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INFLUENCE OF DIFFERENT POST SYSTEMS WITH VARIOUS WIDTHS ON THE FRACTURE RESISTANCE OF ENDODONTICALLY TREATED SINGLE ROOTED TEETH. (AN IN VITRO STUDY)

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ABSTRACT

Aim: The aim of the present study was to evaluate the influence of different post systems (fiber and titanium posts) with different post sizes and on the fracture resistance of the endodontically treated single rooted teeth.

Methodology: Fifty-four freshly extracted maxillary central incisors were selected and grouped into three main groups according to the post system used; Group A were prepared to receive Rely-X posts with different sizes. Group B were prepared to receive titanium posts with different sizes. Group C were prepared to receive obturation only (control group). The specimens were prepared using Protaper Universal rotary files. Intervention groups A and B were divided, each into three sub groups; Group A was divided into Rely-X yellow coded (R.X.Y.C), Rely-X Red Coded (R.X.R.C), Rely-X Blue Coded (R.X.B.C) while Group B was divided into Short Titanium Posts (S.T.P), Medium Titanium Posts (M.T.P), Long Titanium Posts (L.T.P). Specimens were then loaded to fracture in a universal testing machine. The maximum load at which the teeth fractured and the fracture patterns were recorded.

Results: There was a statistically significant difference among all groups ; the control group showed the highest fracture resistance followed by the Rely-X Red Coded (R.X.R.C.) group, while the Short Titanium Posts (S.T.P.) group showed the least fracture resistance.

Conclusion: The control group (Obturation only) recorded the highest fracture resistance while the short titanium posts (STP) recorded the least fracture resistance.

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INTRODUCTION

Endodontically treated teeth were shown to be more prone to fracture than vital teeth. This may be attributed to the loss of the tooth structure and dehydration as a result of caries and endodontic procedures **(Rodríguez-Cervantes *et al.* 2007)[1].**

Post systems are widely used nowadays as a mean of reinforcement for the endodontically treated teeth while receiving a final restoration **(Walton *et al.* 2002)[2].** However, there is a controversy regarding the use of the posts in endodontically treated teeth **(Faria *et al.* 2011)[3].**

It was thought that posts weaken the endodontically treated teeth by pre-disposing it to fracture through the drilling and the preparation process for post space. The failure rate of these restorations after several years of service was thought to be still high, with a prevalence of failures because of vertical root fractures that ranges between 2% and 5% **(Russell *et al.* 2017)[4].** At most of the cases, these fractures cannot be treated. The appearance of such vertical fractures was related to both the teeth restoration process and post-design **(Khasnis *et al.* 2014)[5].**

On the other hand, many authors thought that posts reinforce the endodontically treated teeth through the bonding to both the dentin and the core material which may improve the distribution of forces along tooth roots, thereby contributing to higher tooth survival rates **(Piovesan *et al.* 2007)**[6].

Post-design is defined by several different parameters such as the length, diameter or material and their longitudinal shape. Greater post-diameter entails removing a greater amount of dentine, thus weakens the tooth structure so it was recommended to limit the diameter of the post (**Rodríguez-Cervantes *et al.* 2007**)[1]**.**

The demands for simpler procedures and esthetic restorations led to the development of prefabricated posts. Therefore, it is of great importance to study the influence of different post systems

With different post sizes on the fracture resistance of the endodontically treated single rooted teeth.

MATERIALS AND METHODS

Materials:

Materials, instruments and devices used in this study are tabulated in table (1)

TABLE (1): Materials, instruments and devices used in this study

Materials / Instruments / Devices	Manufacturers
Autopolymerizing Acrylic resin	Acrostone, Egypt
ADSEAL root canal sealer	METABOIMED, KOREA
Diamond round	Dentsply Maillefer, Ballaigues Switzerland
EDTA	Prevest Dentpro, Ltd.,Jammu, India
Endo access bur	Dentsply Maillefer, Ballaigues Switzerland
Endodontic condenser	Dentsply Maillefer, Ballaigues Switzerland
Gutta percha points	METABOIMED, KOREA
K-files	MANI, Matsutain Seisakusho Co., Tochigi-ken ,Japan
Light cured composite	3m ESPE, USA
Rely-X unicem resin cement	RelyX Unicem Aplicap, 3M ESPE, St. Paul, MN,USA
Rely-X fiber posts	3M ESPE, USA
Protaper Universal rotaryfiles	Dentsply, maillefer, Switzerland
Protaper gutta percha	DENTSPLY, Maillefer, swizerland
Titanium posts	Nordin swiss dental production
Silicon impression material	Lascod, Italy
Universal Testing Machine	LIoyd instruments Ltd., Fareham,UK
Sodium hypochlorite	Clorox, Tenth of Ramadan city, Egypt
Steriomicroscope	Nikon MA 100, Japan

