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RESEARCH ARTICLE

IN VITRO EVALUATION OF EFFECT OF SPREADER SIZE ON THE FRACTURE RESISTANCE TOOTH

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ABSTRACT

To determine the effect of 'flare' spreader size on the fracture resistance of mandibular premolar roots prepared using variable taper rotary files. Crowns of 50 mandibular first premolars having no carious lesions, devoid of any aberrant anatomy were resected 2mm coronal to the cemento-enamel junction. Root canals were prepared in different groups: 1. No canal preparation. 2. Preparation using crown down technique to a size F2 MAF with no obturation performed. 3. Preparation using crown down technique to a size F2 MAF and obturated using lateral condensation; first spreader used being a size 25 flare spreader. 4. Same as 3 except first spreader used being a size 20 flare spreader. 5. Same as 3 except first spreader used being a size 15 flare spreader. All specimens were mounted in addition silicone putty and fractured vertically on a universal testing machine. Fracture load was recorded in kilogram force. Values obtained were analyzed using the ANOVA test. The mean force at fracture for roots obturated using size 15.05 spreaders approached similar values required to fracture uninstrumented samples. But was significantly higher than what was required to fracture samples filled using size 20.05 and size 25.05 spreaders. Spreader size used during lateral condensation of gutta percha may affect the fracture resistance of roots in extracted teeth. Larger size spreaders do decrease the fracture resistance and jeopardize the strength of obturated roots.

INTRODUCTION

Vertical root fracture is a clinical problem of increasing significance. It is defined as a longitudinal fracture of the root, initiating from the crown or root apex, or along the root between these points.[1] The prognosis of vertical root fracture is unfavourable. Their effect on the periodontium is profound and usually results in rapid bone loss, swelling and suppuration. Probing often reveals a deep localized periodontal defect.[2] Most of these cases require extraction of the affected tooth or, in molars, removal of the fractured root. Possible etiologies which have been suggested include trauma, weakened tooth structure from oversized post preparation, excessive pressure during post cementation, stress in the root during obturation and corrosion of posts and pins. Wedging forces of post placement and obturation are considered to be the two most common causes[3.] It has been established that vertical root fracture can initiate following canal preparation and filling, and then progress to more extensive fractures with time and occlusal stress[4]. Cold lateral compaction of gutta percha remains the standard against which other methods of canal obturation are compared.[5] In this technique, the choice of a spreader should be equal to the master apical instrument size or one size larger and touching the canal within 1.0 to 2.0 mm before the end-point of preparation.

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But the method of selecting and manipulating the spreader varies in most textbooks and guides[6], thus creating confusion in the minds of a beginner. In an effort to achieve deep spreader penetration, dentists sometimes use heavy condensation force. 85% of vertical root fractures have occurred due to this excessive force used.[7] The stress generated during filling procedures may be generated by the wedging effect of the spreader.[8] The average force utilized by an endodontist during lateral condensation range from 1 to 3 kg and it has been demonstrated that a vertical root fracture can occur with loads as small as 1.5 kg.[9] This possibility is increased further when a stiff spreader with a greater taper is used.[10] The spreader size is also an important variable since larger size spreaders have shown to decrease the fracture resistance of roots[11]. Canal shape resulting from different canal preparation techniques can alter the stress distribution during lateral condensation. A flared preparation allows condensation forces to the apical third of the canal and gives better distribution of stress than conventional preparation.[12] Rotary Ni-Ti files available today generally come with a complimentary obturating system. A single cone obturation procedure in such canals abates fracture of roots significantly as wedging effects of spreader and compaction forces are not created.[13] But, in clinical practice owing to cost effectiveness, conventional obturating techniques are still followed even when canals are prepared using rotary Ni-Ti files. The effect of size of the spreader with a greater taper (.05 as opposing .02

of ISO spreaders) on the fracture resistance of teeth shaped using variable taper rotary Ni-Ti files remains undocumented. Hence the aim of this in vitro study was to determine the effect of 'flare' spreader size on the fracture resistance of mandibular premolar roots prepared using variable taper rotary files.

MATERIALS AND METHODS

Specimens for this study consisted of 50 human mandibular first premolars extracted for orthodontic or periodontal purposes. The teeth were stored in isotonic saline solution for a period of 2 months. The root surfaces were thoroughly cleaned of soft tissue and calculus with an ultrasonic scaler. All root surfaces were examined under a magnifying glass for any root fracture, root resorption or cracks. Teeth with cracks, root caries, open apices or aberrant canal morphology were excluded. The teeth were radiographed before instrumentation to determine any teeth with previous pulpal obliteration or atypical canal morphology. Premolars featuring a straight root and a single canal throughout the length of root were included. Each tooth was held in gauze saturated with water during instrumentation. The crown of each tooth was rejected using a high speed diamond bur under water coolant 2mm coronal to cemento-enamel junction to facilitate straight line access for instrumentation and obturation. The working length was determined to be 1mm short of the length that a size 10 K-file was observed to exit the apical foramen. The flat surface 2mm above the cemento-enamel junction was used as the reference point. Fifty teeth were randomly divided into 5 groups of 10 each as follows: (Fig. 2)

Group 1: No canal preparation (Control group). The roots (n=10) remained uninstrumented with no obturation.

