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# Evaluate the Effect of Tapered Canal Preparation on the Retention of Posts Cemented with Resin Cement - An in vitro Study

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## ABSTRACT

**Introduction:** In endodontically treated teeth with less remaining tooth structure posts are inserted to provide stability and retention for a core. The posts retention is dependent on various factors related to post like- cement post and cement dentine interaction, type of luting cement, and taper of the post.

**Aim:** This in-vitro study aimed to evaluate the effect of endodontic taper on post retention using parallel-sided prefabricated posts luted with dual-cure resin cement.

**Methodology:** Sixty freshly extracted human maxillary central incisors of approximately the same sizes were selected for this study. The Crown of these teeth was separated at the cemento-enamel junction and divided randomly into six groups of ten teeth each. Biomechanical preparation was carried out using different tapered Ni-Ti file systems ranged as 0.02, 0.04, 0.06, 0.08, 0.10, and 0.12 taper. Root canal obturation was done with gutta-percha using the lateral condensation method.

**Results:** Taper 0.02 represents the taper size where a smaller average force was required to remove the post from the root canal. The average force required to remove the post from the root in taper group 0.02 was statistically different from all other taper sizes. Taper size 0.04 required highest average force to remove the post. Average force for size 0.04 was statistically different from the taper size 0.02, 0.06, 0.08, 0.10, 0.12 tapers.

**Conclusion:** The result of the present study indicates that increasing taper of root canal adversely affect the post retention. The findings of this study indicate that instrument taper size preparation of the canal makes a difference to resistance to post dislodgement.

**Key Words:** Post Retention, Prefabricated Post, Polymerization shrinkage, Resin Cement, Fracture, C-Factor

## INTRODUCTION

Endodontics has become an increasingly routine facet of patient care in general dental practice. Success in endodontic treatment depends almost completely on how well the root canal is shaped and cleaned. Principles of root canal preparation are to remove all organic debris and microorganism from the root canal system and shape the walls of the root canal to facilitate cleaning and subsequent obturation of the entire root canal system.<sup>1</sup>

Parallel sided posts are more retentive than tapered post and serrated or grooved posts are more retentive than smooth

posts. Cement thickness is a very important factor as parallel-sided post relies on even thickness of cement throughout the length of the post to overcome the inherent weaknesses of the cementing medium. With greater taper file systems root, canal walls are prepared to divergent. Parallel sided post-placement in a highly divergent canal lead to uneven thickness of luting cement throughout the post length. Thus highly tapered root canal preparation may have an adverse effect on postretention.<sup>2</sup>

The purpose of this study was to evaluate the effect of tapered canal preparation on the retention of posts cemented

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with resin cement. Retention of the post in canal prepared using 0.04 to 0.12 taper instruments were compared for retention against canal preparation using the traditional 0.02 taper instrument as a positive control. Sixty human maxillary central incisors were used and divided into six groups with different tapered root canal preparation. Prefabricated parallel-sided grooved posts were cemented in prepared post channels with resin cement. Retention of these posts was checked using the tensile testing machine. The hypothesis was that an increase in the taper of root canal results in a lowering of post retention.

## MATERIAL AND METHODS

Sixty Caries free, unrestored human maxillary central incisors recently extracted for periodontal reason were used for this study. Storage, handling, and Sterilization of extracted teeth were used in this study followed the occupational safety and health administration and the Centre for the Disease Control guidelines.

### Selection, preparation and storage of specimens-

All teeth were approximate of similar size and free of caries. Care was taken to select teeth to obtain 12 to 13 mm root length after crown removal at Cemento- Enamel Junction (CEJ). All teeth were free of open apices, fracture lines, resorptive areas.

Clinical crowns of teeth were removed at CEJ using high-speed air- rotor handpiece and diamond taper fissure burs. Teeth were observed at the cross sectional view of the root canal at CEJ and selected according to the internal diameter of the uninstrumented root canal so that the intracanal variation can be minimized.

Now the total of 60 teeth was selected and randomly divided into six groups consisted 10 teeth each group.

