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## FRACTURE RESISTANCE OF DIFFERENT RESTORATIVE TECHNIQUES FOR ENDODONTICALLY TREATED TEETH

Maisoun Latrash\* | Nagwa Sayed\*\* | Roula Abiad\*\*\* | Mohammad Rayyan\*\*\*\*

### Abstract

Eighty endodontically treated premolars were prepared and divided into four groups according to the amount of tooth loss: group 1) OD cavity; group 2) MOD cavity; group 3) only buccal wall was left; group 4) decapitated teeth. The prepared crowns were subdivided into two subgroups according to the type of restoration: subgroup A) glass fiber post and core and subgroup B) auto polymerizing composite core. Metal copings were constructed and cemented for all groups. Fracture resistance of the entire samples was measured using universal testing machine. The findings indicated a statistically significant difference between the groups. The mean load required to fracture the Nayyar's core was higher than the glass fiber post and core ( $p < 0.005$ ). It was concluded that Nayyar's core increased the fracture resistance of the teeth more than the fiber post. Nayyar's core could be recommended as a substitute for fiber post in structurally compromised premolars.

Keywords: Fiber post –Nayyar's core - mutilated teeth - fracture resistance.

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## RÉSISTANCE À LA FRACTURE DE DIFFERENTES TECHNIQUES DE RESTAURATION POUR DES DENTS TRAITÉES ENDODONTIQUEMENT

### Résumé

Quatre-vingts prémolaires traitées endodontiquement ont été préparées et réparties en quatre groupes selon le degré de perte de la substance dentaire: groupe 1) cavité occluso-distale; groupe 2) cavité mésio-occluso-distale; groupe 3) seule la paroi vestibulaire persiste; groupe 4) couronne décapitée. Les dents préparées ont été subdivisées en deux sous-groupes selon le type de restauration. La résistance à la rupture des échantillons a été mesurée. Les résultats indiquent une différence statistiquement significative entre les groupes. La charge moyenne nécessaire pour rompre le noyau de Nayyar était plus élevé que pour le tenon en fibres de verre ( $p < 0,005$ ). Le noyau de Nayyar a augmenté la résistance à la rupture des dents; il pourrait substituer le tenon en fibres de verre dans le cas des prémolaires à structure compromise.

Mots-clés: tenon en fibres de verre – résistance à la rupture.

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## Introduction

Extensively damaged endodontically treated teeth present a challenge for prosthetic rehabilitation. The extensive structural damage of the crown can sometimes be a result of trauma, dental caries, or previous restoration [1], can make the restorative procedure difficult and can compromise the prognosis for a long-term successful restoration of the tooth [2]. Furthermore, tooth strength is directly related to the remaining amount of tooth structure [3]. According to Reehet al. [4], the loss of two marginal ridges may decrease the crown stiffness by 63 %.

There are many factors that determine if a post and core is necessary or only composite core is sufficient to restore compromised endodontically treated teeth. The most critical factor is the amount of remaining walls to retain the core [5]. Several materials have been used to restore crown defects, with the aim of increasing the resistance of the weakened tooth, such as composites, resin modified glass ionomer and silver reinforced glass ionomer [6]. Also, various techniques have been recommended and described in the post crown construction in order to reinforce the weakened endodontically treated teeth [7].

The fracture resistance tests of endodontically treated teeth restored by post and core were clinically acceptable [8]. It is true that post is indicated to support the core in mutilated endodontically treated teeth [9], but with removal of the intraradicular dentine during post space preparation, further weakening of the tooth could occur [7]. On the other hand, there is a remarkable progress in composite materials and adhesion protocols [10]. Can mutilated endodontically treated teeth be restored with composite cores alone without the need for post and cores? The debate around this idea urged the authors to lay down this study.