The trial was double blinded, where the outcome assessor and statistician were blinded during outcome evaluation.

Sound Freshly extracted human single canaled maxillary central incisors were used and obtained from the surgical department at the faculty of dentistry, Cairo university, Cairo, Egypt.

The collected teeth were cleaned of any hard deposits by using an ultrasonic scaler and were disinfected in 5.25% sodium hypochlorite for 5 minutes.

A standard access cavity was prepared in all the samples, using a diamond round bur andendo access bur with air-water cooling spray.

Apical patency was determined by inserting a size 10 k-file till it was evident from the apical foramen. Working length was established by inserting #10 K-file till it was shown at the root apex then the length was measured (tooth length), followed by substracting 1 mm from it (Salameh *et al*. 2008)[(7)].

Root canals were mechanically prepared using the Protaper Universal rotary files according to the manufacturer recommendations (Mobilio *et al*. 2013)[(8)].

The canals were enlarged up to F3 rotary file of the Protaper Universal system, then the canals were irrigated with sodium hypochlorite solution 5.25% between each successive files through a side vented needle 27 gauge to remove the debris (Salameh *et al*. 2008)[(7)].

All canals were finally rinsed with 5 ml of 17% EDTA solution for 1 minute followed by5 ml 5.25 % sodium hypochlorite to remove the smear layer then finally rinsed with 3ml saline solution. (Jayasenthil *et al*. 2016)[(9)]. They were then dried with paper points size F3.

For root canal obturation, ADSEAL root canal sealer was used along with Protaper gutta percha point size F3 using modified single cone technique with accessory gutta percha and spreaders size 25.

