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The effect of 2 different diameter cast posts on tooth root fracture resistance in vitro

Linards Grieznis, Peteris Apse, Una Soboleva

SUMMARY

Prosthetic treatment frequently involves the restoration of endodontically treated teeth (ETT), which in turn implies that there has been a reduction of the crown due to previous restorative treatment, trauma and/or endodontic manipulations. The prognosis of a restored ETT is very much dependent on pre-endodontic status of the tooth, the quality of the endodontic treatment, the amount remaining tooth structure and the bone support.

The aim of this study is to measure fracture resistance of extracted premolar teeth restored with 2 different diameter posts.

Extracted premolars were collected and stored in physiologic solution at 5°C. The teeth were examined for fractures by direct and transillumination observation and 40 premolars were accepted for the study. The PC were modelled using the appropriate diameter plastic pattern for the post and Pattern Resin (GC) was used to model the core part of the PC. The PC patterns were invested and cast in cobalt chromium alloy and then cemented using zinc phosphate cement. Fracture resistances of the samples were tested in an "Instron 4301" (Instron Series IX Automated Material Testing System Version 5) with a loading speed of 0.5 mm/min.

The data for each sample was recorded graphically. Both groups were analyzed using the t-test ($p<0.01$) in relationship to the mean value of that group.

Post and cores significantly reduce the fracture resistance of the tooth and should be used only to secure retention and resistance form for full coverage crowns. Teeth with a larger diameter post have a reduced fracture resistance than teeth with a smaller diameter.

Key words: post and core, endodontically treated teeth, Material Testing System.

INTRODUCTION

Prosthetic treatment frequently involves the restoration of endodontically treated teeth (ETT), which in turn implies that there has been a reduction of the crown due to previous restorative treatment, trauma and/or endodontic manipulations. It has been shown [1] that an ETT is less fracture resistant than an intact tooth.

The prognosis of a restored ETT is very much dependent on pre-endodontic status of the tooth (periapical lesions, symptomatology, primary or secondary treatment, type of obturating material) the quality of the endodontic treatment, the amount remaining tooth structure and the bone support. Furthermore the restorative procedures such as preparation of post and cores to improve retention of the prosthesis can weaken the tooth making it more liable to fracture.

However, ETT are frequently encountered in the process of providing prosthetic treatment. Leempoel et al found that with single crown restorations, 39% were ETT [2]. Therefore ETT must be carefully assessed when they are included in the prosthetic construct, and all efforts must be made not to weaken its biomechanical properties.

The accepted method of providing retention and resistance for a crown on a tooth is the construction of a post and core (PC). A cast PC as a prerequisite to crown construction on a ETT with less than 50% natural tooth material, is and accepted treatment modality and are considered the 'gold standard' [3].

The PC, construct as the base for a crown, consists of a post that occupies the root structure of the tooth and the core which is the structure above the root which provides the retentive and resistant factors for the artificial crown. However the preparation of the post segment of the PC, involves a certain amount of tooth material loss, which reduces the tooth's fracture resistance. Research has shown that the ETT biomechanical behavior is directly related to the amount of remaining natural tooth material. ETT without PCs are more fracture resistant than teeth with PCs [4,5].

There are a number of parameters in the design of PC that influence the success and failure of the restoration of an endodontically treated tooth

Post and core retention is generally associated with length of post, parallel sided post walls and surface configuration where as resistance to root fracture is influenced by length of post and its diameter.

Purpose

The aim of this study is to measure fracture resistance of extracted premolar teeth restored with 2 different diameter posts.

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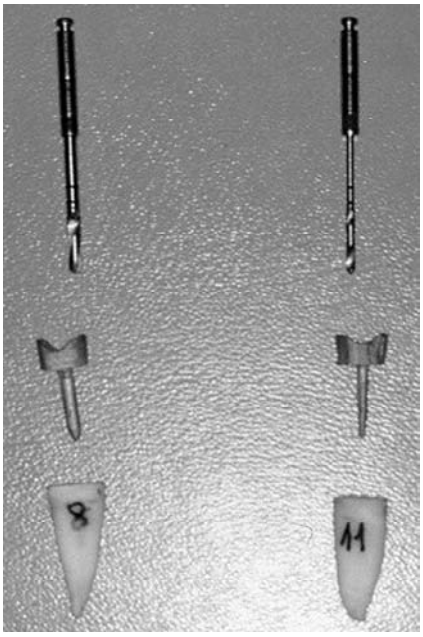