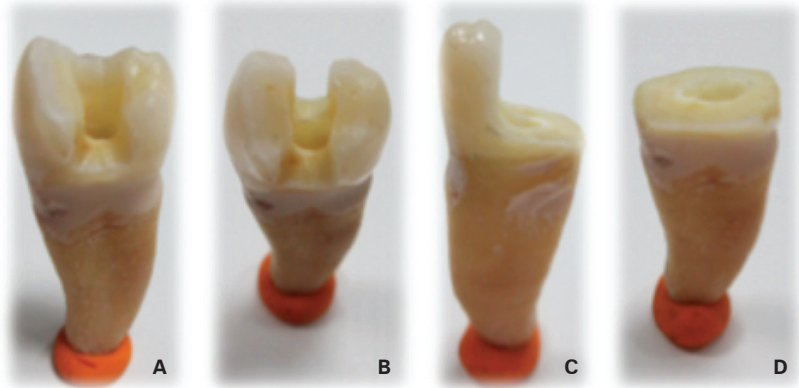


Fig. 1: Sample grouping: a) OD cavity; b) MOD cavity; c) only buccal wall left and d) decapitated crown.

Files	Tip size	Taper	Torque
SX	19	4%	3-4 N/cm
S1	17	2%	2-3 N/cm
S2	20	4%	1-1.5 N/cm
F1	17	7%	2-3N/cm
F2	25	8%	3-4N/cm

Table 1: ProTaper® universal rotary files sizes, tapers and torques.

## Materials and methods

A total of eighty freshly extracted, human premolars were collected for this study. Teeth were clinically and radiographically selected to be of similar dimensions. They were prepared using a water-cooled high-speed hand-piece with round-end tapered carbide bur. A class I occlusal cavity was prepared then teeth were grouped according to the amount of coronal structure removal into (Fig. 1):

Group 1: One wall was removed: the distal wall from the distobuccal line angle to the distopalatal line angle, 2mm coronal to the cemento-enamel junction (CEJ).

Group 2: Two walls were removed: the distal wall from the distobuccal line angle to the distopalatal line angle

and the mesial wall from the mesio-buccal line angle to the mesio-palatal line angle, 2mm coronal to the CEJ.

Group 3: Three walls were removed; only the buccal wall was left, from the mesio-buccal line angle to the distobuccal line angle, 2mm coronal to the CEJ.

Group 4: The crowns were amputated horizontally 2 mm coronal to the CEJ.

All teeth were accessed; the root canal was prepared according to the crown-down technique using ProTaper® universal nickel titanium rotary files (Table 1) with brushing motion and a speed of 300 rpm.

The working length was standardized 1mm short of the tooth length. 5% sodium hypochlorite irrigation

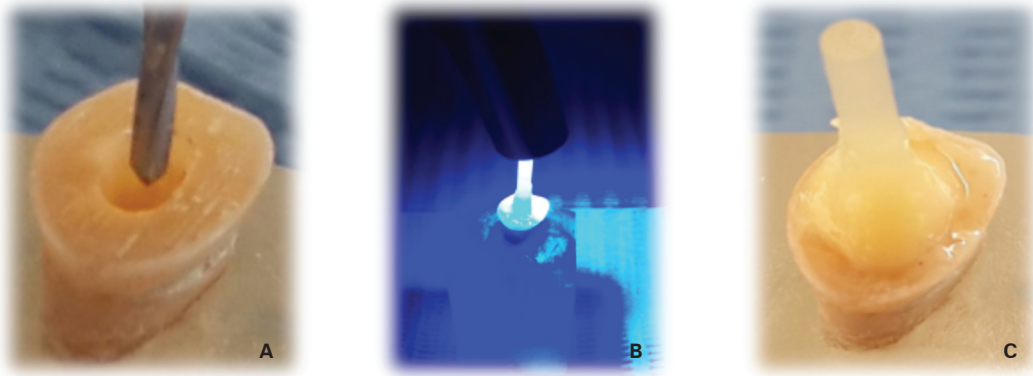


Fig. 2: a) Preparation of post space, b) curing of resin cement, c) cemented fiber post.