Group 2: Preparation to a size F2 MAF. No obturation Glide path was established with a size 10 and size 15 stainless steel K-file. Canals were prepared with ProTaper rotary files (Dentsply, India) in accordance with the manufacturer's instructions, using the crown down technique. An endodontic motor with torque control and a reduction gear handpiece (X-Smart, Dentsply, India) was used for shaping of root specimens. Coronal shaping was done with S1 and S2 files. Apical shaping and finishing was done with F1 & F2 files. Adequate amounts of Glyde (Dentsply, India) was used a lubricant to aid in the instrumentation of the canals. Two millilitres of 2.5% sodium hypochlorite was used as the irrigant to remove debris during and after instrumentation. Apical patency was maintained with a stainless steel size 10 K-file. A final rinse of 17% EDTA solution for 3 minutes followed by 2.5% sodium hypochlorite irrigation for 2 minutes was done. Teeth were stored in distilled water after the instrumentation procedure to prevent dehydration.

Group 3: Preparation to a size F2 MAF. Lateral compaction; Flare spreader- Size 25 (Mani, Japan). The 10 roots were instrumented as in group 2. Lateral compaction was performed as follows: After the root canals had been dried using absorbent paper points, a size 25 gutta percha master cone was tried in at working length. Prior to obturation, size 25.05 finger spreader (Fig. 1) was set to length with a silicone stop, and tried in the canal space without binding, to within 1mm of the working length. Next, the obturation was initiated by placing AH Plus sealer (Dentsply, India) on the canal wall using a size 20 stainless steel K file. The master cone was coated with sealer and seated to length. The size 25 spreader, already set to the desired length was inserted into the canal with apical pressure and left in place for 10 seconds to allow the gutta percha cone to reconform to this pressure. The spreader was removed with a reciprocating motion and immediately replaced by a size 25 auxiliary point inserted to full depth of the space left by the spreader. Following compaction of master cone using the initial spreader, only size 15.05 spreader was used subsequently. Size 15 auxiliary cones were added until size 15 spreader could not penetrate more than 2 mm beyond CEJ. When the obturation phase was completed, excessive gutta percha was removed with a hot instrument.

Group 4: Preparation to a size F2 MAF. Lateral compaction; Flare spreader- Size 20. The 10 roots were instrumented and filled in the same manner as in group 3 except the first spreader was equal to a size 20.05 (Fig. 1). A size 20 gutta percha cone was used as the first accessory cone followed by size 15 accessory cones only.

Group 5: Preparation to a size F2 MAF. Lateral compaction; Flare spreader- Size 15. The 10 roots were instrumented and filled in the same manner as in group 3 except the spreader utilized was a size 15.05 (Fig. 1). Only size 15 gutta percha cones were used as the accessory cones.

All the specimens were then mounted in Addition silicone putty (Coltene-Whaledent). A base of cold cure acrylic (DPI, India) was made over which each root was mounted vertically, such that the apex of the root rests on a hard surface and prevents displacement of the root during force application. The root specimens were embedded to a level of 2mm above the cemento-enamel junction. The putty was allowed to set for at least 30 minutes before teeth were tested. A circular cross sectioned tip having an area of $6mm^2$ was mounted on a universal testing machine (Autograph machine Shimadzu, Japan) to apply vertical force to the root. The root was centered under the tip and its coronal cut surface was parallel to the lower plate. A speed of 0.5mm/min was used to fracture the root (Fig. 3). The fracture was evidenced by an audible 'crack' and/or a sudden release of the tip load as seen on the graph. The load at fracture was recorded in kilogram force. Data was analyzed using ANOVA test to determine variances among all groups. All statistical analysis was performed at 95% level of confidence.