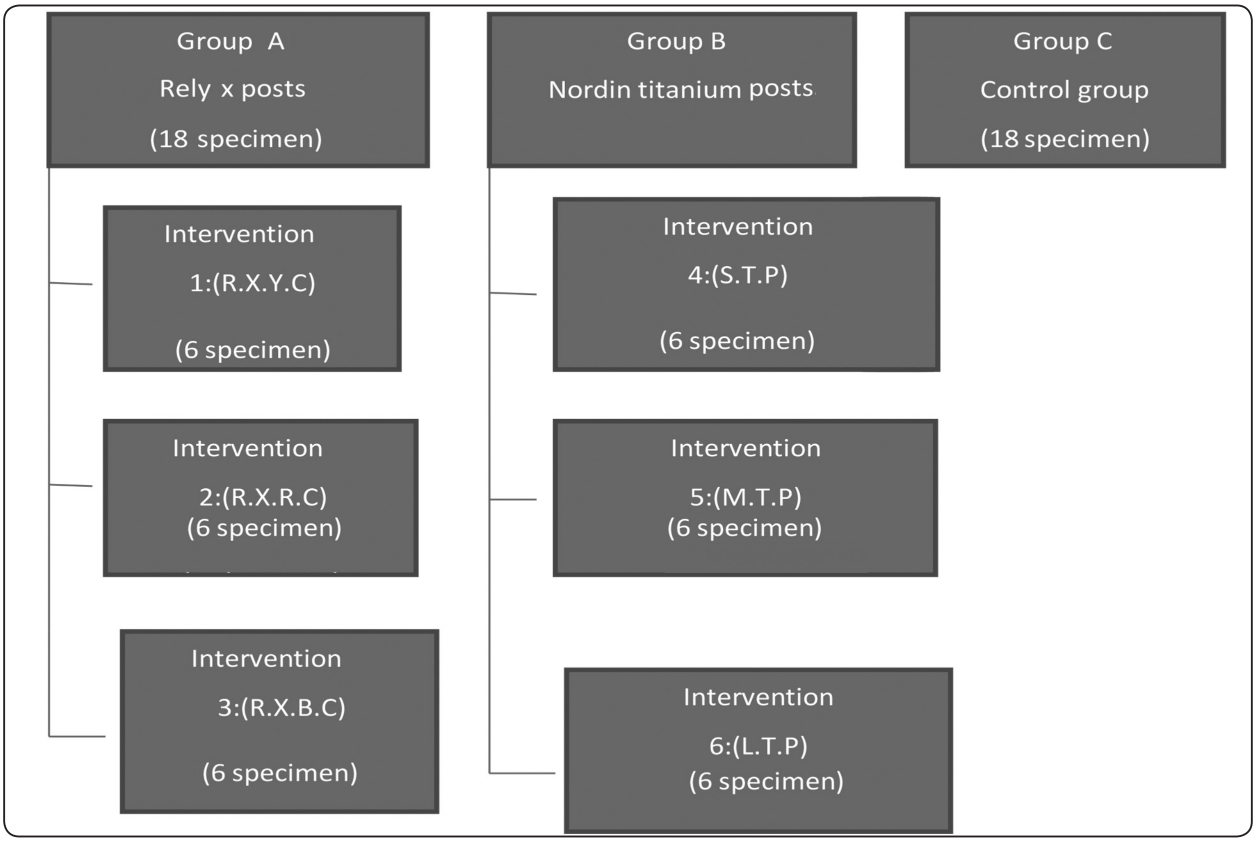

Fig. (1): Grouping of samples

Excess gutta-percha was removed using a flame-heated endodontic condenser of suitable size, and vertical condensation was performed.

Grouping of the samples

Prepared root canals were divided into three groups, 18 specimens each, according to the post system used.

The post length should be two thirds the root length. The post space was prepared using the specific drill assigned by the manufacturer for each post.The Rely x posts are color coded according to the drills.

- The yellow drill for size one posts, color coded yellow.
- The red drill for size two posts, color coded red.
- The blue drill for size 3 posts, color coded blue.

The drills used for titanium posts are as follows:

- Drill no. 3 for posts size 3.
- Drill no.5 for posts size.5.
- Drills no. 6 for posts size .6.

Post cementation was done using the Rely-X luting cement for all the study samples which were applied inside the canals using an intra-canal tip (Salameh *et al*. 2008)[7].

To simulate the periodontal ligament as in case of natural condition, the following steps weredone:

Root surfaces of all the teeth were marked at a point 2mm. apical to the cementoenamel junction and were immersed in a blue inlay wax to create a 1 mm thickness space, simulate the periodontal space

Each tooth was mounted in vertical direction within a resin block, prefabricated cylindricalplastic tubes of 2 cm length and 2 cm diameter were used.

The samples were then inserted into the acrylic resin blocks. When the acrylic resin showed partial signs of polymerization, specimens were removed from the resin blocks and then the blue inlay wax was removed from the root surfaces.

A silicon based light body, impression material was immediately injected into the acrylic resin molds and the teeth were reinserted into the resin blocks.

By doing so, a standardized silicon layer simulating the periodontal ligaments was created around the roots (Akkayan and Gülmez 2002) [10].

Loading of the samples:

All the samples were subject to the fracture resistance test using the universal testing machine.

Fracture resistance was tested on the universal testing machine at a crosshead speed of 1 mm/minute and an angle of 135 degrees to the long axis of the tooth at the center of the palatal fossa (Akkayan and Gülmez 2002) [10].

The load at which fracture had occurred indicated by the software of the load testing machine, recorded in Newton's and was considered as the fracture resistance.

The fractured specimens were examined under a stereomicroscope at 30X to determine the fracture pattern.

Fracture patterns were classified into:

1. Vertical fracture.
2. Horizontal fracture.
3. Oblique fracture (chisel).
4. Vertical + horizontal fracture.
5. Vertical + oblique fracture.
6. Comminuted fracture.

Statistical analysis:

Statistical analysis between the three main groups was performed with IBM[3®] SPSS[4®] Statistics

Version 25. Parametric data were analyzed using one-way ANOVA followed by Tukey post hoc test for multiple group comparisons. The significance level was set at $P \leq 0.05$ within all tests.

