resistance and failure mode of endodontically treated teeth restored with three different post and core systems before and after load cycling. In this interventional study, forty-two maxillary incisors selected. After root treatment, they were randomly divided into six groups of 7. In group 1 and 2, casting post and core was used. In group 3 and 4, Dentatus-posts and composite cores were used and in group 5 and 6, FRC posts were used. Cyclic loading was performed in group 2, 4 and 6. There after compressive load was applied at a 45° angle to the long axis of the tooth at a crosshead speed of 1 mm min^{-1} until the fracture occurred. One-way ANOVA and Tukey-Karmer test were used to determine the difference of the failure loads between the groups. The load cycling had no statistically significant effect on fracture strength among groups. Teeth restored with cast posts-and-cores exhibited significantly higher resistance to fracture than para post group ($p<0.05$). In cast post and core group and para post group, fracture mainly occurred in the root and it was unrestorable but in FRC post and composite group, it mainly occurred in the composite cores. Fracture resistance of teeth restored with cast post and core, dentatus post and FRC pose were not affected by load cycling. The created fractures in casting post and core and dentatus post were undesirable and in root, which made the restoration of the teeth impossible.

Key words: Fracture resistance, load cycling, cast post and core, dentatus post, FRC post

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued eight times per year on paper and in electronic format.

For further information about this article or if you need reprints, please contact:

Nafiseh Asadzadeh Aghdaee
Department of Prosthodontics,
Faculty of Dentistry and Dental Research Center,
Mashhad University of Medical Sciences,
Vakilabad Blvd,
Postal Code 91735,
P.O. Box 984,
Mashhad, Iran

ANSInet
Asian Network for Scientific Information

Dental Research Center, Department of Prosthodontics,
Mashhad Dental School, Mashhad University of Medical Sciences,
Mashhad, Iran

INTRODUCTION

The restoration of endodontically treated teeth is very important. It is even said to be more important than root canal therapy. Unsuitable tooth restoration will result in failure because of an undesirable coronal seal; due to the restoration leakage, oral microbial flora will penetrate to the root canals and finally get to the peri apical region and create peri apical lesion which causes treatment failure (Cohen and Burns, 1998).

Since, the incisors have an important role in beauty, speaking and occlusion, their restoration is very critical. With the development of dentistry and dental materials, different methods such as prefabricated pins or FRC posts with composite cores have taken the place of old methods of casting post and core (Hemmings *et al*., 1991).

Using the prefabricated metal and nonmetal posts restore the desirable function and strength of teeth and reduce the danger of tooth fracture following casting restoration (Thougthammachat and Platt, 2006).

In some studies, there are various ideas about the extent of produced forces during swallowing which is due to tooth position, transducer location in mouth, vertical morphology of the face, sex and periodontal support (Field and Proffit, 1986).

Heydecke (2002) and Lee *et al*. (2003) used a force of 30 N to determine the fracture strength of some post and core system in central incisor teeth for fatigue testing.

Post rigidity is the first key factor to cause resistance to bending under function. Occlusal forces are transferred to root via dowels. The more dowels, cements and restorative materials act similar to dentin, the less force will be focused in the forming components of the root. Laboratory studies indicated that root fracture with metal dowels (prefabricated or cast) is more (Isidor *et al*., 1996).

Reagan *et al*. (1999) examined the effect of cyclic forces on some kinds of post and core systems (2 kinds of prefabricated post with amalgam core, the same two kinds of prefabricated posts with composite core and the last group of casting post-core). There was not statistically a distinct difference among the various post core groups in this research.

In Lee's (2003) study on central maxillary incisor, after removing the coronal section of the teeth and root treatment of them,he placed them in three groups. C-post in the first group, fiber glass post (Para Post FiberWhite) in the second group and titanium post (Post Para X) in the third group were used. Ti-core was used for crown part in all groups. Specimens were placed under a 30 N force at an amount of 100000 cycles. There was not a significant difference among the 3 groups from the standard point of fracture strength. The first and the second group showed the less willingness to root fracture. Except for one case in group 3, all fractures occurred at the upper part and outside the acrylic block (Lee *et al*., 2003).

Thougthammachat and Platt (2006) did a research on static resistance before and after performing fatigue loading in reconstructed teeth with four types of post and core systems. The results showed that the fracture resistance is less after fatigue testing. So, the maximum resistance strength was recorded for fiber fill groups and there was not a significant difference between fracture strength in gold casting post and core and para-post.