RESULTS

The mean force at fracture for each experimental group is presented in Table I. The smallest fracture load was 78.07 kg

Table I: Mean force at fracture for each experimental group

Groups	Mean force (kgf) ± SD
1	199.14 ± 3.64
2	81.58 ± 2.22
3	110.62 ± 2.73
4	151.67 ± 2.97
5	179.51 ± 2.63

kgf: kilogram force; SD: standard deviation

Table II: Intercomparison of fracture load among 5 groups using ANOVA test

Source of Variation	SS	df	MSS	F	P-value	Significance
Between groups	93694.72	4	23423.68	2821.918	< .001	HS
Error	373.52	45	8.30			
Total	94068.24	49				

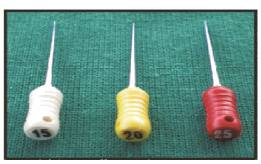
SS: sum of square; df: degree of freedom; MSS: mean sum of square; F: fisher's test; P-value: probability of error; HS: highly significant

Table III: Intercomparison of fracture load among 5 groups using ANOVA test

Group	Mean	Difference
2	81.59	
3	110.62	29.29
4	151.68	41.06
5	179.52	27.84
1	199.15	19.63
CD=2.60		

CD: critical difference

Fig. 1



Flare spreaders (5% taper)

Fig. 2

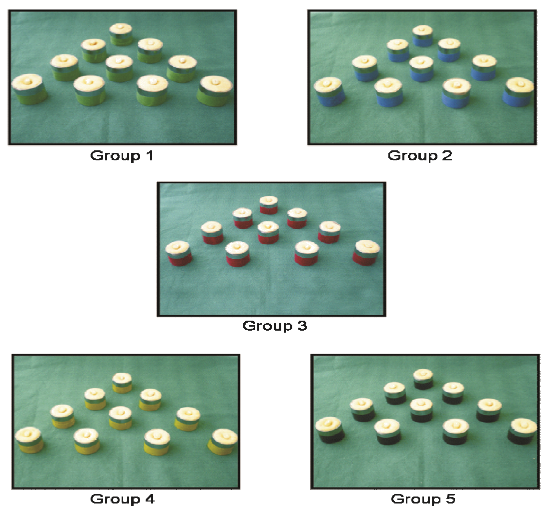
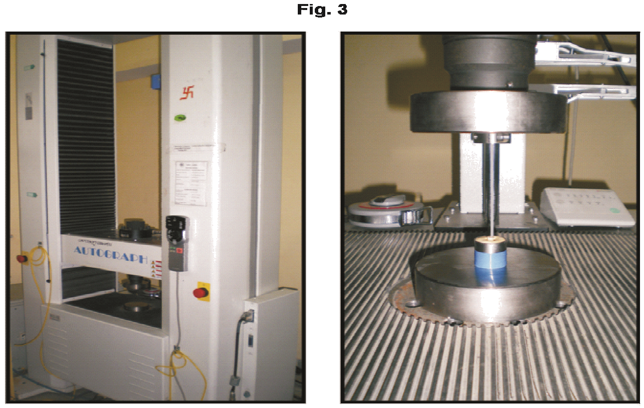


Fig. 3



Autograph, Universal Testing Machine

Compression load test for a sample

Figures

for a sample in Group 2 in which only canal preparation was done while the highest fracture load was 205.38 kg of a sample in Group 1, which was the uninstrumented group. The load required to fracture the root samples in the uninstrumented group was the highest (199.14 ± 3.64 kg). The root samples in group 5, obturated using a size 15 spreader required more force to fracture (179.51 ± 2.63 kg) than those root samples obturated using size 20 spreader in group 4 (151.67 ± 2.97 kg) and using size 25 spreader in group 3 (110.62 ± 2.73 kg). The load required to fracture the roots was lowest for group 2 (81.58 ± 2.22 kg) in which canal preparation was done followed by no obturation. On application of ANOVA test (Table II), the null hypothesis was refuted at 0.1% level of significance and it was concluded that all groups differ significantly. Intercomparison of fracture loads among the five groups was done according to which, the critical difference was calculated to be 2.60. Comparing the differences with critical difference (Table III), it was found that any given group differs significantly from each of the other groups. Hence, if the choice was made among the four techniques used in Group 2,3,4 & 5 (Group 1 being the control group), the obturation of roots using a smaller size spreader (Group 5) did not weaken the tooth to a greater extent as opposed to the other groups in which significant weakening of tooth samples was seen.

DISCUSSION

Cold lateral condensation of gutta percha is taught and practiced in every part of the world[14] and is the standard against which other methods of obturation are compared.[15] In this technique, the initial spreader should reach to within 1 to 2 mm of the working length. The importance of spreader penetration depth was reported by Allison et al.[16] Lateral condensation has been blamed as a cause of vertical root fracture.[7] Studies have suggested that this technique creates stresses in the root which could lead to subsequent fracture.[12]