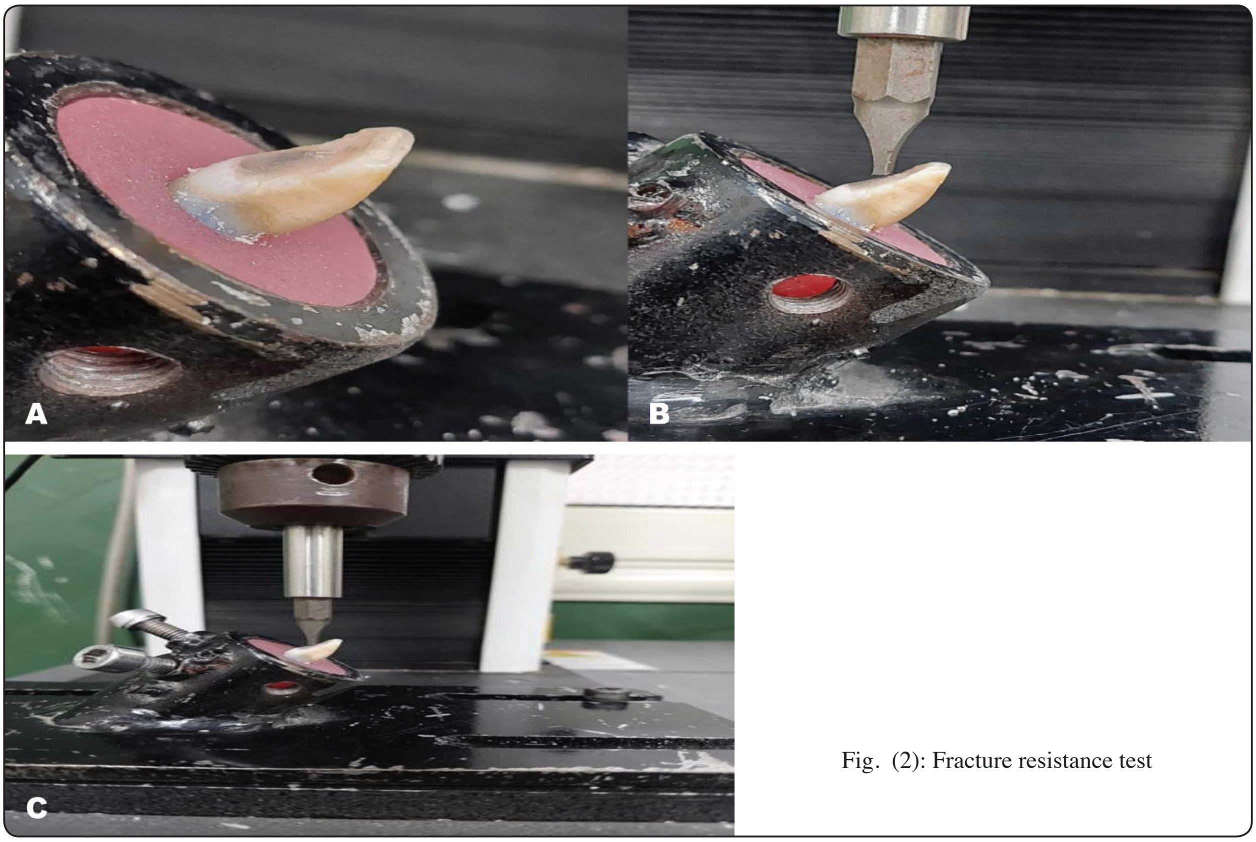

Fig. (2): Fracture resistance test

RESULTS

The highest fracture resistance value was found in the control group with a mean and standard deviation of 783.3±437.6N followed by the R.X group with a mean and standard deviation of 501.01±132.79N. The least fracture resistance value was found in the T.P group with a mean andstandard deviation of 347.31±115.8N.

TABLE (2) The mean and the standard deviation of the fracture resistance values between the three main groups

	Group control(N)	Group R.X (N)	Group T.P (N)	p value
Fracture resistance	783.3 ± 437.6	501.01 ±132.79	347.31 ±115.8	<0.001

(*): denotes significant difference versus control group.
(#): denotes significant difference versus R.X group.

