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Research / Araştırma Makalesi

In Vıtro Evaluatıon of The Resıstance of Three Dıfferent Post Systems Agaınst Functıonal Forces

Üç Farklı Post Sisteminin Ağız İçinde Oluşabilecek Kuvvetlere Karşı Dayancının in Vitro Değerlendirilmesi

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ABSTRACT

Background: In order to ensure sufficient resistance against functional forces for dentin, which is severely weakened by excessive material loss in single-root single-canal teeth with previous root canal treatment, maximum retention and resistance must be the target.

The main purpose of this study is to evaluate the shear rupture resistance of the chosen three kinds of posts placed in the teeth roots, against forces that could occur in the replicated mouth.

Methods: Freshly extracted 45 teeth -maxillary canin and maxillary central- have been used in our study. Crown portion of the tooth was removed by cutting away 1 mm over the enamel cement junction. Root canals were obturated with a lateral condensation technique using AH-26 and gutta percha sealer. In the study, 15 specimens each from Flexi-Post, Cosmopost, and FRC Postec post systems have been placed in sockets opened down through teeth by using specific burs for each system. A dual cured composite cement Variolink II Low Viscositywas used to bind posts. Prepared specimens were put in steel hose by using acrylic resin. Standardized core material Coradent was applied onto top side of posts, and steel hoses were connected to Lloyd test instrument with an angle of 45 degrees. A force with a speed of 1 mm/min was applied to the specimens. Compression shear rupture values were recorded and One Way ANOVA and Kruskall-Wallis analyses were conducted for statistical evaluation.

Results and Conclusion: Highest values were obtained in Flexi-Post group. FRC Postec was the second, and Cosmopost had the lowest strength values. However, all the systems provided adequate resistance against forces that could occur in the mouth, hence it was concluded that they can be utilized clinically.

Key words: posts and cores, post system, prefabricated post systems

ÖZ

Öz: Kanal tedavisi uygulanmış Tek köklü dişlerde aşırı madde kaybı nedeniyle yapısı zayıflayan dentinin fonksiyonel kuvvetlere karşı yeterli dayanıklılık gösterebilmesi için uygun bir post sistemiyle retansiyon ve rezistans sağlamaya çalışılmalıdır.

Amaç: Bu çalışmanın amacı diş köklerine yerleştirilmiş üç farklı postun ağız içinde oluşabilecek makaslama kuvvetlerine karşı kırılma dayançlarının değerlendirilmesidir.

Gereç ve yöntemler: Çalışmada yeni çekilmiş 45 adet üst-kanin ve santral diş kullanılmıştır. Dişlerin kron bölümü mine-sement birleşiminin 1mm üzerinden kesilerek uzaklaştırılmıştır. Kök kanalları lateral kondensasyon tekniği ile guta perka ve AH-26 kanal dolgu maddeleri kullanılarak doldurulmuştur. Çalışmada Flexi-Post, Cosmopost ve FRC Postec post sistemlerinden 15 er adet örnek kendi drilleri ile dişlerde açılmış yuvalarına yerleştirilerek hazırlandı. Postların yapıştırılmasında düşük vizkoziteye sahip dual cure kompozit siman kullanıldı. Hazırlanan örnekler akrilik rezin kullanılarak çelik manşet içine alındı. Postların üzerine standardize edilmiş core materyali uygulandıktan sonra manşetler 45 derece açıyla Lloyd test cihazına yerleştirildi. Örneklere test cihazında 1mm/dakika hızla kuvvet uygulandı. Uygulanan makaslama testi sonucunda her örnek için kırılma kuvveti değerleri kaydedilerek istatistiksel değerlendirme yapıldı.

Sonuç: En fazla dayancı Flexi-Post gösterdi. İkinci derecede dayancı FRC Postec gösterirken en az dayancı da Cosmopost gösterdi. Ancak yapılan değerlendirmede her üç post sisteminin de ağızda oluşabilecek kuvvetlere karşı yeterli dayancı gösterebileceği ve klinik olarak kullanılabileceği sonucuna varıldı.

Anahtar kelimeler: post ve corelar, post sistemi, prefabrike post sistemleri

INTRODUCTION

A tooth that maintains crown integrity with no structural defects has sufficient strength against masticatory forces. However, if a certain tooth has undergone root canal treatment because of trauma or caries, its dentin integrity would be weakened due to excessive loss of material and cannot provide sufficient strength against functional forces. Supporting such a tooth with a post system ensures that the tooth survives in mouth. ([1,2])

Endodontically treated teeth with excessive loss of material in the crown section are observed to suffer more fractures against functional forces in comparison to vital teeth.([2,3]) It has been shown in literature that stress resistance of these teeth decreases while brittleness increases, both caused by insufficient moisture and material loss in dentin. ([2])

Tooth supported crown and bridge prostheses have biomechanical and physiological advantages over mucosa-supported prostheses. Therefore, oral rehabilitation based on tooth-supported occlusion is preferred. Most significant benefits include masticatory muscle efficiency and tooth stabilization, as well as preservation of vertical size and supporting tissue. Therefore, even when excessive crown destruction is observed, remaining tooth structure utilization should be maximized.([4])

Endodontically treated teeth may have lost a significant portion of their existing crown structure due to an access cavity, an existing restoration, or caries, which is the biggest cause of endodontic problems. In many cases, crown section support from root canals may be required to ensure durability and retention of restoration. Post and core system proves to be significant among methods used for this purpose.([5])

Problems may arise in the treatment of excessively tapered and wide canals caused by incomplete root development, endodontic restorations, pulp pathologies, caries, or idiopathic reasons. Utilizing traditional, tapered, or cast posts may cause fractures in the coronal section, already weakened by wedge effect. Crown restoration conducted by supporting the weak root through the canal with appropriate adhesives and post-core procedures may help prolong teeth functionality in the mouth. Many researchers have advocated that composite resins are similarly suitable materials for core and post construction as well as traditional metallic root posts, and reported successful results.([6])

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This study was planned to compare the resistance of traditional prefabricated metal post systems, glass fiber-based post systems and ceramic post sytems used to support root canals with excessive crown destruction as a result of caries or endodontic treatment, against the forces that they may be exposed to during function in the mouth.

MATERIAL AND METHOD

The research was carried out in Ankara University Faculty of Dentistry Department of Prosthodontics and Özdemir Dental laboratory.

