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Orginal Article

EFFECT OF FIBER BUNDLE POSTS USED IN DIFFERENT THICKNESSES ON FRACTURE RESISTANCE

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ABSTRACT

Objectives: *To evaluate in vitro the effect of three different thicknesses of traditional fibre posts and a novel canal post (bundle post) on the fracture resistance of restored teeth.*

Materials and Methods: *Ninety-two extracted single-rooted, single-canaled upper incisors were selected and prepared for endodontic treatment. The specimens were divided into six experimental groups (n=14 each) based on post type and thickness: Group I (Bundle Post 0.8 mm), Group II (Bundle Post 1 mm), Group III (Bundle Post 1.2 mm), Group IV (Fibre Post 0.8 mm), Group V (Fibre Post 1 mm), and Group VI (Fibre Post 1.2 mm). Additionally, two control groups were included: a negative control group (n=4, untreated healthy teeth) and a positive control group (n=4, canal prepared but unrestored). Fracture resistance was tested using an Instron device, and results were analyzed statistically.*

Results: *The negative control group showed the highest fracture resistance (2133.21 ± 317.42 N), significantly greater than the positive control group (1436.08 ± 334.31 N; $p < 0.05$). Among experimental groups, no statistically significant differences were observed based on post type or thickness ($p > 0.05$). For 0.8 mm posts, fracture resistance was 1211.14 ± 396.85 N (bundle) and 1276.42 ± 339.02 N (fibre); for 1 mm posts, 1355.49 ± 282.45 N (bundle) vs. 1271.86 ± 323.46 N (fibre); and for 1.2 mm posts, 1122.74 ± 311.50 N (bundle) vs. 1062.49 ± 163.10 N (fibre), all with $p > 0.05$.*

Conclusion: *The fracture resistance of teeth restored with bundle fibre posts of varying thicknesses was comparable to those restored with conventional fibre posts.*

Key words: *Bundle Post, Endodontic Treatment, Fibre Post, Fracture Resistance*

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INTRODUCTION

A plethora of factors have been identified as contributors to the outcomes of root canal therapy, including patient characteristics, tooth anatomy, microbiological agents, and procedural aspects of the treatment. Treatment-related factors include the utilisation of a rubber dam, inadequate or excessive canal preparation, the level of canal filling, and coronal filling leakage[1]. After endodontic treatment, it is extremely important to make a coronal restoration that will prevent the tooth tissues from cracking and prevent leakage. For the restoration of teeth that have experienced substantial material loss, a plethora of treatment options are available[2]. Following endodontic treatment, creating a core structure for the post and superstructure supported by the root canal is among the treatment options. Post systems are classified as cast/fabricated, metal, ceramic, ceramic, fiber posts.

In contemporary dentistry, fibre posts are the preferred choice of restorative material due to a number of factors. Firstly, they possess an aesthetic quality that is highly prized by dentists and dental technicians alike. Secondly, their modulus of elasticity is similar to that of dentin, thus ensuring a strong

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and reliable bond with the remaining tooth structure. Thirdly, fibre posts are easy to apply, even in difficult-to-reach areas, and they have low conductivity, which reduces the risk of thermal damage to the surrounding teeth. Finally, a novel method, termed "bundle posts", is also available as an alternative to fibre posts for the repair of teeth with significant material loss[3]. Preparation of the post cavity without removing more dentin for bundle posts and more homogeneous force distribution to the fibre bundle rods are among the important advantages[4,5]. Bundle posts are composed of multiple bundled thin fibres that are held together by a plastic sheath, in contrast to single tapered fibre posts. Rather than a single, large conventional pole, the canal area is lined with several strips of tiny, flexible poles[6]. The resultant structure exhibits a significantly higher degree of resistance to deformation prior to fracture in comparison to a postless or central post restoration. When the sheath is removed, the bundled fine fibres spread into the canal, adapt to the root canal anatomy and increase retention[7]. The parameters that have been demonstrated to influence post retention include canal anatomy, canal filling, post length and diameter, shape, surface characteristics, cement qualities, and cementation technique[8].