There was a statistically significant decrease in the fracture resistance between the R.X and T. P groups in relation to the control group (p value<0.001). There was also a statistically significant decrease in the fracture resistance of the T.P in relation to the R.X group (P < 0.001).

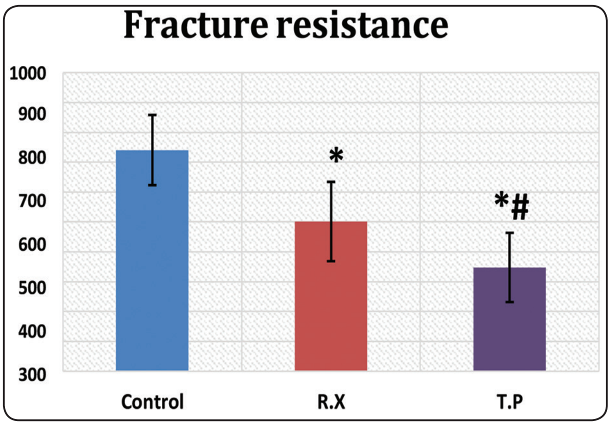

Fig. (3): Bar chart representing the Mean fracture resistance values of the main three groups.

Overall comparison between the seven groups showed a statistically significant difference in fracture resistance. ($p = 0.036$)

Pair wise comparison revealed a statistically significant difference between the S.T.P. group and the control group. However, there was no significant difference between all other group pairs.

TABLE (3): Mean, SD, and the results of Kruskal Wallis test for comparison of fracture resistance between the seven subgroups:

	Mean	SD	P - Value
R.X.Y.C	513.8 [ab]	131.2	
R.X.R.C	562.4 [ab]	149.3	
R.X.B.C	442.3 [ab]	195.9	
S.T.P.	204.3 [b]	99.7	0.036
M.T.P.	400.3 [ab]	128.6	
L.T.P.	380.5 [ab]	106.4	
Control	783.3[a]	437.6	

Different small letters indicate statistical significance by Mann Whitney U test with Bonferroni correction.

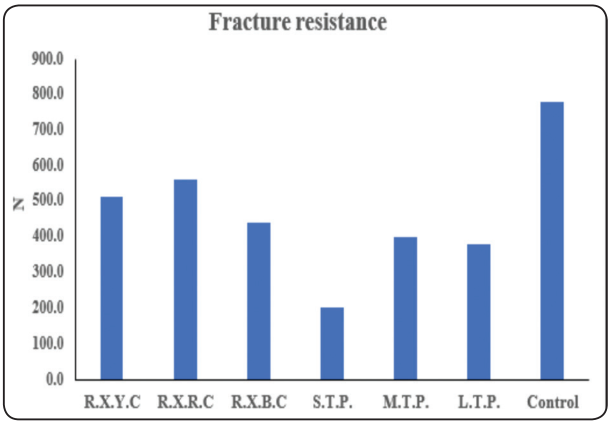

Fig. (4) : Bar chart representing the mean of the fracture resistance values in the seven subgroups

Mode of fracture

There was no significant difference between the seven groups regarding the mode of fracture ($p = 0.610$).

1. In group (R.X.Y.C), vertical fracture pattern (Fig 5 A, B) occurred in 50% of the samples, horizontal fracture pattern occurred in 25% of the samples (Fig 6 A, B) and vertical + horizontal occurred in 25% of the samples (Fig 8 A, B).

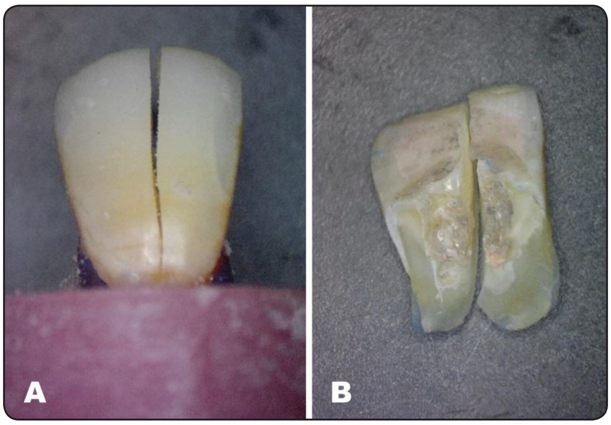

Fig. (5): (A, B) two tooth showing vertical fracture

2. In group (R.X.R.C), vertical fracture occurred in 25% of the samples, horizontal fracture pattern (Fig 6 A, B) occurred in 25% of the samples and oblique fracture pattern occurred in 50% of the samples (Fig 9 A, B).