In this study, post material reinforced with glass fiber (FRC Postec, Ivoclar-Vivadent, Schaan, Lichtenstein), a non-metallic ceramic post material preferred for aesthetic purposes (Cosmopost, Ivoclar-Vivadent, Schaan, Lichtenstein) and a prefabricated metal post material (Flexi-Post, Essential Dental Systems, NewYork, USA) were used, and their strength was investigated by shear test in vitro conditions. (**Fig. 1, 2, 3**)

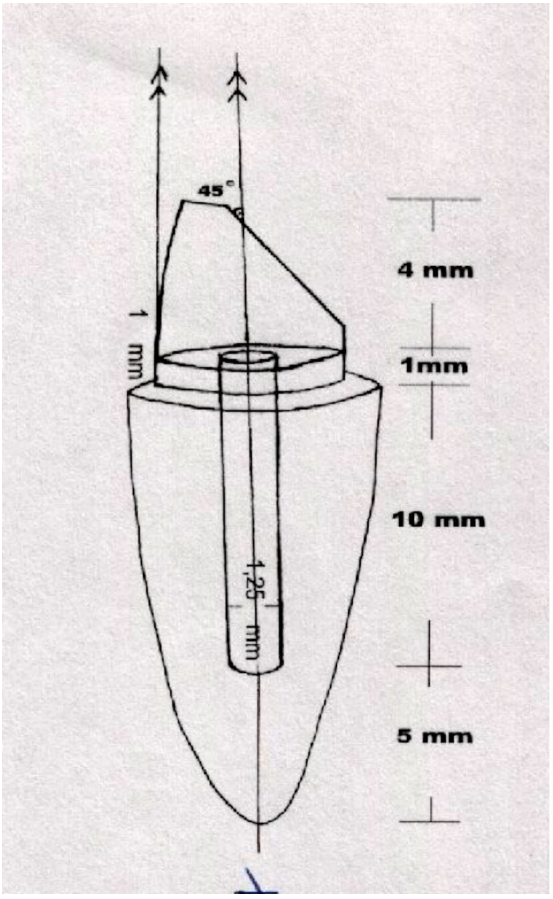

Figure 1. Schematic drawing of prepared tooth samples

Figure 2. a- Acrylic bottom alignment model

b- Top view of brass adapter

c- Side view of the brass adapter

d- Side view of the steel cuff

e- Top view of steel cuff

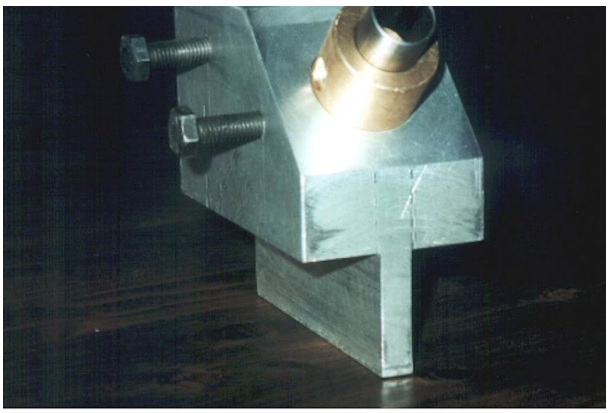

Figure 3. Aparatus, brass adaptor and steel ring

A- Preparation of Test Samples:

In the study, 45 newly extracted maxillary central incisors and maxillary canine teeth were used. The teeth were extracted within last 24 hours, and their pulps were extirpated as soon as they were extracted to prevent dehydration, ensuring that they were preserved in a buffered formol solution. Tooth selection was carried out carefully ensuring that root sizes were close to each other; excessively long and short roots were excluded from the study. Teeth with an average root length of 16 mm, a bucco-lingual diameter of 7 mm, and an average of 6 mm mesio-distal were included in the study. Roots were examined at x4 magnification and teeth with cracks were excluded from the study. During the experiment, gloves and masks were used against the risk of cross infection.

Forty-five maxillary central incisors and maxillary canine teeth were randomly divided into three groups of fifteen. The teeth were kept in buffered formol solution at room temperature until experiment phase.

Selected teeth were cut at 1 mm coronal of enamel - cement junction with a diamond separator under water cooling, and the crown and root sections were separated from each other. The canals were enlarged by step-back method, starting from 1 mm coronal of the foramen apical and master apical file 40 by circumferential filing with K-type files (Roeko, Germany). 2.5% NaOCl was used as irrigation solution while expanding the channels. Utmost attention was paid to ensure that the amount of dentin remaining in the coronal of the tapered root canal space created during the expansion process was equal to each other. For this purpose, at least 1 mm of dentin was left by using caliper.

After root canal preparation was completed, canals were washed a last time with distilled water. It was dried with air spray and paper cones (Roeko, Germany). Canals were completely filled with AH-26 (Dentsply, Germany) paste and gutta-percha (Roeko, Germany) using the lateral condensation method.

After canals have been filled, the post cavities were prepared. Gutta-percha was removed using endodontic plugger with heat technique. A 5 mm canal filling was left at the apical part of the teeth.

A 1 mm deep and wide right angled shoulder margin preparation was made by using a 1 mm diameter diamond fissure bur and an aerotour to provide a ferrule effect on the cervical region of the tooth. (**Fig. 1**)

An acrylic block (**Fig. 2a**) was cast to facilitate the connection to parallelometric milling device (Mariotti C. & SnC., Forli, Italy) and a brass adapter (**Fig. 2 b, c**) prepared for inserting steel ring was placed in the middle of the acrylic plate and waited for polymerization. Polymerized acrylic model and brass adapter were fixed onto the same plane with screws after the lower plane of the parallelometric milling device was fixed magnetically. After the cuff was attached to the brass adapter, autopolymerizing acrylic (Acrybel, Türkiye) was poured into 1 mm thick, 19 mm in diameter, and 20 mm high steel cuffs (**Fig. 2 d, e**), which were previously prepared and covered with stretch foil. The teeth were attached to lentulo, and lentulo to the handpiece of parallelometric milling device, and the autopolymerizing acryl was embedded without hardening, at a right angle to the cuffs placed parallel to the ground plane in paralometric milling device, up to the enamel dentin junction, that is, up to the line where the step starts. Thus, in a position perpendicular to the ground plane, long axes of the teeth were standardized and placed in the cuff.

