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Assessment Of The Fracture Resistance Of Mandibular Premolars Instrumented Using Rotary And Reciprocating Files And Obturated With Different Obturation Techniques:- An In-Vitro Study

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ABSTRACT
AIM OF THE STUDY*: This article evaluates the fracture resistance of mandibular premolars instrumented using rotary and reciprocating files and obturated with different obturation techniques.*
MATERIAL AND METHOD*: Sixty extracted human mandibular premolars were decoronated at the level of cementoenamel junction and working length was determined using #10 K-file. Specimens were randomly divided into five groups as control group (no treatment), K3XF file system group (rotary motion), EdgeEndo file system (rotary motion), ProTaper Next file system (reciprocation motion) and Reciproc Blue file system (reciprocating motion). Except Group I, all groups were prepared using #15 K-file and later, preparation was followed with the respective file systems till 40/0.06. The canals were irrigated using 5% NaOCl, normal saline, EDTA and distilled water. They were sub-divided as group A obturated with single cone gutta percha obturation technique while group B obturated using thermoplasticized gutta percha obturation technique. All the specimen were allowed to set for 7 days and tested under universal testing machine. One way ANOVA and tukey's multiple comparisons were applied to test for evaluation of fracture resistance among all the groups.*
RESULTS*: The results showed that group I had the highest fracture resistance among all the groups followed by group IV, group II, group V and lowest was seen in group III. When group A and B were evaluated, then group A depicted higher fracture resistance than group B.*
KEYWORDS*: Endodontics, Obturation, Biomechanical preparation, Irrigation, Fracture resistance.*

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I. INTRODUCTION

One of the key phases to ensure the success of endodontic therapy is canal preparation as it determines the efficiency of all the following procedures including flushing and irrigation of the root canal, intracanal medicament delivery to all the inaccessible areas of root canal via instrumentation, while maintaining canal geometries and anatomical structure for obturation.[1]

During biomechanical preparation, root canal is shaped by the contact and friction of files against the root dentinal walls. This contact creates numerous momentary stress concentrations areas in dentin which produce dentinal defects and microcracks that are associated factors for increased vertical root fracture susceptibility. Undesirable stresses initiated by various procedures such as obturation, retreatment, and repeated occlusal forces are amplified at these defects and propagate into cracks.[2]

Newer advancements in rotary nickel-titanium (NiTi) instruments have led to innovative design concepts and techniques for their usage during canal preparation. Various forces are generated during instrumentation that are associated to an increased risk of root fracture which is one of the common complications of root canal treatment leading to tooth extraction.[3] Clinically, microorganisms may incorporate into crack lines and progress into the establishment of biofilms on the root surface.[4]

NiTi instruments often fracture during preparation without showing any signs of wear or distortion. Therefore, manufacturers have developed new instruments with innovative design and reduced fracture risk with better efficiency. Their trials involved changing the geometries, heat treatment methods, and kinematic movements of the instruments.[5] Reciprocating instruments were introduced with the specific goal of increasing cyclic fatigue resistance[6] reciprocating preparation techniques use single-use files of greater taper and are often made of heat-treated NiTi alloys. The cutting motion is an asymmetric clockwise/counterclockwise rotation.[7] In

general, reciprocating root canal preparation is an evolution of the balanced force technique that allows shaping of even severely curved canals with hand instruments to larger apical diameters.[8]

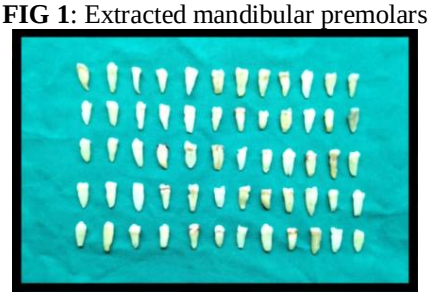
A wide variety of other factors may also contribute to fracture or crack of teeth. These factors include the chemo-mechanical preparation of the canals, the restorative aspects of endodontically treated teeth, the functional aspect of occlusion, and many more. To be precise, different obturation techniques are co-related to vertical root fracture or crown-root fracture.[9] Therefore, the aim of this study is to assess the fracture resistance of mandibular premolars after instrumentation using rotary and reciprocating files and obturating them with different obturation techniques.

