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Comparison of fracture strength between Conservative and Traditional Access Cavity in Endodontically Treated Maxillary First Premolars: In Vitro Study

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Abstract: The aim was to compare in vitro the fracture strength of conservative versus traditional access cavity design assessed in maxillary first premolars teeth. The null hypothesis tested was that there is no difference in fracture strength of sound premolars, premolars with conservative and those with traditional access cavities. Thirty extracted human intact maxillary first premolars were extracted for orthodontic reasons assigned to Traditional access Cavity (TAC), Conservative Access Cavity (CAC) and Sound Control (SC) groups (N=10/group/type). TAC groups were prepared with pulp chamber de-roofing and straight line access. For CAC a soffit and pericervical-dentin were maintained. Working length was determined and canals were left un-obturated and mounted in self-cured acrylic resin molds for testing. Specimens were then tested with a compression testing machine and fracture force data were recorded in Newton for analysis. Data were normally distributed; therefore One-way ANOVA and post-hoc Tukey tests were used for analysis. The software R was used for statistical analysis. Results showed fracture load for CAC was significantly higher (PValue = 0.0297226) compared to TAC groups. The study concluded that Maxillary first premolars after preservation of pericervical dentine and soffit were found to have higher fracture strength compared to teeth with traditional straight-line access.

Keywords: Access, cavity, endodontic, traditional, conservative, pericervical, soffit, dentine.

INTRODUCTION

Root Canal filled teeth have been found to have worse long-term survival than their non root canal filled teeth [1].

They are prone to fracture failure more than other factors of failure and it was found that fracture is the main cause of extraction of endodontically treated teeth (59.4%), only 8.6% of the failures were due to endodontic causes [2].

Helfer reported that the moisture content of dentine from root filled teeth was about 9% less than their vital counterpart [3]. Other studies indicate that there was no significant difference in the moisture content between endodontically treated teeth and vital teeth [4]. Later studies showed that endodontically treated teeth do not become more brittle intrinsically following treatment, and suggested that other factors may be more critical to failure [4, 5].

Traditional endodontic access cavity involves removal of much amount of dentine, coronaly to gain straight-line access to canals, and radiculary by over-flaring of canals orifices, which may weaken the tooth and increases its susceptibility to fracture and eventual extraction [6]. Loss of coronal tooth structure to gain straight-line access has a significant decrease in fracture resistance compared to root canal and post preparation [7]. The concept of minimally invasive dentistry and the newly emerging imaging devices, illumination and magnification have inspired the emergence of the recent conservative endodontic access cavity. The aim is preserving sound dentine by avoiding de-roofing of the pulp chamber and avoiding over-flaring of canal orifices as well as avoiding aggressive dentine removal for shaping [8].

This study investigated the role of the access cavity design (traditional versus conservative) in relation to fracture strength in maxillary first premolars teeth.

Premolars were selected in this study because of their unique morphology. They have smaller functional cusps compared with non-functional cusps. These functional cusps have sharper inclination which can render them more susceptible to cusp fracture under occlusal force [9]. Loss of dentine during endodontic

access in the presence of radicular fluting, with 2 thin roots renders maxillary premolars more prone to fracture[10, 11].

The significance of the study may contribute to the scanty literature available on this subject.

The aim of this *in vitro* study was to assess and evaluate the effects of conservative endodontic access cavities on fracture resistance of extracted maxillary first premolars.

The hypothesis tested was that:

The Null hypothesis:

H0: It is true that $\mu_{sc} = \mu_C = \mu_T$

There is no difference in the mean load required to fracture sound intact premolars, premolars with conservative access cavity and premolars with traditional access cavities.

The Alternative Hypothesis:

H1: it is not true that $\mu_{sc} = \mu_C = \mu_T$

- The mean load required to fracture intact premolars is higher than that required for both root canal treated premolars with conservative or traditional access cavities.
- The mean load required to fracture premolars with conservative access cavities is higher than that required for premolars with traditional access cavities.

MATERIALS AND METHODS

Sample size Calculation/Estimation

Previous studies were found that studied fracture strength of various restorative materials for maxillary premolars and they used sample sizes for N between 8-12 teeth. Therefore, in this study a sample size of 30 maxillary premolars was used i.e. (N=30/Max. Premolars), and (N=10/group) for each TAC, CAC and SC groups.

Sample Collection

Samples were collected from multiple hospitals and dental centers in Khartoum State, Sudan. Thirty extracted human, mature, intact maxillary first premolars extracted for orthodontic reasons were included in this study: (N=30/type) were assigned to the three groups, TAC, CAC or SC (N=10/group). Group allocation was done randomly into the three groups.