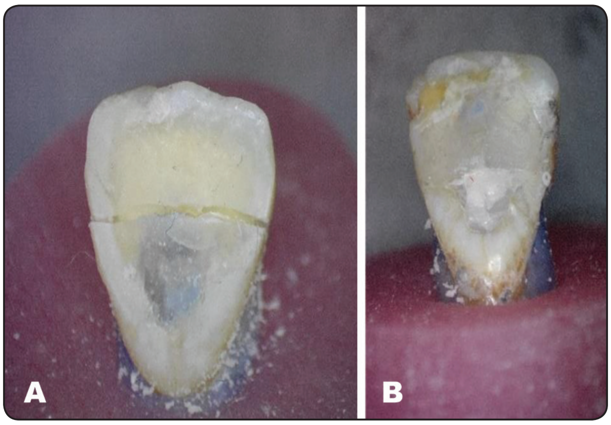

Fig. (6): (A, B) horizontal fracture in two specimens

3. In group (R.X.B.C), oblique fracture pattern occurred in 75% of the samples (Fig 9 A, B) and comminuted fracture pattern (Fig 10 A, B) occurred in 25% of the samples.

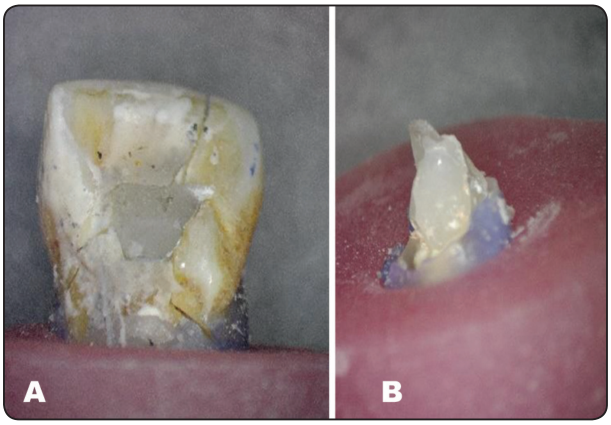

Fig. (7): (A, B) Comminuted type of fracture

4. In group (S.T.P), vertical fracture occurred in 25% of the samples (Fig A, B) oblique fracture pattern occurred in 50% of the samples (Fig 9 A,B). Vertical and Horizontal fracture (Fig 8 A, B) occurred in25% of the samples.

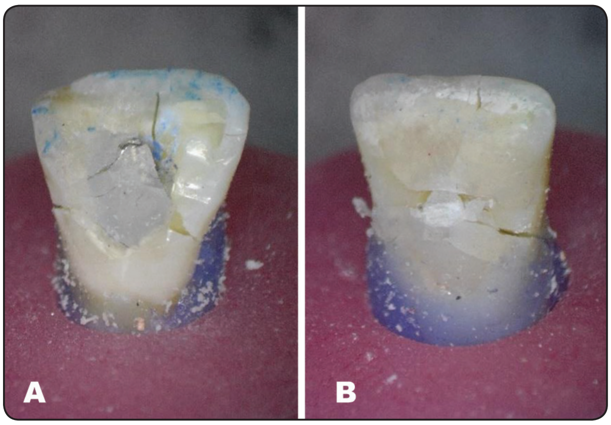

Fig. (8): (A, B) Vertical + horizontal fracture in two teeth

5. In group (M.T.P), oblique fracture (Fig 9A, B) occurred in 25% of the samples, vertical+ oblique fracture pattern occurred in 25% of the samples (Fig 10 A, B) and 50% of the samples showed comminuted fracture pattern (Fig 7A, B).