II. MATERIALS AND METHOD

Sixty human single rooted mandibular premolars, which were indicated for extraction due to poor periodontal prognosis and orthodontic reasons were collected from the Department of Oral and Maxillofacial Surgery, K.D. Dental College and Hospital, Mathura. Collection, storage, sterilization and handling of extracted teeth were followed according to the Occupational Safety and Health Administration [OSHA] and Centre for Disease Control and Prevention recommendations and guidelines.

Teeth were immersed in 5% Sodium hypochlorite solution followed by ultrasonic scaling and were stored in the fresh distilled water. Intact teeth with single root canal and mature apices were selected while teeth with defects on the surfaces, open apex, restoration history and fracture were excluded.

FIG 1: Extracted mandibular premolars



PROCEDURE: Each specimen was decoronated by the diamond disc to get a standard root length of 15mm and randomly divided into five equal groups each consisting of 15 specimens.

GROUP I (Control group): Unprepared teeth stored in the distilled water until the next procedure.

GROUP II (K3Xf rotary file system): Canals were manually prepared till #15 followed by 20/0.06, 25/0.06, 30/0.06, 35/0.06 till 40/0.06 using K3Xf rotary file system at the speed of 300 rpm, torque 2 N cm and continuous motion with crown down technique. Irrigation was done using 5% Sodium hypochlorite solution, 17% EDTA and normal saline. Finally canals were rinsed and specimens were stored in distilled water until the next procedure.

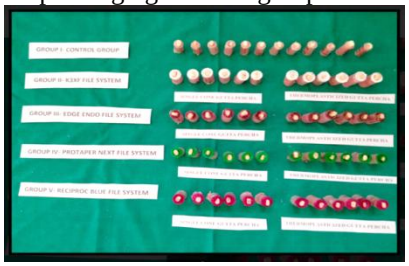
GROUP III (EdgeEndo rotary file system): All procedures were followed as above and preparation was done using EdgeEndo rotary file.

GROUP IV (Protaper next file system): All procedures were followed as above and preparation was done using X1, X2, X3 till X4 Protaper next file system in reciprocation motion with slow in out pecking movement .

GROUP V (Reciproc Blue reciprocating file system): All procedures were performed as above and preparation was done by R25 and R40 Reciproc Blue reciprocating file system Group 2, 3, 4 and 5 were divided into 2 sub-groups, A and B each. In all the groups, AH plus sealer was applied in the prepared root canal.

Group 2A, 3A, 4A and 5A were obturated with single cone gutta percha technique using 40/0.06 gutta percha points, while group 2B, 3B, 4B and 5B were obturated with thermoplasticized gutta percha technique using 40/0.06 gutta percha points and Calamus 3D obturation system.

FIG 2: Samples segregated into groups and sub groups



The samples of all the groups were allowed to set for 7 days after obturation, mounted in self-cure acrylic resin, exposing 5 mm of the coronal part and then placed on the universal testing machine. The tip with a diameter of 3 mm was used. The tip was centered over the canal orifice, and a gradually increasing vertical force was exerted (1 mm/min) until fracture. The maximum force required to fracture each sample was recorded in Newton (N).

STATISTICAL ANALYSIS: One way Analysis of Variance (ANOVA) and Tukey's multiple comparisons were used for statistical analysis in the present study and data were analysed using statistical package for social sciences version (SPSS, v24; SPSS Inc, Chicago, IL) for Windows. The level of statistical significance was set at 95% (P=0.05).

III. RESULTS

When the mean fracture resistance of each group were evaluated, it was seen that the highest fracture resistance was observed in group 1 followed by group 4, group 2, group 5 and lastly by group 3.

Group 1 > Group 4 > Group 2 > Group 5 > Group 3

GRAPH 1: Mean fracture resistance of all groups

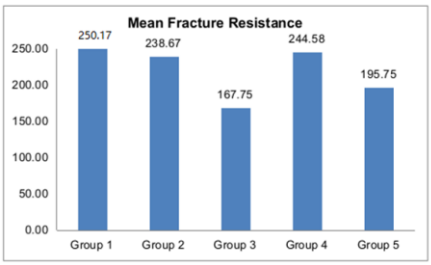


TABLE 1: Comparison between fracture resistance of each group

Group Statistics						
Fracture Resistance	Group1	N	Mean	Std. Deviation	t-value	p-value
Group1	Group1	12	250.17	2.79	100.49	<0.001
Group2	Group2A	6	250.50	2.95	15.04	<0.001
	Group2B	6	226.83	2.48		
Group3	Group3A	6	130.67	3.88	35.61	<0.001
	Group3B	6	204.83	3.31		
Group4	Group4A	6	234.50	3.83	8.71	<0.001
	Group4B	6	254.67	4.18		
Group5	Group5A	6	221.33	2.88	29.19	<0.001
	Group5B	6	170.17	3.19		

When the fracture resistance of group A and group B were evaluated, results showed that group A had more fracture resistance than group B.