Preparation of Flexipost Group Samples:

Following the hardening of autopolymerizing acrylic, 10 mm cavities were drilled into 15 teeth with two burs of Flexipost set at 2000 rpm without losing their position. By using a parallelometric milling device, each was placed in the same position and post spaces were prepared in the same position. As soon as the samples were prepared, they were thrown into the buffered formol solution to prevent dehydration.

Root canals were then dried with a paper cone and oil-free air just before the posts were placed. After 15 seconds of acidification with Total Etch (Ivoclar-Vivadent, Schaan, Lichtenstein), the root canal was removed from acid with pressurized steam (Pressthern, Bego, Germany) for 10 seconds. Afterwards, the root canal was dried with a paper cone and oil-free air and made ready for 10-second Syntac Primer (Ivoclar-Vivadent, Schaan, Lichtenstein) and 15-second Syntac Adhesive (Ivoclar- Vivadent, Schaan, Lichtenstein) applications. After these procedures, Variolink II Low Viscosity (Ivoclar- Vivadent, Schaan, Lichtenstein) adhesive resin cement, mixed with a spatula for 15 seconds without air gaps and applied to both the canal and post surface with the help of a lentulo, was applied to each Flexi-Post post with a compression appliance, and screwed into the canal after that. Flexi-Post posts with a diameter of 1.4 mm and a length of 14.5 mm were used. Excess cement was cleaned with a brush, and the cement was hardened via shining a light source from occlusal (Translux, Kulzer, Germany) for 60 seconds. Samples ready for Core application were connected to parallelometric milling device again. Core material Coradent (Ivoclar- Vivadent, Schaan, Lichtenstein) was mixed with a plastic spatula on a paper pad with slow and circular movements at a ratio of 1/1 and made ready for application. A metal crown was prepared to match the acrylic tooth prepared in predefined proportions. Coradent self-cure composite core material, placed in the handpiece of the paralometric milling device in the same direction and filled in the crown insulated with silicone oil, was applied on the posts. All this effort ensured that the core structure was standardized in terms of placement angle and volume. Excessively incompatible sections of the core structure on the margin preparation were cleaned with aerotour and diamond bur without damaging the step and main structure. Finally, thermal cycles were applied to prepared samples manually at 5-37-55 ºC 100 times.

Preparation of Cosmopost Group Samples:

Post cavity preparation, bonding, core and thermal cycle applications in Cosmopost group samples are the same as Flexi-Post group samples. The only difference was shortening 20 mm Cosmopost down to 14,5 mm using a diamond disc after the bonding process, and core application was started after this process. Cosmopost posts 1.4 mm in diameter and 20 mm in length (shortened to 14.5 mm) were used in our study.

Preparation of FRC Postec Group Samples:

Post cavity preparation, bonding, core and thermal cycle applications in FRC Postec group samples are the same as Flexi-Post group samples. FRC Postec posts 1.5 mm in diameter and 15 mm in length were used.

B- Preparation of the Test Setup:

In order to carry out shear-compression rupture tests, the apparatus that allows the samples to be positioned and connected to the test device was prepared from steel in the dimensions given. (**Fig 3,4**)

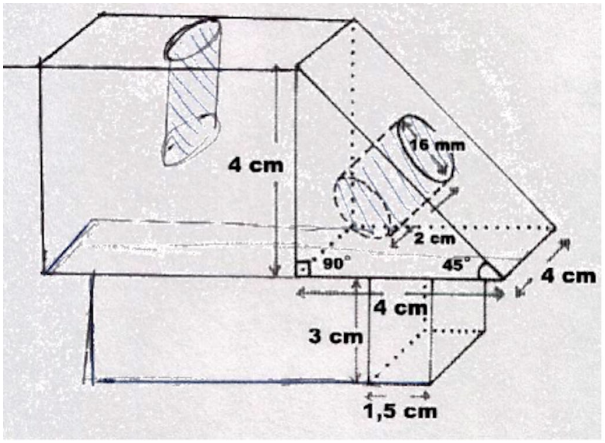

Figure 4. Schematic drawing of adaptör

C- Test technique:

The steel ring in which the specimens were placed were fixed with a screw to the 45 degree section of the apparatus made for adaptation to the test device (Lloyd LRX, England) where the shear-compression rupture test would be conducted. Then, force was applied under pressure set at 1 mm/min until fracture occurred and shear-compression rupture test values were recorded for each sample.

D- Statistical evaluation:

The results obtained from the experimental samples were grouped and listed in a table, and variations were determined by statistical evaluation. One-way analysis of variance (one-way ANOVA), Levene test, Kruskal-Wallis test, Bonforonni correction and Mann-Whitney U tests were conducted for this purpose.

RESULTS

In our study, compression shear rupture values of FRC Postec, Cosmopost, and Flexipost groups are given in Table 1, and graphic examples of the minimum and maximum fracture values are resulted.

Median, standard deviation, standard error, minimum and maximum values and number of samples for the groups according to one way analysis of variance (One way ANOVA) are given in **Table 1**.

Table 1. Statistical Values (Newton) for FRC Postec (P), Cosmopost (C) and Flexipost (F) Groups

	Average	Median	Standard Deviation	Standard Error	Minimum	Maksimum	Sample Size
Group P	270,41	437,82	46,1016	11,9034	195,67	338,83	15
Group C	213,046	217,73	28,1279	7,2626	151,94	251,75	15
Group F	426,316	437,82	69,7451	18,0081	305,62	535,65	15

According to One Way Analysis of Variance (One way ANOVA), limits within 95 % confidence interval are resulted.

Examination of refraction value distribution according to the groups revealed that variances were not homogeneous according to the Levene Test (L= 7.404, p=0.002).

"Kruskal-Wallis Analysis of Variance" test, nonparametric equivalent of analysis of variance, was utilized. The results are shown in **Table 2**.

Table 2. Results of Kruskal-Wallis Analysis of Variance

Group (Fracture Test)	Sample Size	Sequence Number Average	x	P
FRC Postec Group	15	20,73		
Cosmopost Group	15	10,6	32,525	0,0001
Flexipost Group	15	37,67		

According to this, the difference between the groups in refraction values was determined to be significant (Chi-square x2= 35,525, p=0.0001).