Xible *et al*. (2006) examined the fracture strength of reconstructed canine teeth with 3 types of post and core systems after performing fatigue forces. The fracture strength of specimens was measured at universal system with a force of 10 KN at a crosshead speed of 0.5 mm min^{-1} after performing 500000 cycles with a force of 250 N at a frequency of 1.7 Hz. The results showed that fracture did not occur in specimens after performing fatigue forces. Secondly, there was not a significant difference due to fracture strength among groups.

In another research by Hu and Osada (2005) done in Showa University, the static and fatigue resistance of some post and core systems were examined. The results showed that FRC group with composite core significantly had the maximum cycle which resulted in fracture and gold post-core (MPC) group had the most fracture. All MPC and FRC groups had unwanted root fractures.

Nishimura *et al*. (2008) used cow's mandibular incisor teeth to investigate and compare some post and core system before and after cyclic loading. After cutting the coronal part and endodontic treatment, they reconstructed their crown part in the form of human maxillary central incisor teeth. The four post and core systems were composite post and core (R), prefabricated metal post with composite core (P), FRC post and composite core (F), casting post and core (M). The results showed that fracture strength did not have significant difference among M, F and P groups without cycling loading. Also, the fracture strength of group R was significantly less than other groups; this amount was not significantly different before and after cyclic loading in other groups.

In this research the fracture strength of reconstructed teeth with cast post-and-core is compared with two methods of prefabricated post, Para post and FRC post with composite core, before and after load cycling to determine which is more influenced in increasing teeth fracture strength. Due to this fact that many of these studies on fracture resistance of different post and core systems have been done under static loads, their results can be questionable clinically. It is because bite forces

cause fatigue forces and affect fracture resistance of restored teeth. The aim of this *in vitro* study was to compare the fracture strength of restored teeth with three different types of post-and-core systems before and after cyclic loading.

MATERIALS AND METHODS

This study was conducted in Dental Research Center of Mashhad University of Medical Sciences from March 2008 to February 2009. In this interventional study, 42 extracted human maxillary central incisors at an approximately similar size were selected with the aim of comparing fracture strength before and after cyclic loading. Teeth structure was investigated with magnifier and transillumination to make sure that they are free of cracks, fractures or carries in cervical and root areas. Teeth were kept hydrated at room temperature in distilled water prior to the study and during tooth preparation each tooth was wrapped with water-moistened gauze.

The root canals of teeth were filled with an obturation system. After the endodontic treatment, each tooth was sectioned to the long axis 1.5 mm coronal to CEJ, using a super coarse diamond instrument (KS1, Brasseler, USA, Savannah, Ga) so that the length of remained roots were 15 mm. Dowel spaces were prepared 11 mm deep using pizorimer II and then III (MANI,Inc.,Kiyohara Industrial Park, Utsunomiya, Tochigi, Japan) to a diameter of 1.2. After preparing the canals, 42 specimens were randomly divided into 6 groups of 7.

In the first (M1) and second (Mc) groups (custom cast post-and-core), posts were made with autopolymerizing resin (Duralay, Reliance, Dental Mfg Co., Worth, Ill, USA), the root segments and resin patterns were then prepared to receive full chamfer complete crowns with a 1.5 mm ferrule feature included in the remaining coronal tooth structure ; preparation were made with a 1.0 mm diameter diamond rotary cutting instrument (Brasseler USA), creating 1.5 mm of axial wall heights. The resin patterns were invested and cast with super cast (Thermabond alloy msg, Los Angeles, California, USA). Castings were inspected under original magnification ×20 and adjusted to ensure a passive fit, then airborne-particle abraded using 25 μm aluminium oxide under 3 kg cm^{-2} pressure. Glass Inomer Cement (GC Corporation, Hasunuma-cho, Itabashi-Ku, Tokyo, Japan) was mixed according to manufacturer's instructions and used to lute the dowel-and core castings. The cement was delivered to the canal space with lentulo spiral (Dentsply Maillefer, Tulsa, Okla) and castings were held in place under finger pressure for 5 min.

In groups 3 and 4 (dentatus post and composite core), root canals were prepared the same as groups 1 and 2, the dentatus post (size XL2) was shortened to a 14.5 mm length. This adjustment resulted in dowels extending 3.5 mm above the coronal surface of the prepared teeth. Glass Inomer cement was mixed the same as the previous groups and was applied to the dowel and to the canal space with lentulo spiral. The dowels were gently seated to place and held with light pressure until the cement reached initial setting (5 min). Composite cores (Core Max II, Dentsply-Sankin k.k, Japan) in height were made on teeth extending 3.5 mm incisal to the sectioned tooth surfaces were fabricated for these two groups.

