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THE EFFECT OF FERRULE LENGTH ON FRACTURE RESISTANCE OF TEETH RESTORED WITH TWO DIFFERENT POSTS CEMENTED WITH TWO TYPES OF LUTING MATERIALS.

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Abstract

Objectives: To determine the ferrule length influence on fracture resistance of teeth repaired with two distinct forms of posts, luted using two different cement luting kinds.

Materials: Eighty healthy, recently removed, non-caries central maxillary incisors were collected and preserved at room temperature in 0.9% normal saline solution. The teeth were randomly allocated into two equal groups. Based on the cement type utilized in its cementation, each group was further subdivided into two subgroups: composite resin and zinc phosphate. The compressive force was applied at a crosshead speed of 0.5 mm/min using universal testing equipment until all samples were fractured.

Results: Resin cementation of the cast post exhibited greater load values than the resin phosphate cementation of the cast post with and without the ferrule effect. However, increasing the ferrule length with the two types of cement used for cementing various posts in their respective root canals enhanced the fraction resistance.

Conclusion: Root-filled teeth revealed an enhanced resistance to fracture with increasing the Ferrule length. Root-filled teeth that underwent restoration by flexi post and cementation using composite resin had a higher fracture resistance than cementation with zinc phosphate. Root-filled teeth that underwent restoration with cast post and cementation with composite resin had a greater resistance to fracture in comparison with the cast post cemented by zinc phosphate. Restoration of Root-filled teeth using flexi post and Ti core had a greater fracture resistance than cast post and its core.

Keywords: Fracture Resistance; Central Incisors; Ferrule Length

Introduction

Any post and core restoration are inferior to natural dentine regarding fracture resistance. The remaining tooth structure directly relates to the tooth's strength. This demands prudence during endodontic post-insertion tooth preparation. Restoring root-filled teeth using endodontic posts should retain the tooth's structure, limit dental tissue loss, permitand retain an appropriate apical seal, and limit harmful forces. The amount of residual dental tissue surrounding a post impacts its resistance to fracture [1]. Although most previous research proposed preserving coronal tooth structure to increase stress distribution and retention, the influence of retained coronal dentine on the root-filled teeth' strength remains debatable. Results from previous research showed that it boosts tooth fracture resistance, while others determined that it did not[2].

Typically, a post-core system is usedto restore damaged teeth following endodontic therapy to distribute occlusal stresses throughout the root, provide core retention in place of coronal tooth structure, and support or maintain the final restoration[3].

Every post's primary objective is to provide core retention. Classification of prefabricated posts is based on geometry (configuration and form) or retention mechanism [5].

The flexi-Flange post features a split shank; this split minimizes the stress caused by insertion and cementation, and it also might function as a vent for releasing the hydrostatic pressure while the post is being cemented into the canal, delivering superior retention with low insertion and functional stresses[4]. The Flexi-Flange post's multitiered design increases the contact between dentin and metal to transmit functional stresses to the tooth's strongest areas: the root and coronal portions.

The influence of the retained coronal dentine (ferrule) on the tensile strength of root-filled teeth is still debatable. Numerous research demonstrated that it enhances tooth fracture resistance. However, other researchers have reported no enhancement in fracture resistance [7].

Various trials to find the optimal length for the ferrule effect revealed that maxillary incisor roots should be 1.5 mm long at their minimum with post and core-retainedcrowns because it enhances fracture resistance [8].

Our research aimed to determine the influence of ferrule length on the resistance of teeth repaired with two distinct types of posts to fracture, luted with two variations of luting cement.

Material andMethods

A recently removednon-caries eighty healthy maxillary central incisors were selected and preserved at room temperature in 0.9% normal saline solution. Using a No. 15 surgical blade and an ultrasonic sealer, the deposits of calculus and soft tissues on the teeth surfaces were removed. Then, the teeth were dried with oil-free compressed air after being washed with a tough toothbrush and soap under running water. The teeth with developmental anomalies such as fractures, cavities, restorations, and/or roots < 10mm were eliminated and replaced. , using a parallelometer for centralization of damages. The average length of chosen teeth was 23 millimeters.