Since the difference between the groups was significant, comparisons were made after "Mann-Whitney U" test and "Bonforoni" correction were made in pairs.

Comparison between Flexipost and FRC Postec groups gave the results in **Table 3**, and it was determined that the difference in fracture values between Flexipost group and FRC Postec group (U=5.00, p=0.0001) was significant.

Table 3. Comparative statistical results of Flexi-Post and FRC Postec

Group	Sample Size	Sequence Number Average	Sequence Number Sum	U	P
Flexipost	15	22,67	340	5	0,0001
FRC Postec	15	8,33	125		

Comparison between Flexipost and Cosmopost groups gave the results in **Table 4**, and it was determined that the difference in the fracture values between Flexipost group and Cosmopost group (U=0.00, p=0.0001) was significant.

Comparison between FRC Postec and Cosmopost groups gave the results in **Table 5**, and it was determined that the difference in refraction values between FRC Postec group and Cosmopost group (U=39.00 , p=0.002) was significant.(**Fig.5**)

No root fractures were observed during the tests. It was observed that the posts were either fractured in the cervical region, or did not break by flexing. Especially FRC Postec post system did not suffer any fractures. However, it was also observed that the post cracked vertically within itself from the middle of the post towards the root canal.

Table 4. Comparative statistical results of Flexi-Post and Cosmopost

Group	Sample Size	Sequence Number Average	Sequence Number Sum	U	P
Flexipost	15	23	345	0	0,0001
Cosmopost	15	8	120		

Table 5. Comparison of FRC Postec and Cosmopost

Group	Sample Size	Sequence Number Average	Sequence Number Sum	U	P
FRC Postec	15	20,4	306	39	0,002
Cosmopost	15	10,6	159		

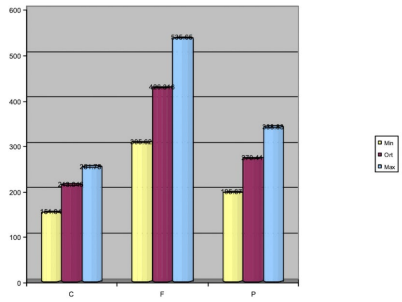

Figure 5. Graph showing the minimum, maximum and average refractive values of the samples (F=Flexi-Post, C=Cosmopost, P=FRC Postec)

DISCUSSION

Despite numerous studies on materials and preperation techniques for posts and cores, there is no consensus. Despite the recent developments in casting techniques, post and core stages of casting take time, require additional appointments, and increase costs. However, both cast and prefabricated posts are used today according to the characteristics of clinical cases.([7,8]) In cast posts, canal undercuts may prevent adaptation. However, in prefabricated posts, undercuts are used for retention and unnecessary material loss is prevented.([8]) Positive casting defects and air gaps are some of the disadvantages of cast posts in terms of stress area and wedge effect, which are not suffered by prefabricated posts. Sorensen and Martinof reported that the biggest failure was in short-length posts, because of a number of reasons including insufficient measurements, yet root canal cavity was easier to prepare in prefabricated posts.([9]) These conditions encourage physicians to produce prefabricated posts. In many cases, the possibility of excessive material loss in coronal region may increase, because in prefabricated posts, a suitable canal is prepared for the post instead of a post suitable for the canal. ([7]) If root canal cross-section is elliptically tapered as opposed to circular, or if material loss is high, cast posts are often preferred. ([10-12]) Techniques using fabricated posts have been standing out in recent studies.([13])

Advantages of prefabricated non-metal posts include use of resins to ensure maximum adaptation of the post onto the canal, and reduced number of sessions and laboratory procedures. FRC Postec and Cosmopost systems, the post systems we used in our research, also have these features.

Studies on Flexi-Post, one of prefabricated posts, determined that Flexi-Post is the most retentive, and delivers sufficient stress distribution in comparison to other metal posts used. ([14,15]) Our study also favoured Flexi-Post and tested due to its retentive properties and stress-distributing structure.

Application of Flexi-Post creates threads in canal. Studies have shown that shortening the last three screw threads on apically may lead to a significant decrease in Flexi-Post retention. ([14,15]) Accordingly, Flexi-Post was not shortened at all. However, both other post systems have gone through shortening; Cosmopost has been shortened from coronal section, and FRC Postec was shortened as well.

Metal posts, and especially those used with metal cores, can lead to fracture as they are corroded by galvanic current in the mouth. ([16]) However, Fovet et al. reported that non-metal posts did not have corrosive properties in the presence of galvanic current and oxygen. ([17]) This is one of the basic principles behind choosing non-metallic posts as an alternative to metal posts in our study.

One of the biggest causes of vertical root fractures is excessive expansion of the root canal cavity diameter for a larger post. ([6]) Trabert reported that root fractures are less common in small diameter posts. ([18]) The posts used in our study are also 1.4 mm in diameter.

According to Goldman, surface shapes of the post are more important than the length, and the parallel-sided is more retentive than tapered, and serrated one is more retentive than the one with a smooth surface. ([19]) It was also reported by the same author that the length of the post is more important than the diameter, and the change in diameter does not make a significant difference in retention. Despite this, achieving standardization was attempted by choosing posts similar in diameter and length for the study.

Following acidification of dentin, the resin material is mechanically locked into the opened dentin canals, thereby strengthening the tooth structure in the cervical and coronal regions. Filling the root canal and access cavity with composite resins provides an effective way to increase tooth fracture resistance in wide root canal teeth. ([20])

When evaluated in terms of form, it has been reported that threaded posts have the highest strength, serrated posts are the second, and tapered posts are the weakest. ([21]) It is reported that parallel-edged threaded metal posts have the best retention and stress distribution attributes among prefabricated posts. Many researchers have reported that the diameter of the post is insignificant in retention, yet the length of the post is important. ([22]) Posts of the same length were prepared and used in our study. However, it was observed that both tapered non-metal post systems which we used were weaker than the metal threaded system in diagonal forces, but were sufficiently resistant to the forces that may occur in the mouth despite this deficiency.