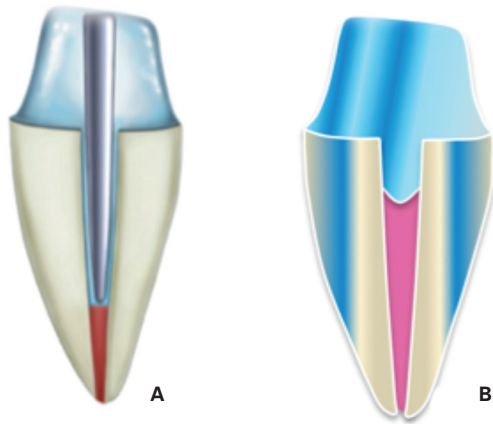


Fig. 3: a) Subgroup A: glass fiber post; b) Subgroup B: Nayyar's core.

was used during cleaning and shaping. Canals were dried with absorbent paper points. The prepared canals were obturated with gutta-percha using the lateral condensation technique and a root canal resin sealer. Vertical condensation for coronal gutta-percha was accomplished using System-B Heat Source.

Then, the prepared teeth were divided into two subgroups, A and B.

In the subgroup A, the coronal gutta-percha was removed from the canal using System-B Heat Source, leaving a 4 mm apical plug. The post space was prepared using Gates Glidden and peeso reamers (Maillefer, Dentsply, Switzerland) (Fig. 2a), then finished using manufacturer-supplied drills (Exacto, Angelus, Londrina,

Brazil). Prefabricated glass fiber posts (Exacto, Angelus, Londrina, Brazil) were cemented using a dual-curing resin cement (RelayX™U200, 3M ESPE, USA) according to the manufacturer's directions. Then the coronal end of each post was light-polymerized for 30 seconds (Figs. 2b & 2c). Excess cement was removed using a scaler (Hu-Friedy, Chicago, USA). Each tooth was etched for 15 seconds using 37% phosphoric acid (Ultra-Etch, Ultradent products, Inc., South Jordan, UT, USA); etchant was removed and cavity water-sprayed for 30 seconds. Bonding agent was placed in the preparation, gently air-thinned and light-cured. Incremental core composite (Filtek Z 350, 3M ESPE, USA) was built up in the pulp chamber till it filled completely. Each layer

didn't exceed 2 mm in thickness; it was light-cured for 40 seconds (800 mW/cm<sup>2</sup>, (Elipar S10 LED, 3M ESPE, USA).

In the subgroup B, the gutta-percha was sheared off till the canal orifice at obturation step. A 2mm depth of coronal gutta-percha was removed from the root canal orifice. Each tooth was etched for 15 seconds using 37% phosphoric acid (Ultra-Etch, Ultradent products, Inc., South Jordan, UT, USA); etchant was removed and cavity water-sprayed for 30 seconds. Bonding agent was placed in the preparation, gently air-thinned and light-cured for 40 seconds (800 mW/cm<sup>2</sup> (Elipar S10 LED, 3M ESPE, USA). Core material (Filtek Z 350, 3M ESPE, USA) was inserted into the space prepared - layers not exceeding 2 mm in thickness each - till

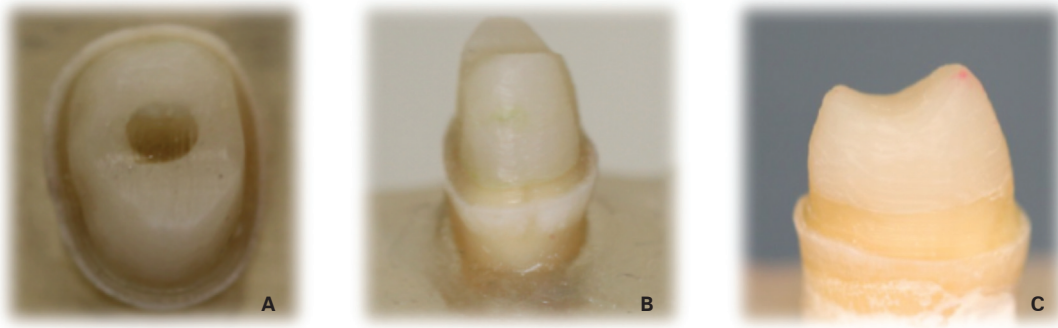


Fig.4: Uniform preparation: a) occlusal view, b) frontal view and c) lateral view.

