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Original Research Article

Comparison of fracture resistance of mandibular central incisors following the use of two different spreaders during lateral condensation obturation technique- An in vitro study

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ABSTRACT

Introduction: The lateral condensation is the most commonly practiced obturation technique during root canal treatment. In this method, the use of spreaders is instrumental in acheiving 3-D obturation. These spreaders can create an unnecessary stress during use, by means of wedging force that might lead to vertical root fracture, resulting in failure of root canal treatment.

Materials and Methods : Sixty extracted mandibular central incisors were taken. All teeth were sectioned 2 mm coronal to CEJ and were wrapped in aluminium foil. The specimens were embedded in acrylic mould. Aluminium foil was scratched and the created space was filled with light body silicone impression material. Then, after working length determination, apical preparation was done with 40 no. K- file. Rest of the canal was prepared using step back technique. The samples were then randomly divided into 3 groups of 20 samples each. Group 1 No obturation (control group). Group 2 Obturation done using stainless steel finger spreaders. Group 3 Obturation done using nickel titanium finger spreaders. After the obturation, all samples were subjected to fracture using metal indenter on the universal testing machine. The load at which fracture occur was recorded. Data thus obtained was subjected to statistical analysis using ANOVA and TUKEY test.

Results: The mean fracture resistance of group 1 was highest followed by group 3 (NiTi spreader) and least in group 2 (SS spreader).

Conclusion: NITI or SS spreaders can affect the fracture resistance of teeth during lateral condensation obturation technique.

1. Introduction

The main goal of root canal treatment (RCT) is to eliminate microbes from the infected root canal or to remove pulpal ramnants and obtain a 3-dimensional seal with a biologically acceptable obturating material. Ideally, all obturating materials must be well condensed and adhere to the instrumented canal walls, seal all foramina, and should end 0.5–1 mm short of the radiographic apex.[1] Achieving the hermetic seal, however, is as complex as the anatomy of the root canal system itself.

So, different obturation techniques have been advocated to achieve the best adaptation of gutta-percha to the canal walls. Amongst all, lateral condensation (LC) still boast one of the most widely used method for obturation of the root canals.[2,3] During LC technique, spreaders apply vertical and lateral forces to create space for accessory gutta-percha cones. These forces exert wedging effect on the tooth[4,5] which can cause stress concentration in some areas leading to vertical root fracture (VRF), ultimately results in

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extraction of the tooth.[5–7]

For decades stainless steel (SS) finger spreaders and hand spreaders have been in use in the process of LC technique.These SS spreaders are rigid in nature, have higher modulus of elasticity and low corrosion resistance. While on the other hand nickel titanium (NiTi) finger spreaders have revolutionized the field of dentistry and they can also be used due to their improved properties of shape memory, super elasticity, and resistance to corrosion leading to decreased chances of vertical root fracture.[8]

Vertical root fracture are longitudinally oriented, complete or incomplete fracture initiated in the root at any level and is usually directed buccolingually.[9,10] Amongst various causes, the prevalence of VRF in endodontically treated teeth found to be 2%–5% due to excessive forces during obturation.[5,11–13] VRF, especially when incomplete poses a diagnostic challenge because the fracture line may not be visible as long as it has extended to the cervical region. Delay in diagnosis results in loss of supporting bone which may influence treatment modalities.[14]

So in order to ascertain the impact of SS and NiTi finger spreaders during obturation of the root canal, this in vitro study was undertaken to compare the fracture resistance of the tooth using these spreaders.

2. Materials and Methods

Sixty mandibular central incisor teeth extracted for periodontal reasons were collected for the study from department of Oral Maxillofacial Surgery, Sardar Patel Post Graduate Institute of Dental and Medical sciences, Lucknow. Intact teeth with straight, completely formed root having one root canal terminating in single apical foramen were included. Calcification or anatomic variations like dilacerations were excluded. Both inclusion and exclusion criteria were confirmed by magnification and radiographic examination. The soft tissues and debris from the teeth were cleaned using ultrasonic scaler. All the teeth were autoclaved at 121^0C, 15lb pressure for 15 min and stored in distilled water at room temperature, to prevent dehydration, till further experimentation.