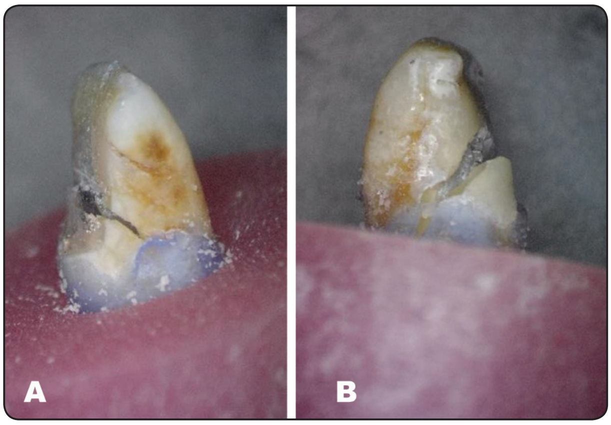

Fig. (9): (A, B) Oblique fracture

6. In group (L.T.P), vertical fracture occurred in 25% of the samples, oblique fracture occurred in 25% of the samples and comminuted fracture occurred in 50% of the samples.
7. In the control group, vertical fracture occurred in 25% of the samples, oblique fracture occurred in 25% of the samples. Vertical + oblique fracture (Fig 10 A, B) occurred in 50% ofthe samples.

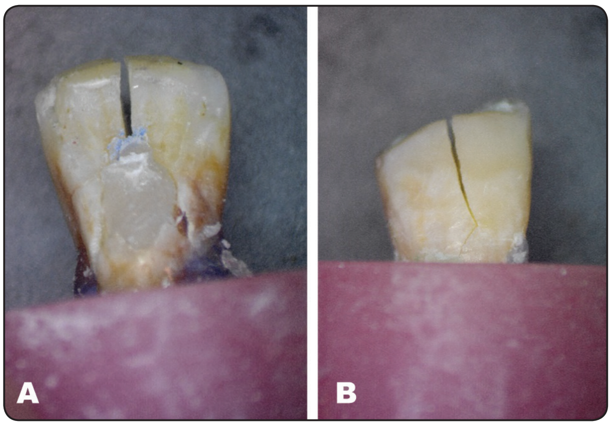

Fig. (10): (A, B) Vertical + Oblique fracture

TABLE (4) Percentages and results of Fisher's exact test for comparison of mode of fracture in the seven groups:

	R.X.Y.C	R.X.R.C	R.X.B.C	S.T.P.	M.T.P.	L.T.P.	Control	*p* value
Vertical	50%	25%	0%	25%	0%	25%	25%	
Horizontal	25%	25%	0%	0%	0%	0%	0%	
Oblique	0%	50%	75%	50%	25%	25%	25%	
Vertical + Horizontal	25%	0%	0%	25%	0%	0%	0%	0.725
Vertical +Oblique	0%	0%	0%	0%	25%	25%	50%	
Comminuted	0%	0%	25%	0%	50%	25%	0%	

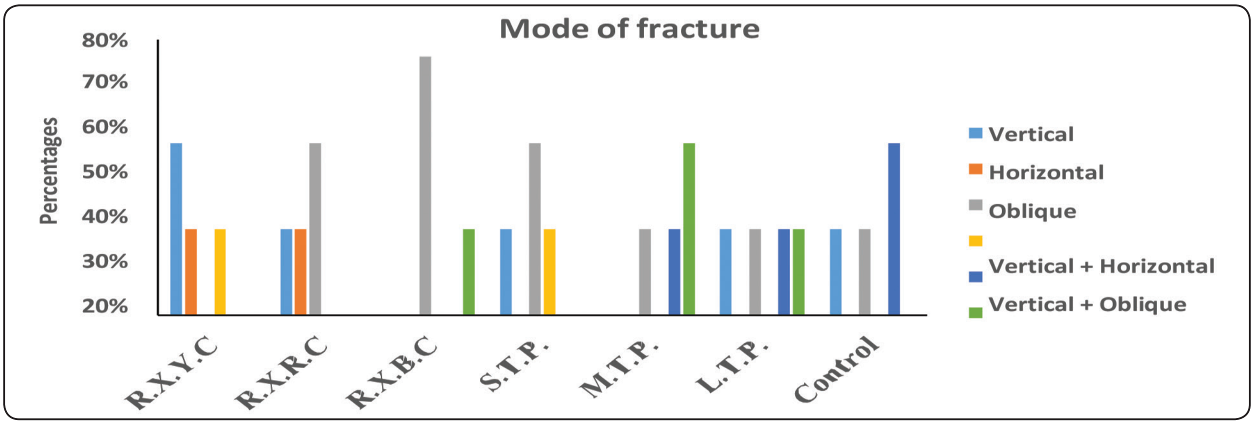

Fig. (11): Bar chart representing the percentages of different fracture patterns in the seven groups.