When the research findings were evaluated, Flexi-Post demonstrated the highest resistance against fracture. In a study conducted with Flexi-Post, it was reported that Flexi-Post gave preferable results compared to systems with non-metal and composite cores. ([23]), in the study conducted with active Flexi-Post and passive posts, strength of active posts was better against torsional forces. ([24]) In the study where Flexi-post was compared with cast and passive-tapered posts, it was reported that Flexi-Post caused horizontal root fractures and others caused vertical root fractures. Many studies that have similar results with our study are reported in the literature. ([25-32])

The fiber-reinforced FRC Postec system showed the second highest anti-fracture value among research groups. This finding shows similarities with the results obtained with fiber reinforced post systems in the literature. ([33, 34])

The fact that the fracture values of the fiber reinforced prefabricated post system we tested in our study were higher than the ceramic prefabricated post system matches the results reported by Vigule *et al*. ([34]) Vigule *et al*. reported that fiber reinforcement gave the composite a strength value of 55%. ([34]) Both ceramic and fiber reinforced posts we used in our study have smooth surfaces. Posts have a smooth surface except for the Al_2O roughening applied for micro retention. Purton and Payne reported that fibers with smooth surfaces were more rigid than rough ones. ([33]) The same researchers, in line with the results of our study, reported that metal posts were more durable and better connected with the composite core, but fiber composites also had sufficient stiffness and core retention for their intended use. Sirimai *et al*. reported that polyethylene mesh fiber posts had the weakest resistance to diagonal forces, but were still suitable for use in the mouth and did not cause any fractures in the root. In our study, similar findings were achieved, and it was determined that glass fibers were more durable than posts with similar properties, and their fracture or ductility values were sufficient. ([35])

The fact that it gives acceptable results with its tested features, when combined with its known aesthetic advantages, shows that glass fiber reinforced prefabricated post systems such as FRC Postec can be used comfortably in the clinic as well as other systems. Another emerging advantage is that the same post system absorbs the force within itself without breaking the tooth with forces. It is thought that the resin cement used and application under suitable conditions have an effect on this, as in the others. ([21])

In our study, the lowest value against fracture was obtained in Cosmopost system. Cormier et al. reported in their study that ceramic posts are more brittle and less flexible than fiber posts. ([36]) The mechanical value obtained for ceramic posts highlights the necessity of evaluating the mechanical properties as well as aesthetic advantages in the selection of clinical materials.

In our study, root fracture was not observed in any specimen with FRC Postec (a fiber-reinforced resin-based post) application. However, 12 of the 15 samples had their core structures broken, and no horizontal separation was observed in the posts, while vertical separations were observed within the structure of the post itself. In the remaining three samples, it was determined that the post, together with the core structure, was separated from the root surface and broke off. While conducting shear rupture test in the laboratory, after a certain stretching time in the fiber post group, it was determined that the post showed significant stretching with core structure compared to ceramic or metal post group before the rupture was observed.

Composite resins are high strength materials, and they can be used in devital teeth both to create core structure and support tooth structures. Treatment of defects in critical areas with classical methods can weaken tooth structures and showed root fractures. Root and coronal regions are strengthened with the composite used to restore teeth with weak coronal regions, and the tooth survives. ([6, 37]) Thus, fracture resistance also increases. ([6, 20]) Filling the root canal and access cavity with composite resins provides an effective way to increase fracture resistance of the tooth. Based on the consensus of the researchers that using composite resins as core material is sufficient in post-core restorations, a hybrid-based core material was also used in our study. ([20]) Chemically polimerizing type was chosen as core material, because the crown is metal, allowing us to standardize it in terms of shape and position by being attached to the paralometer device. Because it is not possible to pass light through metal. In addition, since the application of light-cured composite core materials in layers will prevent standardization of the core shape in prepared tooth form, chemically polimerized core material was chosen in our study.

Greenfeld *et al*. reported in their study where they applied diagonal forces that composite cores can provide sufficient strength in intraoral use. ([30]) Sidoli et al. also reported that composite posts and cores are weaker than gold post-cores, but with sufficient durability. ([38])

Burgess *et al*., on the other hand, found that all four systems they used in their studies with prefabricated posts and composite cores were sufficiently durable against diagonal forces. ([25]) In a similar study, Cohen et al. found that all posts whose superstructure was shaped with composite cores except amalgam and glass ionomer cores were successful. ([15])

Patel et al. reported that partial cores prepared on cast posts were less retentive than full cores, and in their diagonal forces study they demonstrated that cores with buccal walls showed the least durability, and full-core samples showed the most durability. ([39]) One of the main reasons for choosing the full core form in our research was this study.

The ferrule effect is more important than the material in core creation. As long as the ring form is not established, resistance against fracture will not be sufficient. Ring form significantly increases the durability of the post, restoration, and tooth. In addition to these, the ring has a significant contribution to cement solubility. ([13])

Mendoza *et al*. performed mechanical tests by leaving the prepared dentin walls 2 mm above the acrylic resin. ([40]) The purpose here can be interpreted as imitation of periodontal tissues. Teeth should be chosen very carefully due to high standard deviation and wide distribution values in mechanical test studies. The fact that the teeth were chosen from maxillary anterior region in our study is due to their ideal candidacy for post applications in terms of root length and width. ([13])

The system we created in our study; Posts were completed by supporting coronal and apical tissues with composite resin adhesive cements and core material. Conducted experiments demonstrated no root cracks or fractures in any direction, except for insignificant breaks in the 1 mm ring section.

Thanks to recent developments in dentin bonding agents and techniques, dentin surface preparation, smear layer removal or modification, increasing retention with a primary bonding agent, appropriate bonding material and resin cement usage has led to significant advances in post systems that can be bonded onto tooth surface. ([41]) In their study with Luminex Post System applied with and without a dentin adhesive system, Tjan et al. found that lowest retention group was bonded without adhesive. ([42]) It was reported in a study that apical and coronal leakage decreased in root canals filled with resin cement and bonding agents. Resin cement may deform under lateral masticatory forces. However, restorative resin composites can be used in intracanal restoration, and are not affected by this type of deformation with their elasticity modules close to dentin. ([41])

Utilizing glass ionomer cement, which can also establish chemical bonds with hard dental tissues, is also recommended for post bonding. In one study, retention of modified glass ionomer cement and resin cement was found to be higher than other adhesive cements in the tensile test. ([43]) However, their mechanical and physical properties are not as good as composites. ([6, 19, 40, 44]) While Mendoza reported composite resin cement manipulation difficulties, in our study no difficulties were encountered in composite resin cement application. ([45])

Another study reported that posts bonded with composite resin cement provide more retention than cements bonded with other adhesive cements. ([46]) In our study, dual cure composite resin cement was used due to easy application and superior bonding properties. According to the ADA specification, resin cement has a compression strength of 30,000 psi, and this value can be considered sufficient as they are higher than the minimum required value of 12,000 psi in cements used in posts. ([47])

The reason why dual cure resin cement was chosen for cementation of posts in our study is the recommendation of such a cement for FRC Postec and Cosmopost post systems. These cements are also recommended for bonding in shaping the core structure.