2.1. Preparation of specimen

The crown of teeth was sectioned 2 mm coronal to the CEJ using a carborundum disc under copious water cooling (Figure 1A). Thereafter, each tooth was wrapped in a single layer of aluminum foil of 0.15 mm thickness leaving 4 mm coronal tooth structure. Self-polymerizing resin (Dental products of India Ltd, India) was filled into the tubular moulds (25.4mm length x 12.7mm diameter x 1.5mm thickness) and sectioned teeth were embedded into the moulds upto the level of aluminium foil.

After the resin sets completely, the teeth were removed from the moulds and aluminum foil was scraped off. Light body silicone impression material (Coltene, Switzerland) was filled into the created socket and the sectioned teeth were repositioned. During repositioning, light body impression material took the space which was created by aluminium foil. Then, the excess light body material which oozed out of the artificial socket was removed using a No.12 surgical blade.

2.2. Preparation of sample

Access cavity was prepared and working length was determined radiographically in all the prepared specimens. The biomechanical preparation was done using step back technique (apical third was prepared upto K-file size 40 to maintain the uniformity followed by three sizes enlargement of middle and coronal third of the canal). Then, the prepared specimens were randomly divided into three groups of twenty samples each.

Group 1: No obturation was done kept as control group.

Group 2: Obturation was done using SS finger spreaders.

Group 3: Obturation was done using NiTi finger spreaders.

Each sample was centered on the platform of the lower plate of universal testing machine for obturation. The specified spreader mounted on crosshead tip was driven into the canal with a constant load of 1.60 kg at the rate of 1mm/min along the long axis of the tooth. LC obturation with gutta percha and ZOE sealer was carried out (Figure 1B). The samples were then stored in an incubator at 37^0C and 100% humidity for 7 days.

2.3. Fracture resistance testing

All samples were subjected to fracture using universal testing machine. A metal indenter of tip size $4mm^2$ was used to apply force on the sample with increasing load of crosshead tip at the rate of 1mm/min until fracture occurred (Figure 1C) (Figure 1D). The fracture was evidenced by an audible crack or a sudden drop in load as seen on the graph of the monitor screen. Thereafter values were noted and data thus obtained was subjected to statistical analysis using ANOVA and TUKEY post hoc test.

3. Results

3.1. Statistical analysis

Data were summarised as Mean ± SD (standard deviation). Groups were compared by one factor analysis of variance (ANOVA) and the significance of mean difference between (inter) the groups was done by Tukey's HSD (honestly significant difference) post hoc test. A two-tailed (α=2) $P<0.05$ was considered statistically significant. Analysis was performed on SPSS software (Windows version 17.0).

The fracture resistance of Group 1, Group 2 and Group 3 ranged from 16.99 -25.36, 6.49 – 9.73 and 11.41 – 16.81

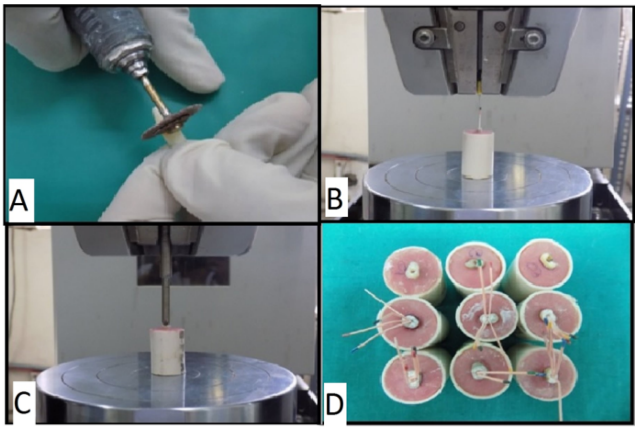

Fig. 1: **A:** Sectioning of tooth with carborundum disc; **B:** Spreader was mounted on the crosshead of the testing machine to apply vertical force of obturation on the prepared sample; **C:** Metal indentor applying force on the obturated sample; **D:** Fractured samples.