Based on the type of post-core system, the teeth were split into two equal groups at random.; Group A: Where prefabricated flexi posts and composite core were used for restoration; and Group B: Where cast post and core were used for restoration. Based on the cement type utilized in cementation, each group was subdivided into two groups: composite resin and zinc phosphate.According to ferrule length, each subgrouping was subdivided into four subgroups (0, 1.5, 2.5, and 3.5 mm), asdemonstrated in Figure 1.

Using diamond stones, each tooth's coronal area was divided into sections at 0, 1.5, 2.5-, and 3.5-mm coronal to the cementoenamel junction, all parallel to the tooth's long axis. Teeth were implanted 2 mm below the cervical line into self-curing acrylic resin mould blocks. The teeth were subjected to endodontic treatment using the step-back method and filled using the lateral condensation technique with epoxy Root Canal Cement (eugenol-free sealer) and gutta-percha.

All teeth were prepared using tapered diamond stones with flat ends to achieve a shoulder finish line of 1.2 millimeters. The wall of convergence of the formulation was around 6 ° degrees. A peso reamer was utilized for removing the gutta-percha from the root canals, leaving a root canal filling of 4 mm in the apical section. Using a Flexi post system kit, the root canal was expanded to accommodate the posts.

Post A was cemented using Flexi-Flow resin cement prepared by the manufacturer's instructions. With spiral paste filler (lentulo spiral), cement was spun down the channels. Zinc phosphate cementwas utilized for cementing Post B (flexi post) (Figure2).

Core fabrication: Ti-Core was utilized based on the manufacturer's directions and was applied to the post-head coronal portion.

A plastic post with identical Flexi post dimensions was put into the root canal space using auto-polymerizing resin (Duralay) to take an impression during the fabrication of post and corecast specimens. After the whole pattern set has been applied, an additional mixture is placed on the coronal portion of the plastic burn-out post to form the core. Using a centrifugal casting machine, nickel-chromium alloys were used to cast the pattern,and the cast post and core were cemented with flexi-flow (a cement made of composite resin) and a zinc phosphate cement according to the same procedures used for cementing the Flexi-post post. Full crown Fabrication: Nickel-chromium basealloy was used for casting all patterns andfinished thenpolished.

A universal testing machine was utilizedto secure the samples, using a device that permits lingual tooth loading tothelongaxis at 130° degrees tosimulateaclassIocclusion contactanglebetween the anteriormandibular and maxillaryteeth,asdemonstratedinFigure3.With computerized testing equipment, at a speed of 0.5mm/min, a compressive force was applied till the tooth fractured.

Results

The last post cemented with composite resin "both with and without ferrule effect" was 1126,6100 at 0 and 3737.2900 ± 206.19 at 3.5, with higher values in comparison with the others cemented by resin phosphate cement “both with and without ferrule effect.” In contrast,increasingtheferrulelengthincreased theresistance to fracturesinthe two types of cementusedforcementingdifferentposts; it was (645.9760) at (0) and was (2772.2680) at (3.5). The flexible post, which was cemented using composite resin “inboth with and without ferrule effect,” had a higher value in comparison with the others cemented byresinphosphate cement“inbothwithandwithoutferruleeff; it was (1216.3200) at (0), was (4411.4320) at (3.5).

However, extending the length of the ferrule in the studied blocks of cement utilized for cementing various posts enhanced the resistance to fracture; it was(1076.3400)at(0)andwas(3200.00)at(3.5).Tables1-5revealedtheStaticallyanalysis.Table6demonstrates the statistical analysis of the Cast-postandFlexi-post using ANOVA.Figure 4 compares the fracture resistance values of Cast-posts and Flexi-posts cemented using (a) Zinc phosphate and (b) composite resin for the two groups. Figure 5 bar graphs demonstrate the mean values for all studied groups.

Statistics were done by GraphPad Prism version 9.5.2

Table (1): Group I Cast-post.