DISCUSSION

Endodontically treated teeth with a great loss of dental structure often require posts and cores to secure retention for a fixed restoration. Loss of retention of posts or root fractures of the restored teeth are considered major obstacles for their use (Vikhe 2021)[11].

Among the three main groups, the highest fracture resistance value was found in the control group (specimens with obturation only) followed by the Rely-X group. The high results of the control group could be due to the meticulous preservation of tooth structure as the quality and quantity of remaining tooth structure is considered a major factor in the fracture resistance of endodontically treated teeth (Soares *et al*. 2008)[12].

Rely-X results were higher than those of titanium. These results could be explained by the value of the virtue of the modulus of elasticity of Rely-X post that is (18.6) GPa being similar to that of dentin (18.2GPa). While that of titanium is extremely higher than that of dentin. This could be responsible for low failure loads of titanium post group specimens (Cantoro *et al*. 2011)[13]. These results were in accordance with Tavano[14] *et al*. 2020 who stated that no other restorative material would be better than the mechanical and aesthetic properties of natural dentin (akkayyan and gulmez 2002[10], Cantoro et al. 2011[13]).

Our results were in agreement with Mondilli[15] *et al*. 2017 who showed that the fracture strength of endodontically treated teeth is inversely proportional to the amount of tooth structure removed and in agreement with Soares[12] *et al*. 2008 who stated that the fracture resistance should be enhanced by minimizing tooth structure loss and keeping the post as small as possible, however they also stated that the use of restorative material with mechanical properties similar to dental structure favour a greater longevity of the tooth restoration complex.

However, they were in disagreement with Bolay[16] *et al*. 2012 who compared three types of post sytems with a control group with no posts, and showed that the fracture resistance of endodontically treated teeth restored with using posts was higher than that of endodontically treated teeth restored without posts. This disagreement could be related to the difference in the methodology, as Bolay[16] *et al*. 2012 performed decronation of the teeth used in their study.

Among the seven subgroups, the control group showed the highest fracture resistance values followed by the Rely-X red coded group of (1.60 mm) diameter, while the short titanium posts group of (1.3 mm) diameter showed the least fracture resistance values. The high fracture strength recorded for the Rely-X red coded posts may be due to its average diameter that minimized the loss of the tooth structure during cavity post space preparation. Our results were in accordance with Zogheib *et al*. 2018[17] who stated that reduced width of the preparation following the concepts of minimally invasive endodontics may lead to an increased fracture resistance. Our results were also in accoradance with Jayasenthil[9] *et al*. 2016 who stated that posts with high modulous of elasticity cause the failure, as they lead to stress concentration to occur. Comparatively low modulus posts cause only little damage to the remaining tooth structure.

Regarding the fracture pattern analysis, the results of this study showed that the fracture occurred in all seven groups exhibited various patterns including vertical, horizontal, oblique, combined oblique + vertical, combined vertical + horizontal and comminuted fracture pattern. There was no significant difference between the seven groups regarding the mode of fracture. Mixed failures would probably be due to the structure of prefabricated post restorations, which created concentrated stresses at the interface between the post, the core and tooth structure that led to such failures (Eid *et al*. 2019)[18].

The results of this study regarding the mode of fracture revealed that the type of fracture is not dependent on the type of the post used, this was in agreement with Torabi[19] *et al*. 2009 who compared the fracture resistance of only obturated teeth (gutta percha obturation and resin sealer) with those restored with cast post and core using a direct technique, the polyethylene woven fiber preimpregnated fiber tape, a glass fiber post carbon fiber post.

CONCLUSIONS

Within the limitations of this study, it could be concluded that:

1. Teeth obturated without the use of posts shows the highest fracture resistance among all materials and post systems.
2. The fracture patterns are not affected by the post systems used either with different diameters or materials.

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