Group A > Group B

GRAPH 2: Fracture resistance of group A and group B

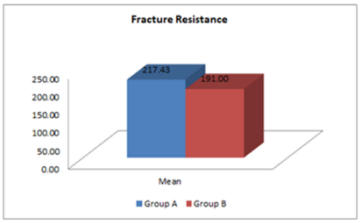


TABLE 2: Overall comparison between group A and group B

Group Statistics						
	Group3	N	Mean	Std. Deviation	t-value	p-value
Fracture Resistance	Group A	30	217.43	45.59	2.029	0.047
	Group B	30	191.00	54.89		

When inter group and intra group evaluation of fracture resistance was done, among the sub divided groups, group 4 having the highest fracture resistance showed more resistance in sub group B. Followed by group 2 having more fracture resistance in sub group A. In group 5, sub group A had higher fracture resistance than sub group B while in group 3, sub group B had more fracture resistance than sub group A.

Group 1 > Group 4B > Group 2A > Group 4A > Group 2B > Group 5A > Group 3B > Group 5B > Group 3A

GRAPH 3: Fracture resistance of sub groups A and B

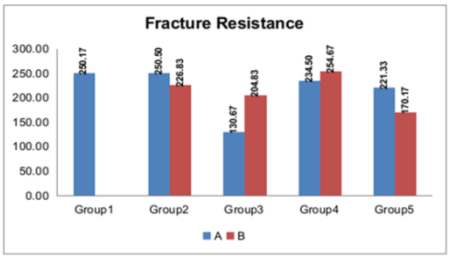


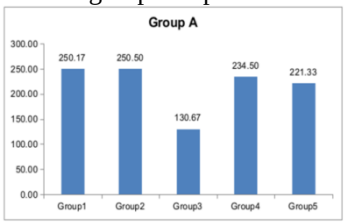
TABLE 3: Comparison between sub groups A and B

Descriptive								
Fracture Resistance								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Group 1(A&B)	12	174.33	79.24	22.88	123.98	224.68	95	254
Group 2(A&B)	12	238.67	12.63	3.65	230.64	246.69	224	255
Group 3(A&B)	12	167.75	38.88	11.23	143.04	192.46	125	210
Group 4(A&B)	12	244.58	11.20	3.23	237.46	251.70	229	260
Group 5(A&B)	12	195.75	26.88	7.76	178.67	212.83	166	225
Total	60	204.22	51.77	6.68	190.84	217.59	95	260

While emphasizing on sub group A of all the groups, it was interpreted that highest fracture resistance was presented by group 2 followed by group 4, then group 5 and group 3.

Group 2A > Group 4A > Group 5A > Group 3A

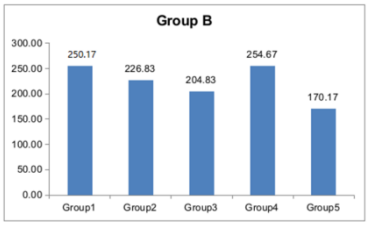
GRAPH 4: Inter group comparison of sub group A



While emphasizing on sub group B of all the groups, it was seen that highest fracture resistance was seen in group 4 followed by group 2, group 3 and group 5.

Group 4B > Group 2B > Group 3B > Group 5B

GRAPH 5: Inter group comparison of sub group B



IV. DISCUSSION

In the present study, biomechanical preparation has been attempted using different types of file systems in rotary and reciprocating motion and two obturation techniques also have been compared to observe the strength attained by remaining tooth structure after finalization of procedure.