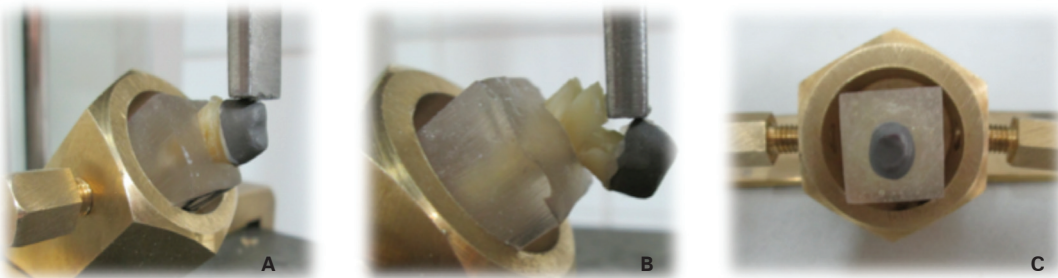


Fig. 5: a, b): Jig obliquely mounted with buccal cusp fit the metal point; c) sample fracture.

the entire occlusal surface of the cavity making the core and the radicular material as a single unit (Nayyar core) (Figs. 3a & 3b).

A vacuum press stent was prepared in a vacuum press device (Easy-Vac, 3AMEDES, Korea) for standardization of the last layer of composite core to give the form and shape of the occlusal surface of the teeth. It was seated over the uncured composite core. Once the stent was removed, the crown was light-cured using a light cure for 20 seconds.

Occlusal reduction of 1.5mm was done by guiding grooves using a round-end taper diamond bur (#6856 Komet, Brasseler, Germany). A uniform preparation was done using round-end taper diamond bur with guiding pin (#8881P Komet, Brasseler, Germany) to provide a standardized even thickness and a heavy chamfer finish line 0.8 mm deep in the axial direction, and 2.0 mm high from a central point

distal to the CEJ (Fig. 4). Copings were constructed and trial fitted on its corresponding cores. Resin cement was mixed and applied to fitting surface of coping until setting. Excess cement was removed using a scaler. All samples were stored in distilled water for one week before testing for aging.

#### Fracture strength test

The buccal cusp of the coping was placed upward to fit the metal point coupled to the upper part of the universal testing machine (Fig. 5a). The load was applied with a custom made load applicator (a steel rod with flat end tip) attached to the upper movable part of the machine. A static load was applied to the copings at 45° angle with cross head speed of 1mm/min (Fig. 5b). The teeth tend to bend palatally with a fulcrum situated on the palatal surface. A palatal coronal wall acts as a critical factor to resist the displacement of the crown. Throughout the tests,

the control system and its associated software record the load of the sample with load values measured in Newtons (N). Once the machine is started, it begins to apply an increasing load on sample until fracture (Fig.5c).

## Results

On evaluating the fracture resistance of all the samples tested in the study, it was found that group 1B showed the highest mean fracture resistance followed by groups 3B, 2B, group 4B, group 1A, group 2A and group 3A, respectively. The lowest mean fracture resistance was recorded in the group 4A (Table 2).

The fracture strength between the subgroups 1A & 2A, 1A & 3A and 2A & 3A showed no significant difference of values ( $p= 0.5480, 0.2094$  and  $0.5095$ , respectively), while the other subgroups of the same group A showed a significant difference. The compari-

Sub-group	Group	Mean $\pm$ SD
A	1	89.78 $\pm$ 25.89
	2	83.48 $\pm$ 26.96
	3	76.56 $\pm$ 34.64
	4	41.39 $\pm$ 15.57
B	1	158.64 $\pm$ 25.44
	2	104.46 $\pm$ 19.13
	3	112.73 $\pm$ 21.16
	4	65.66 $\pm$ 7.60

Table 2: Mean fracture strength (FS) values for subgroups A and B.