In a similar manner in groups 5 and 6, each fiber glass post dowel (Angelus, Industrial Products Odontologics Ltda, Londrina, Brazil) was reduced to 14.5 mm length by cutting the apical end with high speed carbide fissure bur, again resulting in a dowel extending 3.5 mm above the coronal surface of the prepared tooth. A standardized amount of resin luting (Panavia F2, Kuraray Medical Inc, Okayama, Japan) was applied to dowel according to manufacturer's recommendations. At the end, 3.5 mm composite core was fabricated (Core Max II, Dentsply-Sankin k.k,) on the sectioned teeth.

The cores and teeth were then prepared for a complete cast crown using a high- speed medium-grit diamond rotary cutting instrument (Brasseler USA) and water spray. The crown designs were the same as that used for groups 1 and 2. In the next step, wax copings were fabricated for each specimen. Each crown was then invested and cast with super cast (Thermabond alloy msg, Los Angeles, California, USA). After divesting, crowns were inspected under original magnification x20 for fitting accuracy. After correct fit was established, intaglio crown surfaces were airborne-particle abraded using 25 μm aluminium oxide under 3 kg cm^{-2} pressures. The crown was cemented with Glass Inomer Cement (GC Corporation, Hasunuma-cho, Itabashi-Ku, Tokyo, Japan) mixed according to manufacturer's directions. Each crown was held for 10 min under finger pressure.

Pdl with 0.3 mm was made with the Speedex (Speedex Light Body, Coltene Whaledent, Altstatten, Switzerland) around the roots. After that the specimens were mounted in self-polymerizing acrylic resin (Formatray, Ker) at a 45 angle in a center of a cylinder measuring 2 cm height and 2.5 mm diameter 2 mm under the finish line of the teeth. Finally, in all specimens, the crown length was 10 mm (2 mm crown thickness, 3.5 mm core length, 1.5 mm finishing line, 3mm biologic width) and the length of root was 10.5 in acryl.

After final setting, in order to apply fatigue forces similar to the bite force, 21 specimens from groups 2, 4

and 6 were placed at Zwick artificial mouth apparatus (Zwich Gmbh and Co. KG ULM Germany) in Mashhad Dental School (Hu and Osada, 2005).

The load applied to each specimen was (3.6 kg) at an angle of 135 degree to the long axis of the tooth. Time duration to applied force at each chewing cycle was (0.2 sec) and all cycles were 240000 which were equal about one year of applied force inside the mouth. The applying force on teeth was designed in a way not to create any beat but to put pressure on teeth.

Then all specimens were placed under pressure at a crosshead speed of 1 mm min^{-1} with Instron device (Zwick, Japan). The force was applied 2 mm more cervical than the incisal edge at a 45 angle to the long axis of the tooth till the fracture occurred. During the test, data was recorded on the screen as a graph. The data was subjected to Turkey-Karmer and two-way ANOVA to determine significant differences at α=0.05. Classified failure modes were also analyzed by chi-square test at 5% significance level.

RESULTS

At first with the use of non-parametric Kolmogorv Smirnov, the assumption of being normal for 6 groups was investigated. The result indicates that at α = 0.05 level, the assumption of being normal is accepted for all 6 groups. Table 1 indicated the mean fracture strength and standard deviation for each group. As it was seen, the maximum fracture strength is related to casting post-core crown group1 (M1) and the minimum was related to dentatus post in group 3(P1). With Leven test then the assumption of equality to make the variance analysis possible was confirmed (p-value = 0.4>0.05).

With the help of two way ANOVA, the effect of tooth reconstruction method, cycling loading on each group and their effect on fracture strength variable was investigated.

It became clear in Table 2 that:

- Load cycling factor did not have significant effect on fracture strength (p-value = 0.74)
- The factor of tooth reconstruction method had significant effect on fracture strength (p-value = 0.003)
- There was not an interaction between 2 factors (p-value = 0.536)

With regard to the significance of tooth reconstruction method, the best method was investigated with of Tukey karmer. Tukey karmer test at the level of α = 0.05 indicated that there is a significant difference between M and P reconstruction method (0.0328) but no significant difference was seen between F and those 2 other methods (0.078).