### Instrumentation of root canal-

After removal of the pulp tissue remnants by a barbed broach, # 10 K-file was inserted into each root canal until it could be seen through the apical foramen. The working length was established by reducing this length by 0.5mm.

### Group I- (Taper 0.02 Group) /control group

10 teeth in this group were prepared with hand Ni-Ti files (Dentsply/ Tulsa Dental), using RC Help (EDTA Gel) for lubrication and 2.5% NaOCl for irrigation. Teeth were instrumented using the step-back technique up to apical size # 30 and up to # 60 coronally according to the technique proposed by Walton.

### Group II- (Taper 0.04 Group)

10 teeth in this group were prepared using 0.04 taper rotary

Profile Ni-Ti files (Dentsply/ Tulsa dental) by using Crown down preparation using RC Help and 2.5% NaOCl solution. Files were used in contra-angle Gear Reduction handpiece (Technika, Dentsply/Maillefer) and torque control motor.

### Group III- (Taper 0.06 Group)

10 teeth were prepared using 0.06 taper rotary Profile Ni-Ti files (Dentsply/ Tulsa Dental), in crown down the manner in gear reduction handpiece with RC Help and 2.5% NaOCl solution.

### Group IV- (Taper 0.08 Group)

10 teeth were prepared using 0.08 taper rotary NRT files (Mani/Prime dental products), in crown down the manner in gear reduction handpiece with RC Help and 2.5% NaOCl solution.

### Group V- (Taper 0.10 Group)

10 teeth were prepared using 0.10 taper rotary NRT files (Mani/ Prime dental products), in crown down the manner in gear reduction handpiece with RC Help and 2.5% NaOCl solution.

### Group VI- (Taper 0.12 Group)

10 teeth were prepared using 0.12 taper rotary NRT files (Mani/ Prime dental products), in crown down the manner in gear reduction handpiece with RC Help and 2.5% NaOCl solution.

All teeth were thoroughly irrigated with 10 ml of 2.5% NaOCl solution and dried with paper points.

### Obturation of teeth

The root canals were dried thoroughly with appropriately sized paper points. All root canals were obturated with suitable gutta-percha points and AH Plus Sealer. Sealer was mixed according to the manufacturer's directions and applied into the root canals with leptospiral attached to a slow speed Micromotor handpiece. Roots were left undisturbed for 48 hours for thorough setting of sealer.

### Preparation of the post space

All roots were marked at 8mm downward from the CEJ to produce a constant depth of post space preparation. It allowed about 3-5 mm gutta-percha seal apically after post-space preparation in the root canals. Gutta-percha was removed by using heated pluggers. Then post channels were prepared using Peesoreamers. The size of final Peesoreamers was selected after evaluation of prepared root canal size. After post space, preparation corresponding sized EG posts (Effective Groove post) were checked inside the prepared post space for closest fit and to assure 8 mm embedment depth and passivity of fit into the post space.

## Cementation of posts-

### Step I- Etching

- 37% phosphoric acid gel was applied to the root canal for 30 seconds.
- Canals were rinsed for 10 seconds with distilled water.
- Root canals were dried with paper points.

### Step II- Bonding

- A bonding agent was applied to the canals.
- Excess was removed with dry paper points.
- Dried for 5 seconds.
- Light curing was carried out for 10 seconds.

### Step III- Cementation

- 3M RelyX ARC was dispensed on the mixing pad, mixed for 10 seconds and applied to root canal walls with leptospiral.
- A thin layer of cement was placed on the posts and posts were seated slowly in the prepared post channels and held vertically by exerting slight pressure at the post head.
- Excess cement was removed and light-curing of cement was carried out for 40 seconds from the occlusal direction.

## Preparation for testing

Roots of all teeth were embedded in acrylic resin blocks, parallel to the long axis of the root. Then they were stored in the saline solution until tensile testing. All the specimens of six groups were subjected to Scientific Tensile Testing Machine at the crosshead speed of 2 inches/min. the load was gradually increased and the tensile force required to initially break the cement bond and partially or remove the post was recorded.