Fig. 1. Sample # 8 has a post diameter of 1.75 and sample # 11has a post diameter of 1.14

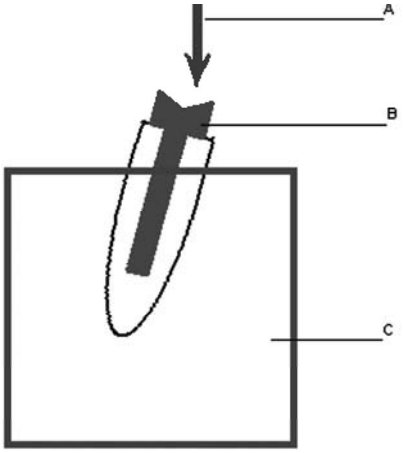

Fig. 2. Prepared test sample: A - loading di rection, B - tooth with a cemented post and core, C - Methylmethacrylate block

Fig. 3. Load test

MATERIALS AND METHODS

Extracted premolars were collected and stored in physiologic solution at 5°C. The teeth were examined for fractures by direct and transillumination observation and 40 premolars were accepted for the study. The tooth crown was cut off at the cemento-enamel junction with a diamond bur.

In order to standardize the post preparation within the parameters of optimal post preparation, a standard cast post system was used (Parapost, Whaledent).

The 40 teeth were divided in 2 groups of 20 each (samples were mixed and then randomly picked for each group).

In one group a post canal was prepared with a 1.14 mm diameter spiral drill and in the other group a 1.75 mm diameter spiral drill was used.

The PC were modeled using the appropriate diameter plastic pattern for the post and Pattern Resin (GC) was used to model the core part of the PC. For all the PC the post preparation was 9mm in length while the core part was 4mm in height.

The PC patterns were invested and cast in cobalt chromium alloy (Figure 1). After the removal of any casting defects, the PC were fitted to the appropriate teeth and then cemented using zinc phosphate cement.

The roots with the cemented PC were imbedded in PMMA blocks to within 5mm apical to the cemento-enamel junction and at 30° to the long axis of the tooth (Figures 2) in order to imitate functional loading directions.

Fracture resistances of the samples were tested in an „Instron 4301" (Instron Series IX Automated Material Testing System Version 5) with a loading speed of 0.5 mm/min (Figure 3). The force was applied until fracture of the root occurred. Load values at time of fractue were automatically recorded in graphic form.

The data was analyzed with t-tests to compare the 1.14 mm and 1.75 mm diameter groups.

RESULTS

The data for each sample was recorded graphically (Figure 4). The highest point on the graph was recorded as the load at fracture (force in Newtons) (Figure 5).

The mean fracture load for the 1.14 mm diameter posts was 2.938.85N while for the 1.75 mm diameter post this value was 1672.7N (Figure 6).

Both groups were analyzed using the t-test ($p<0.01$) in relationship to the mean value of that group (Table).

DISCUSSION

Cast PC construction is an accepted method in the replacement of coronal tooth structure in an ETT. A number of

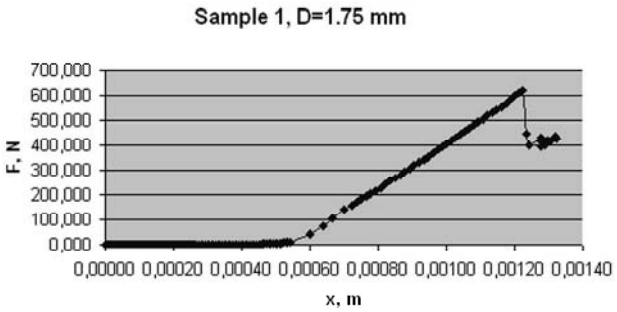

Fig. 4. Linegraph of sample #1. Similar line graphs were ac quired for all 40 samples