	1A	2A	3A	4A	1B	2B	3B	4B
1A		.5480	.2094	1.55E-05	6.06E-09	.1639	.0311	.0237
2A	.5480		.5095	.0001	4.71E-10	.0482	.0065	.0921
3A	.2094	.5095		.0012	2.75E-11	.0093	.0009	.2999
4A	1.55E-05	.0001	.0012		1.72E-17	6.09E-08	2.23E-09	.0229
1B	6.06E-09	4.71E-10	2.75E-11	1.72E-17		1.86E-06	3.70E-05	3.10E-13
2B	.1639	.0482	.0093	6.09E-08	1.86E-06		.4308	.0004
3B	.0311	.0065	.0009	2.23E-09	3.70E-05	.4308		2.47E-05
4B	.0237	.0921	.2999	.0229	3.10E-13	.0004	2.47E-05	

Table 3: P-value among subgroups.

son of FS values among the subgroups of the group B indicated that the FS between 4B & 2A, 4B & 3A, 2B & 1A, and 3B & 2B were of no significance difference ( $p=0.0921$ ,  $0.2999$ ,  $0.1639$  and  $0.4308$ , respectively). Overall, the highest significant difference was shown between subgroups 1B and 1A, 2A, 3A, 4A, 2B, 3B and 4B, while the most non-significant difference was found between 1A & 2A, 2A & 3A and 2B & 3B (Table 3).

## Discussion

Endodontically treated teeth with no residual dentinal walls pose a dilemma to the clinician since their restoration might require a post, due to their questionable prognosis. The loss of large amounts of coronal dentin structure renders the teeth weak and liable to fracture [11], particularly in the posterior region where the stress generated by the normal masticatory forces can lead to fracture.

Ferrier et al. [12] described a method called corono-radicular stabilization; a retentive core is produced by preparing coronal 2 to 4 mm of root canal from the orifice and slightly undercutting the pulp chamber. Core material is inserted into the prepared space making the core and the radicular material a single unit. However, other studies revealed that endodontic posts do not reinforce the crown since the enlargement of the root canal space for post placement after com-

pletion of endodontic treatment can weaken the tooth structure [13].

The prognosis of endodontically treated teeth depends on many factors. The amount of remaining coronal tooth structure prior to the final restoration is more important than the other reported factors such as post material and design, cement and core material.

This study compared the fracture resistance of endodontically treated teeth with one, two, three, and four missing coronal tooth structure with the aim to represent the clinical situations of teeth with less than ideal ferrule [1]. The coronal dentine extension used for all the groups was 2mm because it has been recommended as the minimum length, which can compensate for the difficulties of intraoral tooth preparations. Cervical ferrule of 2mm was done during preparation of the tooth structure to promote resistance to dynamic occlusal loads and help to maintain seal integrity and reduces stress between post and cores.

The results of the present study showed the highest fracture resistance value for subgroup A (OD) which clearly indicated that structural integrity of tooth is of paramount importance to root fracture. The mean values of FS in the subgroup B (MOD) were significantly lower than those obtained in the subgroup A (OD). Reeh et al. [4] reported that MOD preparation resulted in loss of 63 % relative cusp rigidity. Other study reported mean fracture strength for unrestored teeth with MOD preparation was 50% less than that of unaltered premolar teeth.

Only when one dentine wall (the buccal cusp) remained, the samples had lower mean fracture strength values. These results suggest that the restorability of teeth in this situation is questionable.

However, the obtained mean values were lower than those reported by Kivanc et al. [14] who found a mean failure load value of  $920.33 \pm 162.24$  N. for maxillary premolars restored with different post systems and composite cores.

The analysis of the obtained results revealed that lingual cusps fracture tends to occur more frequently in maxillary premolars under compressive loading.

For subgroup B, the mean fracture strength of samples had the lowest mean load value. This can be explained by the findings of Nam et al. [2], when looking at the effect of the number of residual walls on fracture resistances, failure patterns, and photoelasticity of simulated premolars restored with or without fiber reinforced composite posts. In the no-post group, high levels of stress were produced in the remaining internal tooth structure along the canal space. As the number of walls decreased to zero, a higher intensity of stress was noted in the lingual side of crown and the CEJ area.

## Conclusion

The results of the present study raise doubt about the need of post in endodontically treated teeth. Nayyar's core increased the fracture resistance of the teeth more than the fiber post; it could be recommended as a substitute for fiber post in structurally compromised premolars.

The fracture risk of premolars was found to be greater than molars due to the fact that mesio-distal diameter is narrower than the bucco-lingual.

Further studies are needed, with different loading protocols.

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