Depending on the loss of material in the teeth, posts of different thickness are used to ensure retention[9]. As with fibre posts, bundle posts have different thicknesses. However, there are studies showing that post thicknesses can cause vertical fractures in the tooth[10]. There is no study on the use of the new canal post, bundle fibre post, in different thicknesses to examine the tooth strength compared to conventional fibre post.

This study was conducted with the objective of evaluating the impact of a novel canal post (bundle post) and a conventional fibre post, in three distinct thicknesses, on the fracture resistance of restored teeth under in vitro conditions. The null hypothesis of this study is that there is no difference in the fracture resistance of teeth restored with a new type of canal post (bundle post) in three different thicknesses and those restored with a conventional fiber post.

MATERIALS AND METHODS

Utilising a sample of 92 single-rooted and single-channeled upper incisors exhibiting comparable root morphology, previously extracted for reasons pertaining to periodontal, orthodontic and prosthetic treatments (Incisors were extracted due to excessive alveolar bone loss). Based on the data from the study by Grieznis et al. (Grieznis, L., Apse, P., & Soboleva, U. (2006). The effect of 2 different diameter cast posts on tooth root fracture resistance in vitro. Stomatologija, 8(1), 30–32), the number of observations to be used in the study was calculated using an alpha level of 0.05 and a power coefficient of 0.95. Accordingly, the minimum number of samples required per group was determined to be 14, and a total of 92 samples, including the control group, was considered sufficient for the study. In accordance with the present study, teeth that exhibited the following characteristics were excluded from the study sample: perforations, fractures, cracks, incomplete root development, endodontic treatment and root resorption. Subsequent to this, mechanical elimination of the soft tissue and calculus from these teeth was performed. The compliance of this in vitro study with ethical principles was approved by the Non-Interventional Ethics Committee of Zonguldak Bülent Ecevit University with the report dated 27/12/2023 and numbered 2023/25. The teeth selected for this study were crowned and subsequently removed using a procedure involving the removal of 15 ± 0.5 mm of the root length from the enamel-cementum line with a diamond separator under hydrated conditions. Following the extraction of the pulp tissue, a #15 file was inserted into each root canal until its tip was observable at the apical foramen, and the canal lengths were determined through visual estimation.

The discrepancy between measured length and working length was found to be 1 mm. Endoart rotary files (Inci Dental, Istanbul, Turkey) up to size 35.04 were then used in order to carry out the root canal preparation. Irrigation of the channels involved the use of distilled water and NaOCl during file changes. The irrigation process was concluded with the use of NaOCl (2.5%) (produced by Werax, Izmir, Turkey), EDTA (5%) (produced by Werax, Izmir, Turkey), distilled water, and the channel was subsequently dried and filled with AH Plus (produced by DeTrey Dentsply AG, Zurich, Switzerland), containing guttapercha and epoxy resin. Teeth in the 4 sample negative control group did not undergo any expansion or filling procedure; in 4 positive control groups, root canals were expanded up to number 35 and a post cavity was created. Independent examiners were calibrated and their reliability was assessed by the control group. Following the completion of the root canal obturation of the 84 teeth in the study group, with the exception of the control groups (8 teeth), the post cavity was prepared so that 5 mm of guta-percha was left in the region of the apex. The present study examined the effect of post thickness on tooth strength. A total of 84 teeth were examined, with the exclusion of the control groups. The teeth were then categorised into two subgroups based on fibre post type (n=42). The first group received a traditional fibre post (Sanfeng SF, China), while the second group received a bundle fibre post (Biolight Plus, Medicaux, France). Subsequently, these groups were divided into three subgroups according to the use of different thicknesses (0.8, 1 and 1.2 mm) of the canal post (n=14). Following the insertion of the posts into the root canal and the completion of the cementation process, a 4-mm composite resin (Herculate, Kerr, Italy) core structure was formed cervicoincisally in the specimens from the study groups. The specimens were then embedded in acrylic blocks (IMICRYL Dental, Konya, Turkey) (2x2 cm). Crushing test was performed using an Instron device (Stable Mi-crosystem TA-HD Plus, United Kingdom). A force was applied at a speed of 1 mm per minute until fracture occurred. Newton (N) units were utilised to document the values at the time of observed fracture (Figure 1). The subsequent analysis of the collected data was conducted using SPSS software (SPSS 16.0, SPSS, Chicago, IL, USA). In order to facilitate the comparison of groups within and between groups, the Kruskal-Wallis/one-way ANOVA and Mann-Whit-ney U analyses were employed.