Preservation and Storage

After debridement and removal of staining, calculus, and attached soft tissue with hand scaling instruments, the teeth were stored in 10% formalin (Trust chemical laboratories India) for one month until used, and between preparation and testing for fracture strength teeth were stored in distilled water to prevent dehydration.

Specimen Preparation

All preparations were carried out by one operator (the author) to minimise confounding factors and variables. The endodontic cavities were drilled with tapered high-speed diamond burs and a pathway to the pulp space and the canal orifices achieved. Irrigation with sodium hypochlorite 2.5% was used thoroughly between each instrument change and throughout canal preparation, using a 30 gauge needle.

Working length was determined using ISO size 10 K-file to negotiate canals to full working length and then the apical part of canals was negotiated with a series of progressively increasing size hand K-files #15 and #20, 25 and 30.(Manikin, Tochigi, Japan). Balance-force action was used to create a pathway to working length and canal preparation continued in sequence until #25 apical size for both palatal and buccal canals.

Traditional Access Cavity (TAC) preparation

The pathway was unimpeded and unobstructed for TAC group to create straight-line access. The convenience form used was to allow for unobstructed access to the canals orifices, conventional coronal flaring and direct access to the apical foramen (Figure-1).

Conservative Access Cavity (CAC) preparation guidelines

Clark and Khademi [12] conservative access model was used as a general guide. Coronal access preparation used was the removal of as little tooth structure as necessary to locate canals orifices and to maintain a soffit which was defined as a small piece or tiny lip of dentinal roof of 0.5 mm-3.0 mm around the entire pulp chamber [13]. Radicular apical preparation was just wide enough to clean canals and remove the biofilm, without aggressive dentin removal for shaping (Figure-1).

Fig-1: Prepared maxillary premolars

In this study design canals were left prepared without obturation, contrary to normal clinical setting, so as to eliminate and exclude confounding variables such as types, methods and efficiency of obturation and restorations [14].

Specimen mounting and loading for test

All the teeth including the sound control groups, after instrumentation were mounted on polyvinyl chloride (PVC) tubes (25 mm diameter x 25 mm height), with the roots embedded in self-curing resin (Acrostone/England) 3 mm apical to the cemento-enamel Junction to simulate the alveolar bone level. The resin was mixed according to the manufacturer's instructions and was inserted in the PVC cylinder immediately after mixing, and then the teeth were centrally-positioned with the long axis of the tooth parallel to the PVC mold walls (Figure-2).

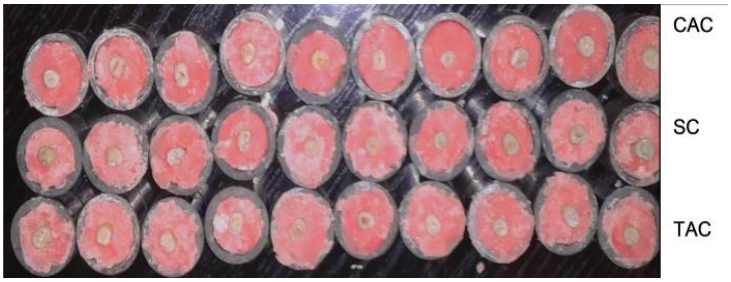

Fig-2: Maxillary premolars embedded in self-cure acrylic resin

The PVC molds were adjusted to place the loading arm of the testing machine over the center of the cavity preparation, with the load applied at the very centre of the occlusal surface of the tooth crown between the buccal and palatal cusps. All teeth were then subjected to gradual continuous nondestructive occlusal loading until failure, in a compression testing machine (Avery compression machine, UK), at the Material Lab Testing, Civil Engineering Department, College of Engineering, University of Khartoum, Sudan. (Fig-3).

Fig-3: A sample tooth loaded for testing

Failure was defined as a 25% or more drop in the applied load and this was noticed to be frequently preceded by a crack sound. The force required to fracture each tooth was then recorded in Kilo force and later converted to Newtons for statistical analysis.

Statistical analysis

The data for all three groups were found to be normally distributed using "Shapiro-Wilk normality test" and therefore the parametric tests (one-way ANOVA and post-hoc Tukey tests) were justified to compare data between groups and within groups (Figure-4).

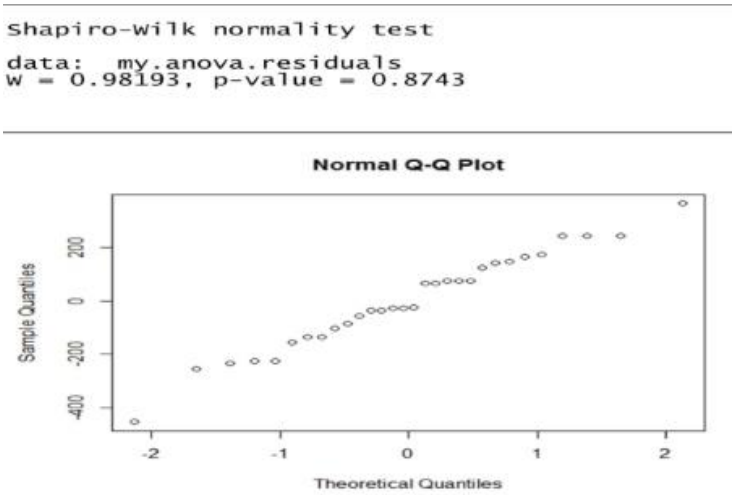

Fig-4: Normality test for fractue strength data

All tests were two-tailed and interpreted at the 5% significance level.