In a study investigating the retention of posts bonded with 4-meta-molecule bonding, C-B Metabond and Panavia, C-B Metabond was the material that provided the highest retention. The 4-meta system can provide a strong bond with non-noble dental alloys because the Cr element they can contain form a stable oxide layer even at the smallest concentrations of oxygen. Another advantage is that it reduces microleakage due to chemical adhesion. ([40])

Failure can be minimized by appropriate cement selection and application. ([13]) Cement fatigue caused by forces in the mouth and related dentin separations are the primary causes of cementation failure. In addition, appropriate mechanical properties of adhesive cements provide the most suitable conditions for distributing the force reaching through the post. ([16, 45])

If the adhesive cement loses its properties and posts are not completely dislodged during force application, the root is at risk of further fracture. ([45]) Despite this, in our study, posts were not completely dislodged, and no root fractures were encountered.

While the modulus of elasticity of resin cements is 3.5GN/m^2, that of dentin is 14GN/m2. ([32]) The modulus of elasticity of dual cure composite resin cement we used in our study is 8.3GN/m^2. No root fractures were observed in our study, and one of the primary reasons of this is considered to be the possibility of using adhesive cement with a modulus of elasticity close to the elasticity of dentin.

The reason behind the preference towards the paste with AH-26 in the study is that it does not contain eugenol. The adhesive resin chosen as the eugenol bonding agent causes deterioration in polymerization and structure of the cement. ([13])

Several post length determination methods have been suggested in studies. ([48]) However, since the common presumption is 2/3 of root length, we also created our system.

Application of rotating instruments at 2000 rpm in canal filling discharge was reported as the best technique by Saraç. ([2]) In general, neither of the techniques where the canal filling is emptied to create a cavity is superior to another. However, researchers often prefer mechanical method. ([49]) In our study, root canals were mechanically drained at 2000 rpm as suggested by Saraç. ([2])

Some studies suggest that post-core restoration tests should be supported by crown restoration regarding similarity to the clinical situation. ([50]) In another group of studies, samples without crown were applied in order to apply the force to core or post, and to reduce more parameters such as crown restoration form, content and adhesive. ([20]) We planned our study by directing the force to the core and the post without applying the crown, with support from literature clarifying that core application for post strength will lead to adequate in vitro results. ([20, 49, 50])

In vitro methods are mostly used to investigate retention and mechanical strength of post cores. Tests on plastic models provide standardization and eliminate extraction damage, but this type of analogues cannot provide dentin properties. ([51]) Therefore, newly extracted human teeth were used in our study. Utmost care was shown to ensure that the teeth were extracted within the last 24 hours. It was observed that there is not much difference in fragility of teeth that have undergone root canal treatment, where there is no substance loss, compared to vital teeth. Studies have reported that there is a 9% difference between devital and vital teeth in terms of free water, but no difference in terms of hydratation. ([14, 20, 52-54]) For this reason, in vitro study was preferred considering the ease of study. In our study, in order to minimize the change caused by dehydratation, as soon as teeth were extracted, pulps were extirpated and preserved in a buffered formol solution, aiming to standardize the teeth in terms of dehydratation.

To imitate the contact angle of diagonal force, 135 degree angle, which is also the occlusion angle, was acquired through a mechanism set as part of the study. ([9])

Several studies, while investigating impact of post placement style or post type on root fractures, apply forces on post or core material. ([20, 40, 45, 55, 56]) In literature, varying forces have been applied at speeds varying between 3-50 mm/min. Our study opts utilizing 1 mm/min, the most commonly preferred speed level for chear rupture test. ([15, 40, 45, 55, 57, 58])

Since the forces formed in the mouth vary between 200-1000 N values, ([6]) and the average fracture values of post systems we investigated are above 200 N, it can be concluded that all materials may be suitable for clinical use with their tested properties. ([22])

New post systems to be developed considering tooth physiology will be able to ensure healthy functionality for established system and protection of the tooth at the highest level. In our study, high figures of shear fracture values obtained from metal posts and the absence of root fractures in any of the samples were encouraging, especially to utilize these posts in posterior group teeth, where aesthetics is not at the forefront.

In fiber posts, stretching observed in many examples before the core structure is separated and separations that occur within its own structure due to root fractures, and mechanical values reached at the stage where these separations are observed are smaller than forces that may occur in the clinic, will ensure that they can be used more safely, especially in the weaker anterior group teeth.

Examination of the findings of this in vitro study with further tests and supporting it with controlled clinical studies will enable us to obtain safer and more successful results in our applications on our patients.

CONCLUSION

In the evaluation of the shear rupture response of post-core systems consisting of prefabricated split shank threaded metal post + composite core (Flexi-Post), prefabricated fiber reinforced tapered smooth surface non-metal post (FRC Postec) + composite core and prefabricated tapered non- metal post (Cosmopost) + composite core, all of which were prepared using the same techniques and preparations using the same core material and adhesive cement;

Flexi-Post core system (average 426,3160 N), Cosmopost (average 213.0460 N), FRC Postec (average 270.4100 N) values were obtained.

When the findings were evaluated statistically, the difference between each post system in pairs was found to be significant. According to this:

- Flexi-Post is more durable than Cosmopost,

- Flexi-Post is more durable than FRC Postec,

- FRC Postec is more durable than Cosmopost.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu çalışma danışmanlığın 2002 tarihinde tamamladığım "In Vıtro Evaluatıon of The Resıstance of Three Dıfferent Post Systems Agaınst Functıonal Forces Üç Farklı Post Sisteminin Ağız İçinde Oluşabilecek Kuvvetlere Karşı Dayancının in Vitro Değerlendirilmesi" başlıklı yüksek doktora tezi esas alınarak hazırlanmıştır.

Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

This article is the version of the presentation named ".....", which was presented orally at the ..... Symposium, but whose full text was not published, by improving and partially changing the content.

This study has been prepared on the basis of the doctoral thesis titled "In Vıtro Evaluatıon of The Resıstance of Three Dıfferent Post Systems Agaınst Functıonal Forces Üç Farklı Post Sisteminin Ağız İçinde Oluşabilecek Kuvvetlere Karşı Dayancının in Vitro Değerlendirilmesi" which we completed on 2002 under the supervision of Dr Mustafa KOCACIKLI.

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

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Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: HY (%35), EK (%35), YAÖ (%30)

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Veri Analizi | Data Analysis: HY (%40), EK (%35), YAÖ (%25)

Makalenin Yazımı | Writing up: HY (%40), EK (%35), YAÖ (%25)

Makale Gönderimi ve Revizyonu | Submission and Revision: HY (%40), EK (%35), YAÖ (%25)

KAYNAKLAR / RESOURCES

1. KEYF F. Flexi-Post'un Çekme ve Basma Kesme Kuvvetlerine Karşı Retansiyonunun Diğer İki Prefabrik Post- Core Sistemiyle Karşılaştırılması. (thesis) Ankara: Hacettepe Üniv.; 1990.
2. SARAÇ ŞY. İki Farklı Kanal Dolgu Patı İle Doldurulmuş Dişlerde Değişik Post Boşluğu Hazırlama Yöntemlerinin Apikal Sızdırmazlığa Etkisinin Spektrofotometrik Yöntem İle İncelenmesi. (thesis) Ankara: Hacettepe Üniv. ; 1995.
3. TJAN AHL, ABBATE, MF. Temperature Rise at Root Surface During Post Space Preparation. J Prosthet Dent. 1993;69:41-5.
4. AKKAYAN B, CANİKLİOĞLU, M. B. Farklı Post Tiplerinin Kök Kırıklarına Etkileri ve Post Seçim Kriterleri. Hacettepe Dişhekimliği Dergisi. 1997;21:75-84.
5. MORGANO SM, Mılot P. Clinical Success of Cast-Metal Posts and Cores. J Prosthet Dent. 1993;70:11-6.
6. YOLDAŞ HO. Aşırı Harabiyet Gösteren Diş Köklerinin Işık İleten Post Sistemiyle Restore Edilmesi. (thesis) Ankara: Gazi Üniv; 1998.
7. DESORT KD. The Prosthodontic Use of Endodontically Treated Teeth; Theory and Biomechanics of Post Preparation. J Prosthet Dent. 1983;49:203-6.
8. ZIEBERT AJ, DHURU, V. B. The Fracture Toughness of Core Materials. J Prosthet Dent. 1995;4:33-7.
9. Sorensen JA MJ. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. J Prosthet Dent 1984;51:780-4.
10. INGLE JI, TEEL, S., WANDS, D. H. Restoration of Endodontically Treated Teeth and Preparation for Overdenture. Philadelphia: Lea & Febiger; 1994.
11. REOSENSTIEL SF, LAND, M. F., FUJIMOTO, J. Contemporary Fixed Prosthodontics. 2 ed. St. Louis: Mosby Co.; 1995.
12. RUEMPING DR, LUMD, M. R., SCHIRNEL, R. J. Retention of Dowels Subjected To Tensile and Torsional Forces. J Prosthet Dent. 1979;41:159-63.
13. ALAÇAM T, NALBANT, L., ALAÇAM, A. İleri Restorasyon Teknikleri. 1 ed. Ankara Polat Yayınları; 1998.
14. COHEN BI, CONDOS, S., MUSIKANT, B. L., DEUTSCH, A. S. Retention Properties of a Splint Shaft Threaded Post Cut at Different Apical Lengths. J Prosthet Dent. 1992;68:894-8.
15. COHEN BI, CONDOS, S., MUSIKANT, B. L., DEUTSCH, A. S. Comparison of Retentive Properties of Four Post Systems. J Prosthet Dent. 1992;68:264-8.
16. DEUTSCH AS, MUSIKANT, B. L., CAVALLARI, J., BENARDI, S. Retentive Properties of a New Post and Core System. J Prosthet Dent. 1985;53:12-4.
17. FOVET Y, POURREYSON, L., GAL, J. Y. Corrosion by Galvanic Coupling Between Carbon Fiber Posts and Different Alloys. Dental Materials. 2000;16:364-73.
18. TRABERT KC, CONNEY, J. P. The Endodontically Treated Tooth. Dent Clin North Amer. 1984;28:923-51.
19. GOLDMAN M, DE VITRE, R., PIER, M. Effect of The Dentin Smeared Layer on Tensile of Cemented Posts. J Prosthet Dent. 1984;52:485-8.
20. TROPE M, MALTZ, D. O., TRONSTAD, L. Resistance to Fractures of Restored Endodontically Treated Teeth. Endodon Dent Traumatol. 1985;1:108-11.
21. STANDLEE J, CAPUTO, AA., HANSON, EC. Retention of Endodontic Dowels Effects of Cement Dowel Length Diameter and Design. J Prosthet Dent. 1978;39:400-5.
22. DEUTSCH AS, MUSIKANT, B. L., CAVALARI, S., LEPLEY, J. B. Prefabricated Dowels a Literature Review. J Prosthet Dent. 1983;49:498-503.
23. COHEN BI, PAGNILLO, M. K., NEWMAN, I., MUSIKANT, B. L., DEUTSCH, A. S. Retention of a Core Material Supported by Three Post Head Designs,. J Prosthet Dent. 2000;83:624-8.
24. COHEN BI, PENUGONDA, B., PAGNILLO, M. K., SCHULMAN, A., HITTELMAN, E. Torsional Resistance of Crowns Cemented to Composite Cores Involving Three Stainless Steel Post Designs,. J Prosthet Dent. 2000;84:28-42.
25. BURGESS JO, SUMMITT, J. B., ROBBINS, J. W. The Resistance to Tensile Compression and Torsional Forces Provided by Four Post Systems: Quintessence Int.; 1988.
26. COHEN BI, CONDOS, S., DEUTSCH, A. S., MUSIKANT, B. L. Fracture Strength of Three Different Core Materials in Combination with Three Different Endodontic Posts. Int J Prosthodont. 1994;7:178-82.
27. COHEN BI, CONDOS, S., MUSIKANT, B. L., DEUTSCH, A. S. Pilot Study Comparing the Photoelastic Stress Distribution for Four Endodontic Post Systems. J Oral Rehabil. 1996;23:679-85.
28. COHEN BI, PAGNILLO, M. K., CONDOS, S., DEUTSCH, A. S. Four Different Core Materials Measured for Fracture Strength in Combination with Five Different Designs of Endodontic Posts. J Prosthet Dent. 1996;76:487-95.
29. COHEN BI, PAGNILLO, M. K., NEWMAN, I., MUSIKANT, B. L., DEUTSCH, A. S. Retention of Three Endodontic Posts Cemented with Five Dental Cements. J Prosthet Dent. 1998;79:520-5.
30. GREENFELD RS, ROYDHOUSE, R. H., MARSHALL, F. J., SCHONER, B. A Comparison of Two Post-Core Systems under Applied Compressive Shear Loads. J Prosthet Dent. 1989;61:17-24.
31. LEPE X, BALES, D. J., JOHNSON, G. H. Tensile Dislodgement Evaluation of Two Experimental Prefabricated Post Systems. Oper Dent. 1996;21:209-12.
32. WILSON NH, SETCOS, J. C., DUMMER, P. M., GORMAN, D. G., HOPWOOD, W. A., SOUNDERS, W. P., HUGHLOCK, R. J., HUNTER, M. J. A Split Shank Prefabricated Post System; A Critical Multidisciplinary Review. Quint Int. 1997;28:737-43.
33. PURTON DG, PAYNE, J. A. Comparison of Carbon Fiber and Stainless Steel Root Canal Posts. Quint Int. 1996;27:93-7.
34. VIGULE G, MALQUARTI, G., VINCENT, B., BOURGEOIS, D. Epoxy Carbon Composite Resins in Dentistry; Mechanical Properties Related to Fiber Reinforcements. J Prosthet Dent. 1994;72:245-9.
35. SIRIMAI S, RIIS, D. N., MORGANO, S. M. An Invıtro Study of the Fracture Resistance and Incıdance of Vertical Root Fracture of Pulpless Teeth Restored with Six Post and Core Systems. J Prosthet Dent. 1999;81:262-9.
36. CORMIER CJ, BURNS, D. R., MOO, P. In vitro Comparison of the Fracture Resistance and Failure Mode of Fiber, Ceramicand Conventional Post Systems at Various Stages of Restorations. J Prosthet Dent. 2001;10:26-36.
37. LUI JL. A Technique to reinforce Weakened Roots With Post Canals. Endodon Dent Traumatol. 1987;3:310-4.
38. SIDOLI CE, KING, P. A., SETCHEL, D. J. An Invitro Evaluation of a Carbon Fiber Based Post and Core System. J Prosthet Dent. 1997;78:5-9.
39. PATEL A, GUTTEİDGE, D. L. An In Vitro Investigation of Cast Post and Partial Core Design. J Of Dentistry. 1996;24:281-7.
40. MENDOZA DB, EAKLE, W. S., KAHL, E. A. HO, R. Root Reinforcement with a Resin Bonded Preformed Post. J Prosthet Dent. 1997;78:10-4.
41. MOWAFY OME, MILENKOVIC, M. Retention of Paraposts Cemented With Dentin Bonded Resin Cements. Oper Dent. 1994;19:176-82.
42. TJAN AHL, TJAN, A. H., GREIVE J. H. Effects of Various Cementation Methods on The Retentive of Prefabricated Posts. J Prosthet Dent. 1987;58:309-13.
43. MANSFİELD B, GALLBURT, R., ABOUSHALA, A. Tensile Bond Strength Comparison for Endodontic Posts and Luting Agents. J Dent Res. 1997;76:69.
44. MORGANO SM. Restoration of Pulpless Teeth Aplication Of Traditional Principals İn Present and Future Contexts. J Prosthet Dent. 1996;75:379-80.
45. MENDOZA DB, EAKLE, W. S. Retention of Post Cemented with Various Dentin Bonding Cements. J Prosthet Dent. 1994;72:591-4.
46. WOOD WW. Retention of Posts in Teeth with Nonvital Pulps. J Prosthet Dent. 1983;49:504-6.
47. GOLDMAN M. An SEM Study of Posts Cemented With Unfilled Resin. J Prosthet Dent. 1984;63:1003-5.