RESULT

As demonstrated in Table 1, the mean fracture resistances for the various groups are presented. The strongest average force required to break the roots was detected in the negative control group. A statistical analysis was performed, which revealed a significant difference between the negative and positive control groups ($p < 0.05$). The mean fracture resistance for the negative control group was found to be 2133.21 ± 317.421, whereas for the positive control group, it was 1436.08 ± 334.310. With regard to the investigation of fracture resistance, the present study did not identify any statistically meaningful disparities among the various post types ($p > 0.05$). Additionally, no statistically significant variations were observed across the range of thicknesses ($p > 0.05$).

The groups with Biolight bundle post 0.8 mm and the groups with SF fiber post 0.8 mm did not differ statistically significantly in terms of post diameters and thicknesses ($p > 0.05$). Although the Biolight bundle post 1 mm group demonstrates increased fracture strength ($p > 0.05$), there is no statistically considerable difference between it and the SF fiber post 1 mm group. Notwithstanding the greater fracture strength exhibited by the Biolight bundle post 1.2 mm group in comparison to the SF fiber post 1.2 mm group, a statistically meaningful

Fig 1: The Instron device used for the fracture test

Table 1: Means ± standard deviations of the fracture test results of the Groups (N).

Thickness of the post	Bundle Post	Fiber Post	P value
0.8 mm	1211.14 ± 396.851a	1276.42 ± 339.020A	p > 0.05
1 mm	1355.49 ± 282.449a	1271.86 ± 323.461A	p > 0.05
1.2 mm	1122.74 ± 311.500a	1062.49 ± 163.102A	p > 0.05
P value	p > 0.05	p > 0.05	

There is no significant difference between the groups in columns with the same superscript.

difference was not observed ($p > 0.05$).

DISCUSSION

Dental decay, trauma, the presence of previous restorations, access cavities created for endodontic therapy, and the biomechanical preparation of the root canal are some of the factors that can result in the loss of material from teeth that have undergone endodontic treatment[11]. In cases of prosthetic and conservative restorations of teeth with excessive material loss, post-core restorations are the most preferred treatment modality, providing support for restorations in the absence of sufficient coronal structure[12,13].

The preference for metal posts in the context of in-canal retention in root canal treated teeth is a long-standing one, spanning the historical and contemporary eras. Metal posts have been shown to possess a higher level of flexibility than dentin, which suggests the potential for root fracture[14]. The development of fibre post systems has sought to address these shortcomings. Fibre posts have emerged as a prominent solution, offering a number of advantages. One of the factors under consideration is a dentin-like flexibility parameter, which has been demonstrated to provide adequate resistance to functional forces, thereby reducing the damage that these loads cause to tooth tissue. Additionally, they exhibit corrosion resistance, aesthetic appeal, and the ability to be attached to the tooth structure. Furthermore, they can be applied in a single treatment session, streamlining the procedure[15,16]. Given that the full elasticity compliance of fibre posts to dentin was inadequate, a new post system, the bundle fibre posts, was developed. In contrast to the preceding post designs, which are produced as a single conical post, this variant is constituted by a cluster of slender posts that are interconnected via a plastic sheath[17,18].