Table 1: Mean fracture strength and standard deviation for each group

Studied groups	No. of samples	Mean fracture strength	SD
(M1)	7	407.5	64.2
(Mc)	7	382.8	58.4
(P1)	7	318.2	48.2
(Pc)	7	335.1	39.6
(F1)	7	371.9	42.6
(Fc)	7	364.6	34.5

Table 2: p-value in 2 investigated factors

Investigated factors	Sig. (p-value)
Load cycling	0.724
Reconstruction method	0.003
The effect of 2 factor on each other	0.536

Table 3: The numbers and location of fractures in all groups

	Fracture location				
Studied groups	A	B	C	D	Total
1 (M1)	0	0	1	6	7
2 (Mc)	0	0	1	6	7
3 (P1)	0	0	2	5	7
4 (Pc)	0	0	1	6	7
5 (F1)	5	2	0	0	7
6 (Fc)	6	1	0	0	7
Total	11	3	5	23	42

In this study the fracture position was investigated in groups. 4 positions based on created fracture places in teeth are:

- **Fracture A:** The lowest fracture line is placed above the metal crown margin
- **Factor B:** The lowest fracture line is placed between crown margin and tooth region inside acrylic cast
- **Fracture C:** The lowest fracture line has reached the tooth root inside acrylic cast
- **Fracture D:** There is more than one fracture line that has extended vertically as well as horizontally

As it is clear from Table 3 fracture C and D were seen in groups Pc, P1, Mc and fracture A and B was only seen in F1 and Fc groups.

DISCUSSION

In similar researches which have investigated the fracture strength in different restored endodontically treated teeth, the results were related to the specimen selection, different posts size, the kind of used post and materials and technique. Of course in most studies no attention has been paid to the application of load cycling (Mc Donald *et al*., 1990; Insuna *et al*., 1998; Sendhilnathan and Nayar, 2008).

In this research, the focus was to compare the fracture strength of reconstructed teeth with three different methods (cast post-and-core, parapost and FRC post with composite core) before and after load cycling to determine if load cycling has any effect on them or not.

There is no significant difference in the fracture resistance between restored teeth with metal post and carbon fiber post (Mc Donald *et al*., 1990).

This is in agreement with present study. No significant difference was seen between FRC groups and those 2 other methods.

Minimum fracture load in post and core casting group was higher than in carbon- fiber post with composite core (Insuna *et al*., 1998). The results of this study are in agreement with present study too. The fracture load in post and core casting group was higher than in carbon-fiber post with composite core.

The fracture strength of reconstructed teeth with casting post-core was more than reconstructed teeth with Titanium prefabricated post and composite core (Sendhilnathan and Nayar, 2008).

However, in Xible and Reagane research on fracture strength of some kinds of post and core system after applying cyclic loading, there was not a significant difference between FRCpost fracture strength with composite core and Titanium post with composite core (Reagan *et al*., 1999; Xible *et al*., 2006).

In Nishimura's *et al.* (2008) study too, the fracture strength of metal prefabricated posts with composite core and FRC post with composite core and casting post-core before and after cyclic loading was investigated and showed there was not any significant difference before and after cyclic loading. Present study confirmed the Nishimura's *et al.* (2008) study, load cycling factor did not have significant effect on fracture strength.

In the present research, although load cycling factor did not have significant effect on fracture strength, tooth reconstruction method had a significant effect on fracture strength and fracture strength of reconstructed group with Para-post and composite core was significantly less than cast post-and-core, but in other groups was not significantly different. Though maximum fracture strength is related to casting post-core and after that to FRC post with composite core and at the end to para post with composite core, but there was not significant difference between cast post-and-core and FRC post with composite core and the difference between 2 groups of RRC and Para post with composite core was not significant.

In research done by Reagan *et al.* (1999) on some post and core systems, cyclic loading did not make any significant difference in groups under the study.

Also, in Xible *et al.* (2006) and Nishimura's *et al.* (2008) cyclic loading did not make significant effect on fracture strength of studied groups. The present study confirms the result that cyclic loading does not have significant effect on fracture strength of mentioned group before and after the application of loading.

In the studies on the type and position of created fractures in different kinds of post and core systems, similar results have been obtained. In a research done by Krejci and Muller (1994), it was seen that in Para post group with composite core, most forces have been transferred to root and caused fracture. But, in FRC post and composite core group, all fractures occur at crown.