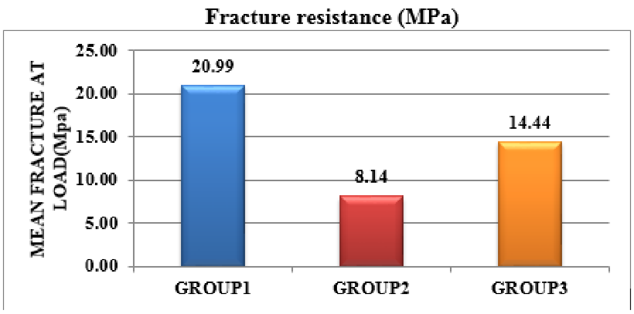

Fig. 2: Mean fracture resistance of three groups.

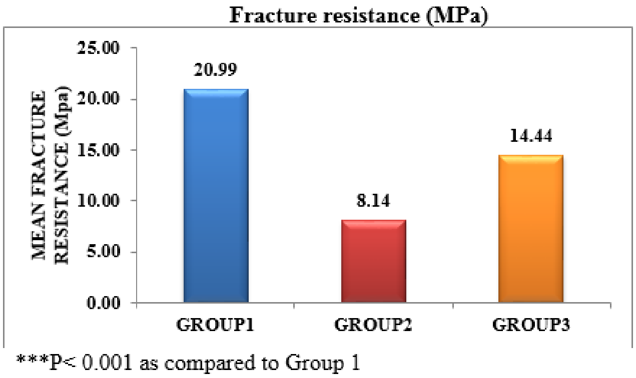

Fig. 3: Comparison of mean fracture resistance between three groups.

respectively with mean (± SD) 20.99 ± 2.45 MPa, 8.14 ± 0.94 MPa and 14.44 ± 1.66 MPa respectively and median 21.16, 8.12 and 14.83 respectively. The mean fracture resistance of Group 1 was the highest followed by Group 3 and Group 2 the least (Table 1 and Figure 2).

Comparing the mean fracture resistance of three groups, ANOVA showed significantly different fracture resistance among the groups (F= 257.17, P<0.000) (Table 2).

Further comparing the mean fracture resistance between the groups, Tukey test showed significantly different and lower fracture resistance of Group 2 (61.24%) (20.99 ± 0.54 vs 8.14 ± 0.21, mean difference =12.85, q= 21.34, p< 0.001), Group 3 (31.21%) (20.99 ± 0.54 vs 14.44 ± 0.37), mean difference =6.55, q=11.40, p< 0.001) as compared to Group 1 (Table 3 and Figure 3).

According to the final statistical analysis, the mean fracture resistance of Group 1 was the highest followed by Group 3 and Group 2 the least - (Group 1 > Group 3 > Group 2)

4. Discussion

The main goal of ideal obturation is to prevent reinfection by acting as a barrier for microorganisms. Among the various obturation techniques, lateral condensation has been the most widely used standardized technique.[6,15]

Lateral condensation technique utilizes either stainless steel or nickel titanium finger spreaders. Finger spreaders were used in the current study, due to the fact that they provide better tactile sensation and are less likely to induce root fracture as compared to hand spreaders. The advantages of SS spreaders include stiffness and lower cost while, NiTi spreaders has high flexibility, shape memory, and minimum work-hardening properties.[8,16–18] In the present study single rooted extracted human mandibular central incisors were taken because they have most susceptible roots showing VRF subsequently after maxillary or mandibular premolars.[19] The teeth were decoronated 2 mm coronal to the cemento enamel junction as it eliminated the variable of access cavity preparation and to ensure standardization of the tested sample. The sectioned teeth were embedded in self cure resin mould to act as alveolar bone and light body silicone impression material was used to simulate PDL as in clinical conditions.[20] For endodontic treatment, step-back preparation using 3% sodium hypochlorite and 17% Ethylene diamine tetra acetic acid as irrigant was done as it is the frequently practiced technique by the clinicians.[21]

It has been reported that during lateral condensation, the vertical and lateral forces applied by the spreaders may result in microcracks or incomplete VRF. Saw and Messer, 1995[3] suggested that the wedging effect of the spreader during obturation was either by direct contact with the canal walls or transmitted via gutta-percha. Generally, the VRF may occur when it is subjected to loads higher than 1.5 kg.[22] Therefore, in present study, constant higher load of

Table 1: Summary of fracture resistance (MPa) of three groups

Group	N	Mean	Median	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Group 1	20	20.99	21.16	2.45	0.55	19.84	22.14	16.99	25.36
Group 2	20	8.14	8.12	0.94	0.21	7.69	8.58	6.49	9.73
Group 3	20	14.44	14.83	1.66	0.37	13.66	15.21	11.41	16.81

Table 2: Comparison of mean fracture resistance by one wayAnova.