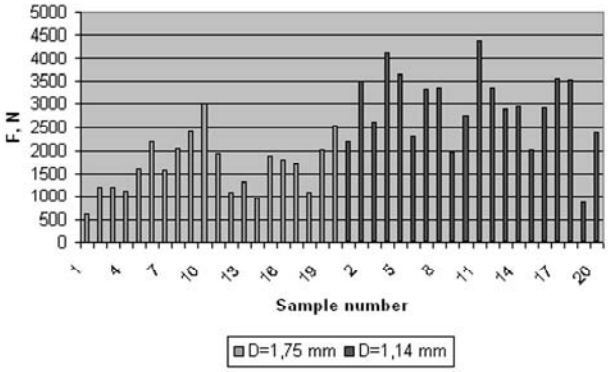

Fig. 5. Loads at fracture for all 40 samples

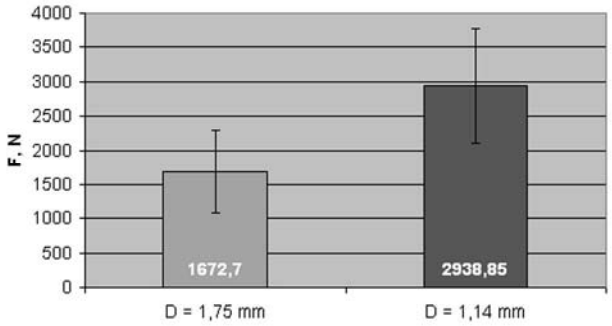

Fig. 6. value of the fracture force (n) in both groups

factors must be taken into consideration in order to ensure long-term success:

Adequate post length, parallel post form, minimal diameter, maintenance of coronal tooth structure and luting material.

Specific emphasis is placed PC diameter in this study, because it is directly related to remaining root structure, which influences its fracture resistance [4,6]. Goodacre and Spolnik [7] stated that the post diameter should not exceed 1/3 of the root diameter throughout the post length and the apical part of the post should not be more than 1mm in diameter to avoid weakening the remaining root structure.

Martinez-Insua et al [8] studied the facture resistance of ETT and concluded that fracture resistance is directly related to the amount of remaining tooth structure. They further stated that the preparation of a post channel for the PC reduces the amount of tooth with a resultant reduced fracture resistance. They justified the use of cast PC in situations where there was inadequate coronal dentine, however standard PC could be used where coronal dentin was deemed adequate.

Sedgley and Messer [9] concluded that the tooth fracture resistance depended on the remaining tooth structure, endodontic procedures and from loss of some proprioceptive sensory mechanism which could result in higher loads on ETT as pain threshhold may be higher than in vital teeth.

Sorensen and Martinoff [10] concur that the quality of dentin remaining after endodontic treatment and post canal preparation are a major factor in root fracture resistance. As in this study, a smaller PC diameter increased the root's facture resistance. They concluded that, in order not to negatively influence the tooth's facture resistance, a maximum of natural tooth structure should be maintained in the treatment of ETT.

In this study, the smaller diameter post (1.14 mm) in premolar teeth showed a higher load to fracture (2938.85N) than the wider diameter (1.75 mm) posts (1672.7N).

Table. Mean value of the T-test

t-Test: Two-Sample Assuming Equal Variances		
	Variable 1	**Variable 2**
Mean	1672.7	2938.85
Variance	363656.9579	690411.1868
Observations	20	20
Pooled Variance	527034.0724	
Hypothesized Mean Difference	0	
df	38	
t Stat	-5.51525774	
P(T<=t) one-tail	1.31566E-06	
t Critical one-tail	1.685953066	
P (T<=t) two-tail	2.63131E-06	
t Critical two-tail	2.024394234	
SD	603.04	830.91
	P < 0.01	

Although the study is in agreement with the general consensus of the effect of post diameter on the fracture resistance of ETT, there are a number of limitations that should be mentioned:

Lack of a periodontal ligament, which may act as damper to the loads, may increase the load to fracture values. However since both groups were treated similarly, the load to failure proportions may be similar in clinical situations.

The roots were imbedded in PMMA material, which has different modulus of elasticity to bone, and may influence the load to failure of the root.

The roots may have become dehydrated during the preparation process and thus have influenced the results.

The forces applied to the core in the study may not be representative of forces applied in masticatory function.

The study samples consisted of a post and core without a full coverage crown. The contact of crown margins on the tooth margins may significantly influence the fracture pattern of the tooth.

CONCLUSIONS

1. Qualitative endodontic treatment is a prerequisite to a successful treatment of the ETT.
2. Post and cores significantly reduce the fracture resistance of the tooth and should be used only to secure retention and resistance form for full coverage crowns.
3. One of the main goals in endodontic treatment and PC preparation is to preserve as much tooth material as possible.
4. Teeth with a larger diameter post have a reduced fracture resistance than teeth with a smaller diameter.

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