## OBSERVATIONS AND RESULTS

In this study, the influence of tapered canal preparations on post retention was evaluated using a Scientific tensile testing machine. This study was conducted in vitro using 60 extracted human maxillary central incisors. Six groups were created and ranged as 0.02, 0.04, 0.06, 0.08, 0.10, and 0.12. Each group comprises ten teeth.

The required force to dislodge posts from the specimens were recorded in kilograms and summarized in (Table-1) (Graph1&2). Following observation was made with each experimental group-

### GROUP I (Control group)/ 0.02 taper Group-

The mean force required to dislodge posts was 8.53 Kg. The minimum value of force required was 7.23 Kg and the maximum value of force was 9.58 Kg.

### GROUP II / 0.04 taper Group-

The mean force required to dislodge posts was 23.25 Kg. The minimum value of force required was 21.91 Kg and the maximum value of force was 24.97 Kg.

### GROUP III /0.06 taper Group-

The mean force required to dislodge posts was 19.21 Kg. The minimum value of force required was 18.24 Kg and the maximum value of force was 20.89 Kg.

### GROUP IV /0.08 Taper Group-

The mean force required to dislodge posts was 19.10 Kg. The minimum value of force required was 17.84 Kg and the maximum value of force was 20.59 Kg.

### GROUP V / 0.10 Taper Group-

The mean force required to dislodge posts was 16.38 Kg. The minimum value of force required was 15.18 Kg and the maximum value of force was 17.33 Kg.

### GROUP VI / 0.12 Taper Group-

The mean force required to dislodge posts was 14.76 Kg. The minimum value of force required was 14.07 Kg and the maximum value of force was 15.59 Kg.

Dislodged posts were observed after tensile testing for failure mode. In all groups, failure was noted at the resin cement-dentin interface i.e. adhesive failure. Most of the resin has adhered to the post with little remaining on the root canal. No root fracture was noted in any group. Thus failure noted was due to the loosening of posts in all groups with increasing tensile forces.

## STATISTICAL ANALYSIS

Statistical analysis was conducted by using a one-way ANOVA test. Results are summarized in the table. One-way ANOVA indicated a very highly significant difference between means of all groups, i.e.  $p = 0.0000$  ( $p < 0.0001$ ). (Table 2) (Graph 3).

Tukey HSD (Honestly significant test) test was conducted to find out homogeneity between groups. Only 0.06 and 0.08 taper groups were found homogenous. (Table 3) (Graph 4)

Taper 0.02 represents the taper size where a smaller average force was required to remove the post from the root canal. The average force required to remove the post from the root in taper group 0.02 was statistically different from all other taper sizes.

Taper size 0.04 required the highest average force to remove the post. Average force for size 0.04 was statistically different from the taper size 0.02, 0.06, 0.08, 0.10, 0.12 tapers. All taper sizes were different from each other except 0.06 and

0.08 taper sizes were found homogenous as per the Tukey HSD test.

## DISCUSSION

In this study six groups of ten teeth, each were prepared with tapers of 0.02, 0.04, 0.06, 0.08, 0.10, 0.12 and parallel-sided grooved posts were cemented in prepared post space with the help of dual-cure resin cement.<sup>3-6</sup> Resin-based AH plus sealer is used as eugenol based sealers are reported to inhibit polymerization of the composite resin.

The depth of the post preparation was 8 mm in all teeth to produce a constant post embedment depth. The dentin smear layer produced during the endodontic procedure is removed during the etching and rinse process. Infiltration of exposed collagen fibrils network with resin permits the formation of resin dentin interdiffusion zone with resin tags and adhesive lateral branches, thus creating the micromechanical retention of the resin to the demineralized substrates. Post cementation was carried out using dual-cure resin luting cement (Rely X ARC, 3M, ESPE). Composite material is suggested as a luting agent for endodontic posts because it allows a latitude of 500 $\mu$  during the adaptation of the root canal.<sup>7</sup> Advantage of dual-cure cement is in areas deep inside the post space which are not accessible to light curing, thus requiring a chemical cure.<sup>8,16</sup>

All specimens were subjected to tensile force using a Scientific Tensile testing Machine after embedding in acrylic blocks. The increasing tensile force was applied at constant speed until post dislodgement occurs. Forces are recorded in kilograms.