Group I Cast post	**0mm**	**1.5mm**	**2.5mm**	**3.5mm**	**P**	**P**
Zinc phosphate (Mean ± S.D)	645.976±135.44	1340.32±171.96	2200.2±147.23	2772.268±385.09	0.034	0.042
Composite resin (Mean ± S.D)	1126.61±123.89	1700.91±185.84	2483±174.59	3737.29±206.19	0.028	

Table (1) and Figure (1) showed significant variation has been noticed between the two groups ($P<0.05$).

- As shown in figure (2), Significance variation has been found between Zinc phosphate values with regards to ferrule length ($P<0.05$).
- Figure (3) shows that Significance variation has been found between Composite resin values with regards to ferrule length ($P<0.05$).
- Composite resin had significantly increased values in comparison with Zinc phosphate.
- * = significance ($p<0.05$).
- The two groups showed the highest value with ferrule 3.5mm and the lowest with ferrule

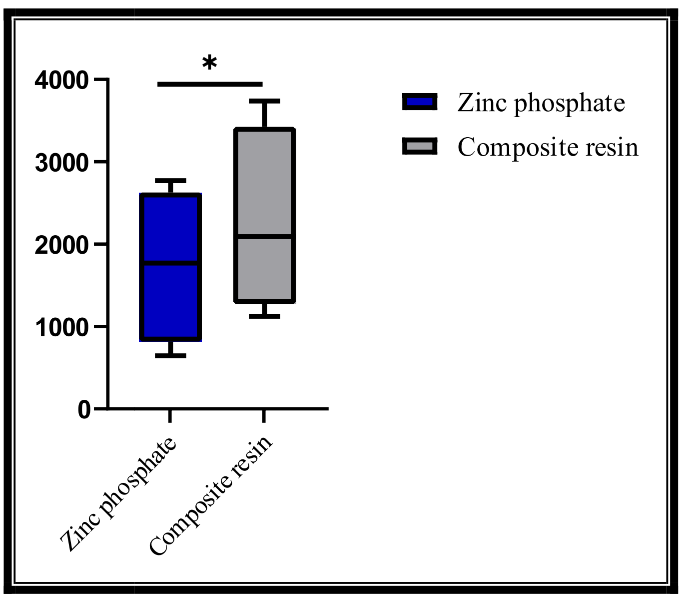


Figure (1):Components' comparison of Group I Cast-post

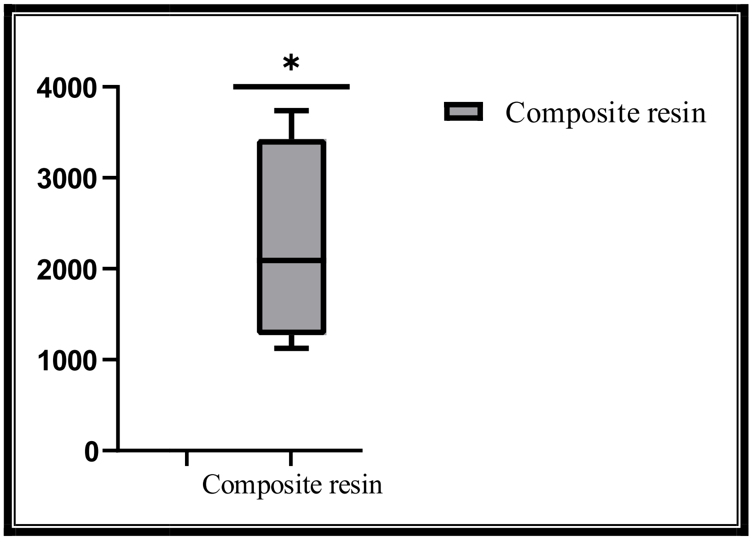


Figure (2): Composite resin values

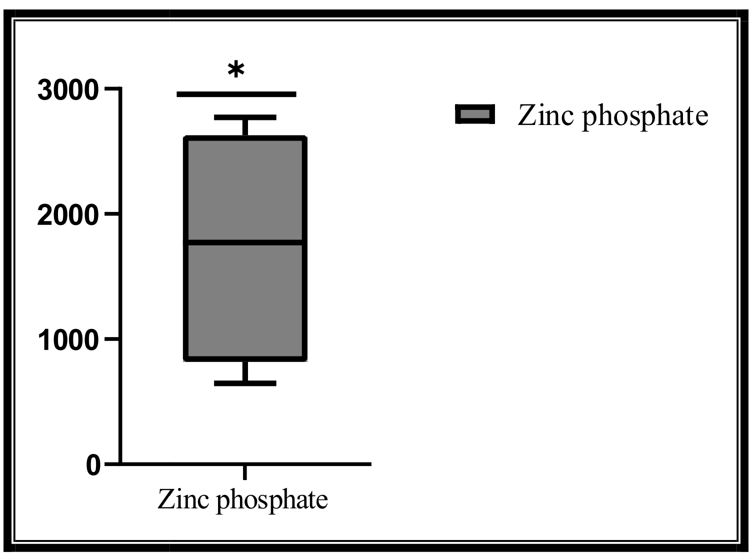


Figure (3): Zinc phosphate values