The software R & Rstudio for statistical computing and graphics was used for statistical analysis and for most of the graphics in this study

RESULTS

Fracture strength of CAC *was statistically significantly higher* (P Value = 0.0297226) compared to TAC groups, without differing significantly from the sound control groups (Figure-5), (Table-1).

Fracture pattern observed more often among TAC group was complete crown breakage and fracture extending to and below the cemento-enamel junction. Among CAC group wall fractures were observed more often.

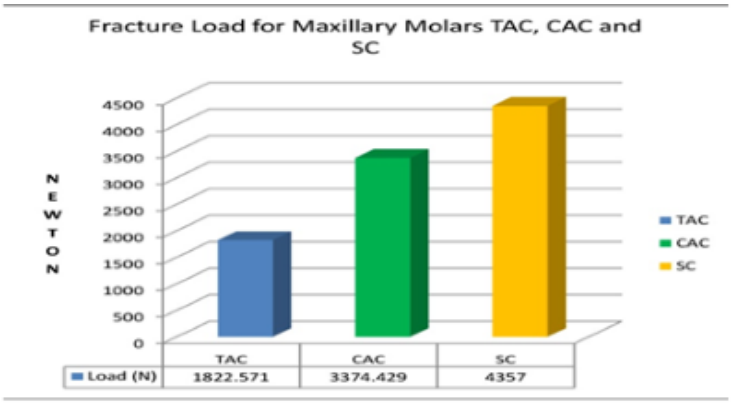

Fig-5: Fracture load in Newtons for maxillary pmolars SC, TAC and CAC groups

Table-1: Fracture load in Newtons (mean & standard Deviation), P Values in ANOVA and Tukey multiple comparisons of means for Maxillary Pre-molars TAC, CAC and SC groups

Fracture strength in Newton	TAC	CAC	SC	P Value (One way ANOVA)	Post-hoc Tukey test P Values
Mean	323.9 **d**	553.0 **D**	632.9 **D**		SC-CAC 0.6159595
ST.Deviation	±135.4437	±242.0698	±172.7950	0.00307 **	TAC-CAC 0.0297226 *
					TAC-SC 0.0029878 **

Similar letter case indicates nonsignificant differences (P >0.05); different letter case indicates a significant difference (p < 0.05). * Indicates significant difference, ** Indicates highly significant difference

DISCUSSION

This in vitro study was undertaken to assess the fracture strength of maxillary first premolars teeth with conservative access cavity (CAC) compared to traditional access cavity (TAC) using counterpart sound teeth as control groups (SC).

This study showed that fracture strength of CAC *was statistically significantly higher* (P Value = 0.0297226) compared to TAC groups, without differing significantly from the sound control groups.

Endodontically treated teeth are more susceptible to fracture than sound teeth primarily because of internal tooth structure removal during endodontic therapy [15]. The concept of minimally invasive dentistry [16] has led to the emergence of the recent conservative endodontic access cavity, aiming at preserving sound dentin by avoiding de-roofing of the pulp chamber and avoiding ove-flaing of canal orifices as well as avoiding aggressive dentin removal for shaping [17]. This trend to cut smaller-sized access cavities was influenced by the use of the operating microscope, lighting and magnification, highly flexible instruments and better imaging devices such as CBCT and micro-CT.

In this study, the results are consistent with previous work of Ibrahim A *et al.*, [17] and also in agreement with Plotino G *et al.*, [18] who found fracture load was significantly higher for CAC groups in all posterior teeth.

In clinical settings, to treat carious-free teeth for endodontics is very rare and although there is no published data, but a study has given an estimate of 8% [19]. The shape and size of the access opening is governed by the extent of caries or previous restorations, and the CAC model even if applied partially may increase the fracture strength of endodontically treated maxillary premolars.

CONCLUSION

It is important to have a balance between cleaning and preserving tooth structure and if tooth condition permits, preservation of pericervical dentin and some soffit as practically as possible needs to be taken into consideration. In conclusion, in this in vitro study, preserving dentine coronaly (soffit) and cervically (pericervical dentin) increased the fracture strength significantly in maxillary premolars prepared with CAC model.

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