Newer methods led to the advent of NiTi files. Higher stresses during rotary instrumentation increase dentinal defects risks as stress concentrating areas and are one of the secondary factors predisposing the tooth to vertical root fracture.[10]

The results of this study indicate that instrumentation decreases the fracture resistance of teeth irrespective of rotary or reciprocating motion leading to microcrack propagation in the radicular dentin,[11] eventually propagating to canal surface creating fracture lines.[12]

Single circular canals show uniform stress distribution than oval canals and greater stresses are present at the labial and lingual canal extensions. Premolars are more influenced by forces during instrumentation as circular cross section results in uniform distribution of load.[13]

Here, sequential preparation of each group using respective file systems till 40/0.06 and segregation into sub groups according to the different obturating techniques was done. Control group was left untreated. Comparison of rotary and reciprocating motion was done using 4 types of file systems: K3XF file system and EdgeEndo file systems in rotary motion while ProTaper Next file system and Reciproc Blue file systems were used in reciprocating motion.

K3XF rotary file system developed with the R-phase by heating and cooling protocol with an alteration in the manufacturing process and reduced radial land minimizes friction. R-phase is a transition between austenite and martensite phases with a rhombohedral structure, manufactured through thermal treatment that controls the memory of material, making the alloy extremely flexible.[14]

EdgeEndo rotary file system made of heat treated nickel-titanium alloy brand named Fire-Wire, torsional behavior and flexibility including cross-section, alloy composition, electro-polishing and thermo-mechanical processing are enhanced.[15]

Reciprocating motion reduces the stress on the instrument but removes peculiar amount of dentin using single instrument.[16]

ProTaper Next files have off-centered rectangular cross-sectional design with variable taper on a single file, manufactured using M-Wire NiTi alloy that minimizes stress as only two points of the file's cross section contact with the root canal wall, thus decreasing the damage.[17]

Reciproc Blue manufactured using M-Wire NiTi alloy and S-shaped cross section, undergoes thermomechanical treatment transforming the molecular structure and a characteristic blue color with increased resistance to cyclic fatigue resulting in less surface microhardness values.[18]

Sodium hypochlorite (NaOCl) possesss unique tissue proteolysis capacity and microbial suppression, destroys spores, viruses and bacteria and degenerates vital and necrotic pulp tissue.[19] EDTA promotes emulsification of vital tissue, facilitates the negotiation of the canal blockages or calcifications, eliminates smear layer, opens dentinal tubules against which obturation materials adapt efficiently.[20] Epoxy resin-based sealers penetrate deeper into dentinal tubules, enhancing the retention of the obturating material by inducing mechanical locking with the canal walls. [21]

Groups were sub divided further according to the obturating techniques into two sub groups each.

The single- cone (SC) technique of obturation utilizes greater taper gutta- percha cones resembling the shape of rotary nickel–titanium instruments as well as the prepared root canal anatomy. Thermoplasticized obturation technique includes downpack and backfill equipment in one unit. Heated pluggers are used to thermoplasticize obturating material at the apical third while remaining canal is backfilled with obturating material and condensed vertically.[22]

Results revealed that the highest mean fracture resistance was observed in Group I (control group) as the structure was preserved and no dentinal surface was altered followed by Group IV (Protaper Next file system group) attributed to the unique off centered cross sectional design and swaggering motion of the file.[23] This was followed by Group II (K3XF file system group) where fracture resistance may be affected by its reduced radial angle that removes more tooth structure.[24] Group V (Reciproc Blue reciprocating file system) showed lesser fracture resistance than these groups, as reciprocation motion removes large amount of tooth structure in clockwise and counterclockwise directions, simultaneously contacting large surface area in one cycle.[25] Least fracture resistance was observed in Group III (EdgeEndo file system) with excessive removal of dentinal surface due to dynamic cross sectional design incorporated with heat treatment and electro polishing.[26]

While comparing the obturation techniques, it was seen that Group A (Single cone Gutta percha obturation technique) showed higher fracture resistance than Group B (Thermoplasticized Gutta percha obturation technique) due to intimate adaption and conformation of gutta percha with the canal providing monoblock effect.[27]

V. CONCLUSION

Within the limitations of this study, the conclusion drawn is that as the conservation of remaining dentin thickness is emphasized while biomechanical preparation of root canal system, it leads to enhancement the fracture resistance of endodontically treated teeth providing it better functioning capacity during mastication.

This strength can further be increased using different obturation techniques which incorporate a monoblock effect within the root canal anatomy.

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