Table (2): Group 2 flexi-post of zinc phosphate cement and composite resin.

Group 2 Flexi-post	0mm	1.5mm	2.5mm	3.5mm	P
Zinc phosphate (Mean ± S.D)	1076.34±135.44	1660.97±171.96	2694.56±147.23	3200±385.09	0.166
Composite resin (Mean ± S.D)	1216.32±123.89	1958.45±185.84	2887.11±174.59	4411.432±206.19	

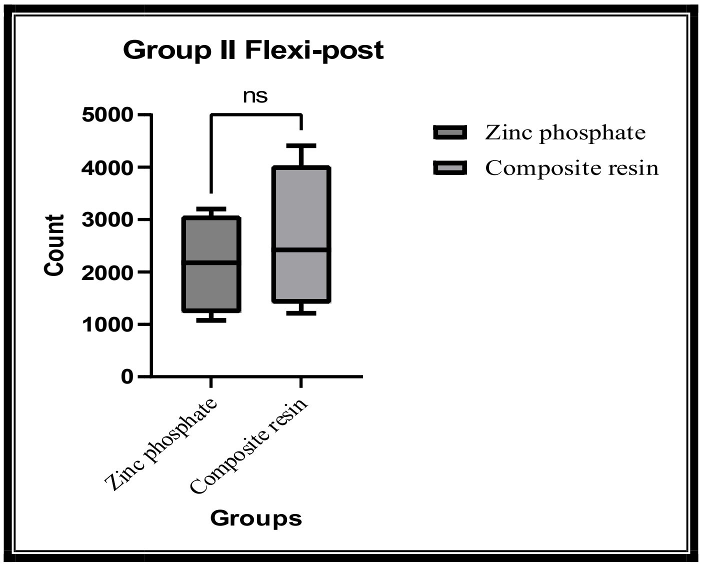


Figure (4): Group 2 flexi-post of zinc phosphate cement and composite resin.

No significant variation was found between Zinc phosphate and Composite resin values regarding the ferrule length (P>0.05). table (2), figure (4)

Flexi-post and Cast-post	0mm	1.5mm	2.5mm	3.5mm	P
Zinc phosphate Group 1 (Mean± S.D)	1076.34+135.44	1660.97+171.96	2200.2+147.24	2772.268+385.09	NS
Zinc phosphate Group 2 (Mean± S.D)	645.976+102.89	1340.32+270.15	2694.56+403.23	3200+433.56	

Table (3): Flexi-post and Cast-post cemented by Zinc phosphate

.

Flexi-post and Cast-post 0mm 1.5mm 2.5mm 3.5mm P

Zinc phosphate Group 1 (Mean± S.D) 1076.34+135.44 1660.97+171.96 2200.2+147.24 2772.268+385.09 NS

Zinc phosphate Group 2 (Mean± S.D) 645.976+102.89 1340.32+270.15 2694.56+403.23 3200+433.56