All failures were noted at the cement-dentin interface which is usually noted with post luted with resin luting cement. Bonding of resin blocks of cement is mainly impaired by unfavourable root canal configuration, related to a high C-factor (cavity configuration factor), which may be up to 40 times higher compared to direct intracoronal restorations with similar cement thickness.<sup>9</sup> The C-factor indicate the ratio between the bonded and non-bonded surface areas. It allows resin flow with the consequent reduction in polymerization shrinkage stress.<sup>10,11,12</sup> With the reduced non-bonded area inside the root canals, reduces stress is not enough and polymerization shrinkage is higher than the bond strength, give rise to the formation of voids at the cement-dentin interface.<sup>13, 14,15</sup>

This in-vitro study has limitations as the tests were carried out in uniradicular teeth with specific dimensions and post preparations, under static tensile loading. Diverse retention values in the present study may be attributed.

- Various quantities of dentin particles in the prepared canal after cleaning and in smeared layers.

- Absence of control to ensure the identical position of all posts in the channel centre for uniform width of the cement layer surrounding the posts.
- Differences in the dentin of teeth resulting from moisture content, pulpal condition at the time of extraction, age of the patient, and direction of dentin tubules.
- Inconsistent and unpredictable cementing pressure during the setting process.
- Another factor of importance to consider is the shape of the root canal. Since root canals are seldom entirely conical, there will likely be uneven film thickness and possible voids.<sup>16</sup>

## CONCLUSION

The result of the present study indicates that increasing the taper of the root canal adversely affect post retention. The findings of this study indicate that instrument taper size preparation of the canal makes a difference to resistance to post dislodgement. Therefore it seems that the taper size is important in the restoration of endodontically treated teeth. More studies are needed to see how to taper preparation size affects the strength of the remaining root structure.

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Ethical Clearance: Not required (In-Vitro study)

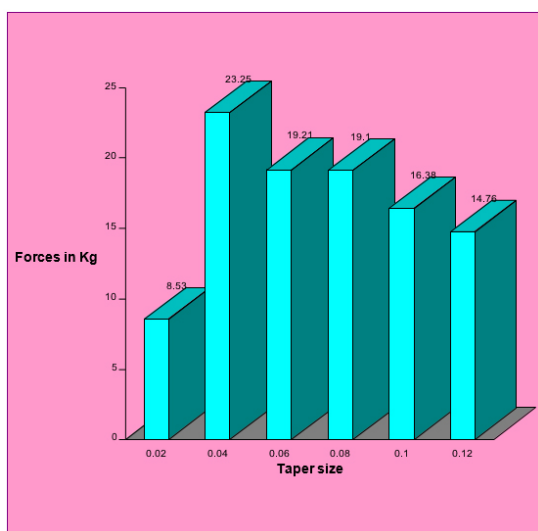
Patient consent: Not required (In-Vitro study)