48. SCHILLINGBURG HT, HOBO, S., WHITSETT, L. D., JACOBI, R., BRACKETT, S. E. Fundamentals of Fixed Prosthodontics. 3 ed. Chicago: Quıntessence Co.; 1997.
49. KWAN EH, HARRRİNGTON, G. W. The Effect of Immadiate Post Preparation on Apical Seal. J Endodon. 1981;7:325-9.
50. ASSIF D, FERBER, A. Retention of Dowels Using a Composite Resin as a Cementing Medium. J Prosthet Dent. 1992;48:292-6.
51. COHEN BI, PAGNILLO, M. K., CONDOS, S., DEUTSCH, A. S. Comparison of The Torsional Forces of Failure for Seven Endodontic Post Systems,. J Prosthet Dent. 1995;74:350-7.
52. CHARBENGOU GT. Principles and Practise of Operative Dentistry. 3 ed. Philadelphia: Lea & Febiger; 1998.
53. SHEETS C. Dowels and Core Foundations. J Prosthet Dent. 1970;23:58-67.
54. WALTON RE, TORABINEJAD, M. Principles and Practise of Endodontics. Philadelphia: W. B. Saunders Co.; 1989.
55. GUZY GE, NICHOLLS, J. I. In vitro Comparison of Intact Endodontically Treated Teeth With and Without Endo-Post Reinforcement. J Prosthet Dent 1979;42:39-44.
56. KANTOR ME, PINES, M. S. A Comperative Study of Restorative Techniques for Pulpless Teeth. J Prosthet Dent. 1977;38:405-12.
57. ASSIF D, BITENSKI, A., PILO, R., OREN, E. Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent. 1993;69:36-40.
58. STANDLEE JP, CAPUTO, A. A. Endodontic Dowel Retention with Resin Luting Systems. J Dent Res. 1994;70:446-8.