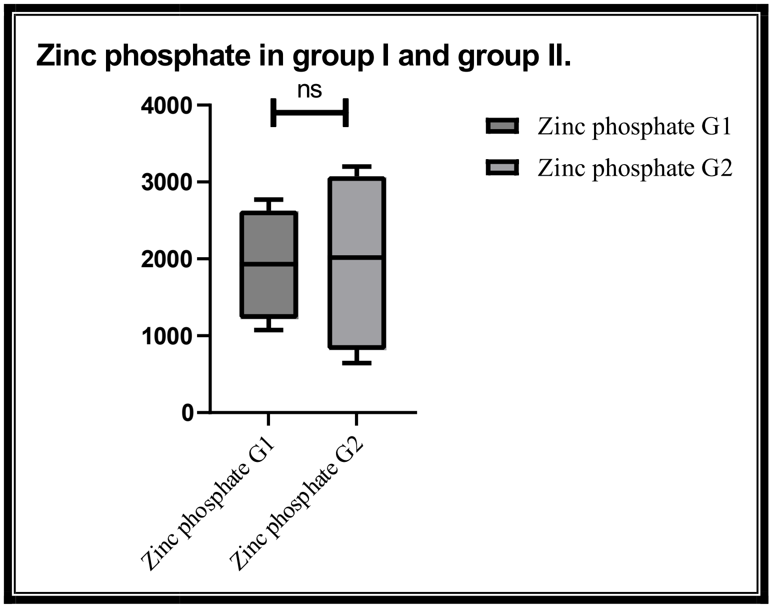


Figure (5): Flexi-post and Cast-post cemented by Zinc phosphate the two groups.

Table (3) and Figure (5) showed no significant difference between Cast-post and Flexi-cost regarding Zinc phosphate and Composite resin in all ferrule lengths (P>0.05).

Table (4): Flexi-post and Cast-post cemented with composite resin in the two groups.

Flexi-post and Cast-post	0mm	1.5mm	2.5mm	3.5mm	P
Composite resin Group 1 (Mean±S.D)	1126.61±123.89	1700.91±185.84	2483±174.59	3737.29±206.19	0.0637 NS
Composite resin Group 1 (Mean±S.D)	1216.32±159.58	1958.45±244.23	2887.11±402.64	4411.432±1211.72	

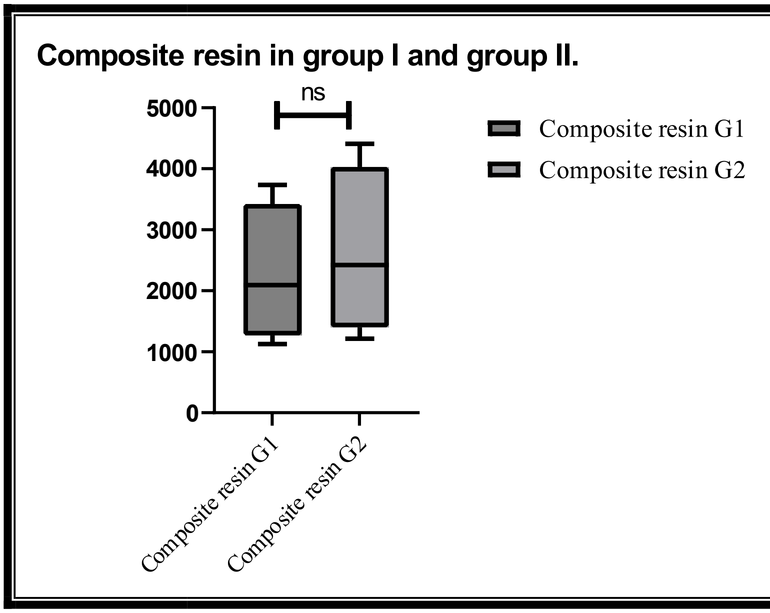


Figure (6): Flexi-post and Cast-post cemented by composite resin in the two groups.

Table (4) and Figure (6) revealed no significant variation between values of Composite resin in both groups (P>0.05).

Group I cast-post

Table (5): Zinc phosphate cement (0 length on 1.5, 2.5, and 3.5 mm)

Ferrule Length	Zinc phosphate cement (0 length) **Mean** + S. D	P
1.5mm	584.63±73.89	0.0715 NS
2.5mm	1123.86±58.87	
3.5mm	1695.9280±251.33	

p>0.05,a non-significant difference has been found for Zinc phosphate values regarding the ferrule length.