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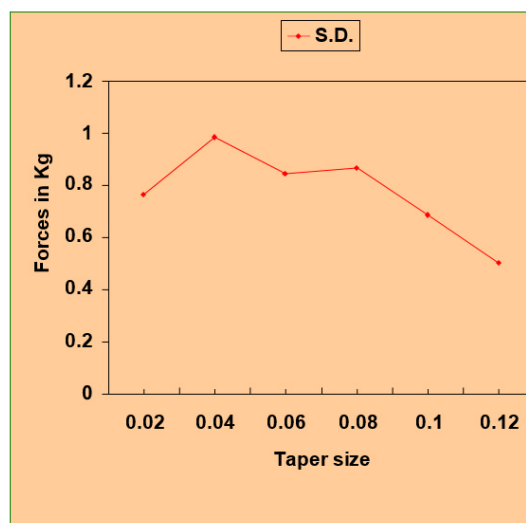
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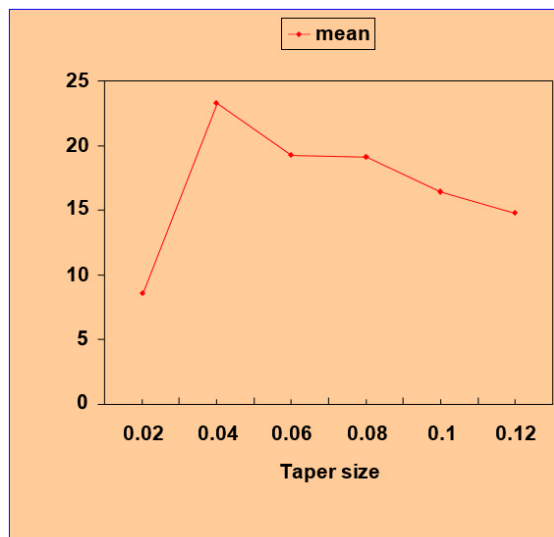
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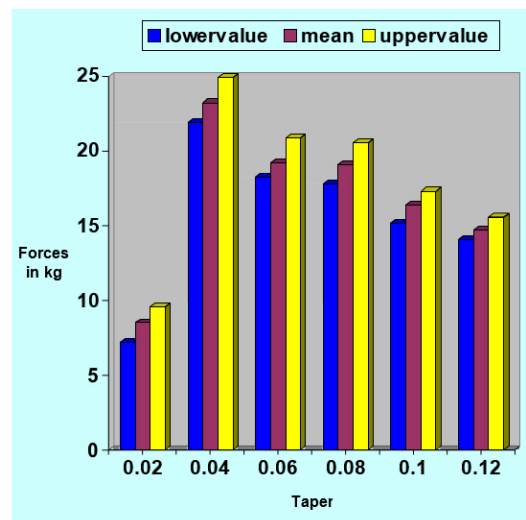
**Graph 1:** Comparison of Mean Force Value in Kilograms to Dislodge Posts from Different Taper Groups.



**Graph 3:** Comparison of Standard Deviation in Different Taper groups.



**Graph 2:** Comparison of mean forces in kilogram to Dislodge Posts In Different Taper groups.



**Graph 4:** Comparison of Upper and Lower Value of Force for Dislodgement of Post in Each Taper Group.

**Table 1: Mean Forces to Dislodge Posts from Different Tapered Canal Preparations**

Serial number	Taper Groups					
	0.02	0.04	0.06	0.08	0.10	0.12
1	8.97	23.03	18.75	19.06	16.10	14.98
2	7.23	23.24	19.16	19.57	16.10	14.48
3	8.15	21.91	20.18	20.59	16.72	14.16
4	7.74	23.14	18.85	17.84	16.30	14.07
5	7.95	21.91	20.89	18.96	15.18	15.59
6	8.35	23.44	18.35	19.37	16.82	15.09
7	9.17	23.24	18.24	18.35	17.12	14.78
8	9.37	24.67	18.76	20.18	15.49	15.18
9	8.76	22.93	19.98	18.14	17.33	15.08
10	9.58	24.97	18.96	18.96	16.72	14.27
Mean	8.53	23.25	19.21	19.10	16.38	14.76

**Table 2: Statistical Analysis by One Way Anova Test**

Group	Number	Mean	Standard Deviation	Significance
0.02	10	8.53	0.7653242	0.0000
0.04	10	23.25	0.9834751	0.0000
0.06	10	19.21	0.8455794	0.0000
0.08	10	19.10	0.8687641	0.0000
0.10	10	16.38	0.687084	0.0000
0.12	10	14.76	0.5012163	0.0000

**Table 3: Statistical Analysis by Tukey Test**

Group	Number	Subset for Alpha = 0.05				
		1	2	3	4	5
0.02	10	8.53				
0.12	10		14.76			
0.10	10			16.38		
0.08	10				19.10	
0.06	10				19.21	
0.04	10					23.25