	Sum of Squares	Degree of freedom	Mean Square	F-Value	P-Value
Between Groups	1652.855	2	826.427	257.17	0.000
Within Groups	183.173	57	3.214		
Total	1836.028	59			

*P< 0.001 consider statistically significant.

Table 3: Comparison of mean fracture resistance byTukey's HSD post hoc test.

Comparison	Mean Difference	Mean Difference (%)	q-value	P-Value	95% Confidence Interval
Group 1 vs. Group 2	12.85	61.24	21.34	< 0.001	11.49 to 14.22
Group 1 vs. Group 3	6.55	31.21	11.40	< 0.001	5.19 to 7.92
Group 2 vs. Group 3	-6.30	43.65	11.20	< 0.001	-7.66 to -4.94

*P< 0.001 consider statistically significant.

1.6 kg was kept for obturation so that it could result in VRF. It has been speculated that microcracks or incomplete crack line begin during canal instrumentation and obturation might propogate to complete VRF with time under occlusal stress.[20]

The metal indentor of tip diameter 4 mm^2 was used to mimic the clinical situation. Hoffmann et al, 1989[23] described that the total surface area of occlusal contacts in the static occlusion equal to 4 to 6 mm.[2]The force was applied along the long axis on the access cavity margin, resulting in a splitting stress. Therefore, stresses generated from inside the root canal walls were transmitted through the root dentin to the external surface leading to microcracks formation which might result in VRF during continuous occlusal load. The test ended, with an audible crack sound. This study showed most of the complete or incomplete fractures were occurred in bucco-lingual plane. Dhawan et al, 2014[11] and Holocomb et al, 1987[4] also reported that 87% of the fractures were extended buccolingually from the inner canal wall to outer canal wall when viewed in cross-section.

In the present study, the fracture resistance of teeth was compared when SS and NiTi spreaders were used during LC technique. The results showed that the values of mean fracture resistance for group 1(20.99 MPa) was significantly higher than both the obturated group 2(8.14 MPa) and group 3(14.44 MPa). This implied that any form of obturation by lateral condensation either using SS or NiTi spreaders leads to eventually weakening of tooth structure.

Furthermore, on comparing group 1 vs group 2 and group 1 vs. group 3, the mean difference was 12.85 and 6.55 respectively which was significantly high (p< 0.001). Dhawan et al, 2014[11] in their study, reported that the stress concentration during obturation was much more likely to cause the microcracks propogation which might lead to vertical root fracture. They also reported that dentin has sufficient elasticity to permit some absorption of stresses without creating a total fracture. But improper load might cross this limit which induced microcracks formation or vertical root fracture. In current study, the mean difference of group 2 vs. group 3 was 6.30, which was statistically significant (p< 0.001). This showed that the fracture resistance values for group 2 were significantly lower than the group 3. This implied that SS spreaders were indeed detrimental for the structural integrity of root dentin as compared to NITI spreaders. Joyce A et al, 1998[18] in their study found that the stainless-steel spreaders created three areas of concentrated stress mainly coronal area of canal, curvature of canal and apical end of canal. Whereas, the nickel-titanium spreaders distributed stressesall along the surface of the canals, thus reducing the concentration of stress and the potential for vertical root fracture. Moreover, Gharai SR et al, 2005[24] and Vimala N, 2012[25] in their classical study observed that NiTi spreaders require significantly less force than SS spreaders. Therefore, to minimize the risk of VRF, NiTi spreaders should be the spreader of choice for lateral condensation obturation technique.

5. Conclusion

The results of this study showed that the fracture resistance of mandibular central incisors were higher when NiTi finger spreaders were used during lateral condensation technique as compared to SS finger spreaders.

Therefore, within the limitations of this study it can be inferred that SS finger spreaders exert more stress on the root dentin than NiTi finger spreaders. However, more in-vitro/ in-vivo studies are needed to establish more appropriate and conclusive data and the relationship between vertical root fracture and lateral condensation technique of obturation.

6. Source of Funding

None.

7. Conflict of Interest

None.

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