The post is deployed in a thin bundle configuration, which allows it to expand and adapt to the varying dimensions of the root canal. This versatility enables its use in cases where the root canal exhibits elliptical or curved morphology[19]. The greater number of posts in the regions has resulted in an expansion of the surface area in comparison to that of conventional fibre posts. This results in a uniform distribution of force.

Nevertheless, there is a paucity of consensus in the extant literature regarding the optimal post diameter. Researchers are largely in agreement that over-preparing the canal of the root to accommodate a post of greater size than is necessary increases the risk of root fracture and should be avoided[20-23]. The investigators of a preceding investigation by Nokar et al. (2020) assessed the fracture resistance of composite core glass fiber posts in maxillary canine teeth with varying diameters (1.4 mm, 1.6 mm, and 2 mm). The mean fracture resistance of each of the three groups was found to be 574 ± 91.2 N, 617 ± 85.21 N, and 467 ± 99.43 N, respectively. No notable distinction was observed between Groups I and II; however, a considerable disparity was identified between Groups I and III ($p < 0.05$) and between Groups II and III ($p < 0.05$)[24]. In a separate investigation, Ranjkesh et al. utilised 1.4 mm bundle posts and 1.5 mm fibre posts to ascertain the breaking strength. The cracking resistance of single-post and bundle-post teeth was determined to be 787 ± 156 and 850 ± 166 Newton, respectively[25]. Zogheib et al. found that narrower diameter posts provided higher resistance among all post systems[26].

Although the values are different in the present study compared to previous studies by Nokar et al., Ranjkesh et al., and Zogheib et al., they support the findings that post diameter can significantly influence fracture resistance[24-26]. Based on the results, the null hypothesis of our study has been accepted. Despite the similarity in outcomes, the elevated results may be attributable to the utilisation of an array of post materials and techniques, disparate tooth groups, and a range of core materials. In comparison with a solitary post, the Biolight bundle has been demonstrated to demonstrate enhanced adherence to the root canal walls, culminating in a reduced cement thickness. These results are consistent with those reported by Egilmez et al. (2013), who hypothesised that a reduction in cement thickness and an enhancement in bond strength would ensue from an augmented post thickness[27].

Nowadays, composite resins are the most preferred core materials. Composite resins are frequently used as core materials due to their ease of use and adhesive connection to the post material. It has been reported that composite cores fracture at forces lower than the forces that cause fracture of dental tissues. In the studies, composite resins are generally used as the core material[28].

Research has demonstrated that the fracture resistance of teeth that have undergone post-core restoration is contingent on the direction of the force applied to the tooth front[29]. In the research conducted by Akkayan et al. and Mitsui et al., an Instron device and an angle of 130°/135° were utilised to apply strain along the teeth's longitudinal direction[30-32]. Since 135° angulation has been identified as representing the forces comprising compressive and tensile forces in natural teeth[33], the Instron device was employed in this study, with force applied at a 135° angle to the specimens positioned within the test apparatus[34].

Fractures in the restoration or tooth tissues are the most common cause of failure in post-core restorations. Some fractures occurring at the coronal level and fractures occurring in the coronal triple region of the root are repairable in teeth with post-core restoration. On the other hand, apical fractures, especially vertical fractures, cause damage that prevents root repair and requires tooth extraction[35].

The limitations of the study are as follows: In vitro environments cannot fully replicate the complex biological and mechanical conditions of the oral cavity. Dynamic factors such as saliva, temperature fluctuations, and the direction and frequency of masticatory forces are absent. The size, morphology, and dentin density of human teeth vary from one individual to another. These differences in the sample teeth used in the study may affect the results, and complete standardization is difficult to achieve[36].

CONCLUSION

It was concluded that the effect of bundle fibre posts used in different thicknesses on fracture resistance was similar to conventional fibre posts. Clinicians should be aware that, in terms of enhancing breakage resistance, bundle fibre posts are comparable to traditional fibre posts. It is recommended that further research be conducted to validate the findings of the current investigation.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	EY, EB
Acquisition, Analysis or Interpretation of Data:	EY, EB
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All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.