According to Insuna's *et al.* (1998) study, teeth which were restored with carbon-fiber posts and composite cores, showed fracture at the distance between core and post before the fracture occur in tooth; but all the fractures occurred in teeth structure when they were restored with casting post and core.

These results were confirmed in the present study. Post stiffness is the key parameter to cause resistance to bending under function. Occlusal forces are transferred to root through dowels. The more dowels, cements and restorative materials act similar to dentin under function, the less force will be focused in forming components of root. It has been reported that the danger of root fracture with metal dowels is more (Isidor *et al*., 1996).

Carbon-fiber dowels or strengthened composite with glass fiber have similar modulus elasticity to dentin. This increases the ability of force to spread, so the danger of root fracture will decrease.

The created fractures in FRC post group with composite core occurred at coronal region and these fractures were desirable, but in cast post-and-core group and metal prefabricated post and core occurred in root (Nishimura *et al*., 2008).

In this study, the results were the same; it means the created fractures in M and P groups were of undesirable type and in root and in group F desirable restorable coronal fracture was created.

CONCLUSION

With regard to the limitation of this study, it was concluded that casting post-and-core system has more fracture strength than para-post with composite core, but compared to FRC post with composite core this difference is not significant. The created fractures in casting post and core and para-post were undesirable and in root, which made the restoration of the teeth impossible.

ACKNOWLEDGMENT

The authors express their appreciation to the Vice Chancellor of Mashhad Medical University for providing the support for this research.

REFERENCES

Cohen, S. and R.C. Burns, 1998. Pathways of Pulp. 7th Edn., St. Louis Mosby Inc., New York, pp: 691-716.

Field, H.W. and W.R. Proffit, 1986. Variables affecting measurements of vertical occlusal force. J. Dent. Res., 65: 135-138.

Hemmings, K.W., P.A. King and D.J. Setchell, 1991. Resistance to torsional forces of various post and cores design. J. Prosthet. Dent., 66: 325-329.

Heydecke, G., 2002. Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and-core systems. J. Prosthet. Dent., 87: 438-445.

Hu, S. and T. Osada, 2005. Resistance to cyclic fatigue and fracture of structurally compromised root restored with different post and core restorations. Dent. Mater. J., 24: 225-231.

Insuna, A., L. Silva and B. Rilo, 1998. Comparison of the fracture resistance of pulpless teeth restored with a cast post and core or carbon fiber post with a composite core. J. Prosthet. Dent., 80: 527-532.

Isidor, F., P. Odman and K. Brondum, 1996. Intermittent loading of teeth restored using prefabricated carbon fiber post. Int. J. Prosthodont., 9: 131-136.

Krejci, I. and E. Muller, 1994. Effect of thermo cycling and occlusal force on adhesive composite crowns. J. Dent. Res., 73: 1228-1232.

Lee, B.W., Y.J. Yi, L.R. Cho and C.J. Park, 2003. An analysis of failure mode of teeth restored with fiber-reinforced posts under the condition of bony resorption. J. Korean Acad. Prosthodont., 41: 232-242.

Mc Donald, A.V., P.A. King and D.J. Setchell, 1990. An *in vitro* study to comparison fracture resistance of intact root-treated teeth. Int. Endodontic J., 23: 304-312.

Nishimura, Y., Y. Tsubota and S. Fukushima, 2008. Influence of cyclic loading on fiber post and composite resin core. Dent. Mater. J., 27: 356-361.

Reagan, S.E., T.J. Fruits, C.L. Van Brunt and C.K. Ward, 1999. Effects of cyclic loading on selected post and core systems. Quintessence Int., 30: 61-71.

Sendhilnathan, D. and S. Nayar, 2008. The effect of post-core and ferrule on the fracture resistance of endodontically treated maxillary central incisors. Ind. J. Dent. Res., 19: 17-21.

Thougthammachat, S. and J.A. Platt, 2006. Fracture resistance and fracture resistance after fatigue loading of 4 different post and cores in endodontically treated teeth. Compendium Continuing Edu. Dentistry, 27: 396-401.

Xible, A.A., R.R. Jesus Tavarez, C.R.P. Araujo, P.C.R. Conti and W.C. Bonachella, 2006. Effect of cyclic loading on fracture strength of endodontically treated teeth restored with conventional and esthetic posts. J. Applied Oral Sci., 14: 297-303.