A higher value of apical strain than coronal strain is generated during lateral compaction because of the reduced thickness of dentin in the apical portion of the root and the greater wedging effect of the spreader tip in the narrower part of the canal.[8] Mandibular first premolars were selected for this study as these teeth have recorded a high incidence of vertical root fracture.[17] All teeth were decoronated 2mm coronal to the cemento-enamel junction to facilitate straight line access for instrumentation and obturation. It was also considered to preserve as much coronal tooth structure as possible, because this could influence the extent of strain in the coronal aspect of the root.[8] Harvey *et al.*[12] have demonstrated that the shape of the canal preparation using different canal preparation techniques did influence the distribution of stress during lateral condensation. The flared preparation better distributes the condensation stresses generated throughout the length of the canal. This study utilized rotary NiTi files to prepare the resected tooth samples. Lam *et al.*[18] reported that roots prepared with increased taper do not weaken roots anymore than conventional K file preparations and may even increase the fracture resistance. The decreased frequency of canal transportation and perforations as well as superior canal cleanliness, canal centeredness leads to reduced areas of stress concentration which may offset the effect of increased dentin removed during biomechanical preparation.[19]

Spreader design has been related to vertical root fractures in various studies.[3] Selection of spreader type for lateral condensation is based on clinicians' preference. Finger and hand spreaders are frequently used for lateral compaction of gutta percha. Walton has suggested that the more flexible and less tapered finger spreaders[20] are safer than stiff, conventional hand spreaders. Pitts *et al.*[1] studied spreader loads required to cause vertical root fracture in anterior teeth. They reported that VRF occurred at loads as small as 7.2 kg. They further suggested that spreader loads be limited to 70% of the minimum force required to fracture a root. In accordance with that, a safe limit of 5 kg should be used during spreader penetration. The effect of the material of the spreader, whether it is made of stainless steel or nickel titanium has also been studied as regards the stresses produced during obturation by lateral condensation.[21] It was found that there was no significant difference in photoelastic stress induced by both types of spreaders in straight canals. The effect of spreader size used during lateral condensation of gutta percha can affect the fracture resistance of roots in extracted teeth as was previously proven by Piskin *et al.*[11] The present study evaluated the effect of spreader size with an increased taper, 'flare' spreaders, on the fracture resistance of mandibular first premolars. Different methodologies have been utilized in previous studies to study the fracture loads transferred by a spreader mounted on the moving head of a compression testing device either during or after gutta percha obturation. The distribution of stresses has been investigated using strain-gauge measurements, photoelastic techniques and finite element analysis. In accordance with the method used by Piskin *et al.*[11], VRF was produced by using a 6mm^2 tip to apply vertical force to the root in this study. Since the total surface area of occlusal contacts in static occlusion equal to 4-6 mm^2, this method correctly reflected the VRF caused by occlusal forces.[22]

It has been speculated that actual fracture may not occur at the time the force is applied. Rather, the distortions created during the procedure may accumulate in dentin and manifest as actual fracture months and even years later. This may be because dentin has sufficient elasticity to permit separation without complete VRF. These incomplete fractures may become high stress concentration areas. When force is applied during mastication or a restorative procedure, then the crack may progressively propagate from root canal wall to outer surface.[2] The mean force at fracture for Group 5 roots obturated using size 15.05 spreaders (179.51 kgf) approached similar values required to fracture uninstrumented samples of Group 1 (199.14 kgf). But was significantly higher than what was required to fracture Group 3 and 4 samples filled using size 25.05 (110.62 kgf) and size 20.05 (151.67 kgf) spreaders respectively. The present study revealed that larger size spreaders do decrease the fracture resistance and jeopardize the strength of obturated roots. The size of the initial spreader may be an important factor to prevent extra loading of the roots during lateral condensation technique. Although the variations in root morphology, dentin thickness, calcifications and canal preparation techniques alter the results, the values obtained in this study showed a similar pattern to the results of the study done by Piskin *et al.*[11] in which the uninstrumented group had the highest fracture resistance, unfilled roots had lowest fracture resistance and roots obturated using ISO spreader size 25 were significantly stronger than samples obturated using size 35 and 40 spreaders. The samples prepared in this study had acrylic acting as a base. This was to prevent the apical displacement of tooth during force application. Limitations of the sample models prepared for testing such as missing coronal tooth structure, absence of alveolar housing and periodontal ligament fibres may affect the extent of developed stresses.[23] It remains unknown whether equal compaction force could have significantly different effect when exerted on extracted teeth compared with clinical conditions. Another limitation is that elastomeric material used is incapable of withstanding compaction forces in the same way as natural PDL does. Under heavy loads, it would collapse and cause direct tooth to acrylic socket contact which never occurs in vivo (with bone).[24]

CONCLUSION

Within the parameters of this study, the following conclusions may be drawn:

- Mandibular premolars prepared using variable taper rotary files have higher fracture resistance when obturated using smaller size flare spreaders.
- The size of the initial spreader may be important to prevent extra loading of the roots obturated by lateral condensation method.

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