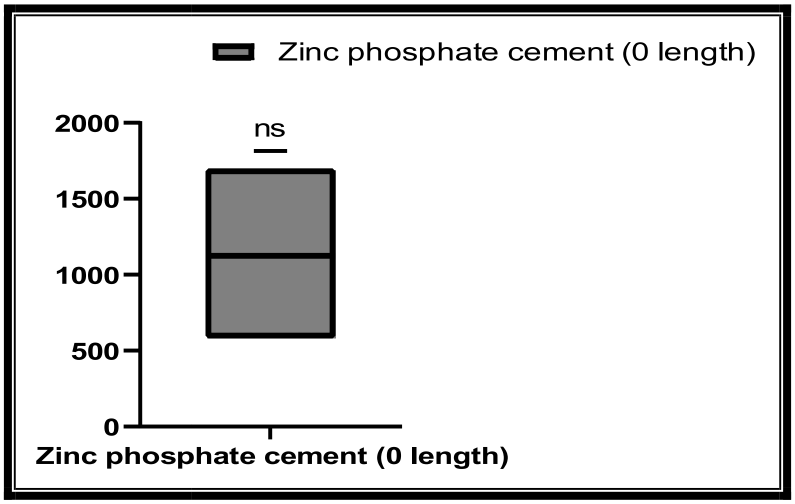


Figure (7): zinc phosphate cement (0 length on 1.5, 2.5, and 3.5)

Ferrule Length	**Composite resin (0 length)**	**P**	
1.5mm	-552.3±69.496	0.166	NS
2.5mm	-1356.39±59.258		
3.5mm	-3284.822±88.394		

Table (6): composite resin (0 length, 1.5, 2.5, and 3.5)

Table (6) and figure (7) showed that there was no significant difference between values of Composite resin (0 length) in all ferrule lengths.

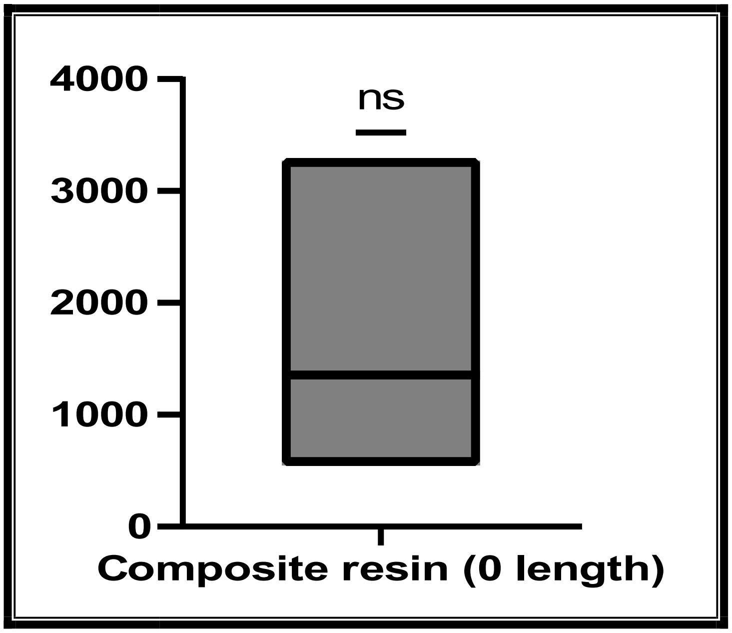


Figure (8): Composite resin (0 length) vs Ferrule length (1.5,2.5 and 3.5)

Group II flexi-post

Table (7): Zinc phosphate cement (0 length, on 1.5, 2.5, and 3.5)

Ferrule Length	**Zinc phosphate (0 length)**	**P**
1.5mm	694.344	0.0783 NS
2.5mm	2048.584	
3.5mm	2314.524	

Table (7) and Figure (8) showed no significant difference between Zinc phosphate cement (0 length and other ferrule lengths (P>0.05).

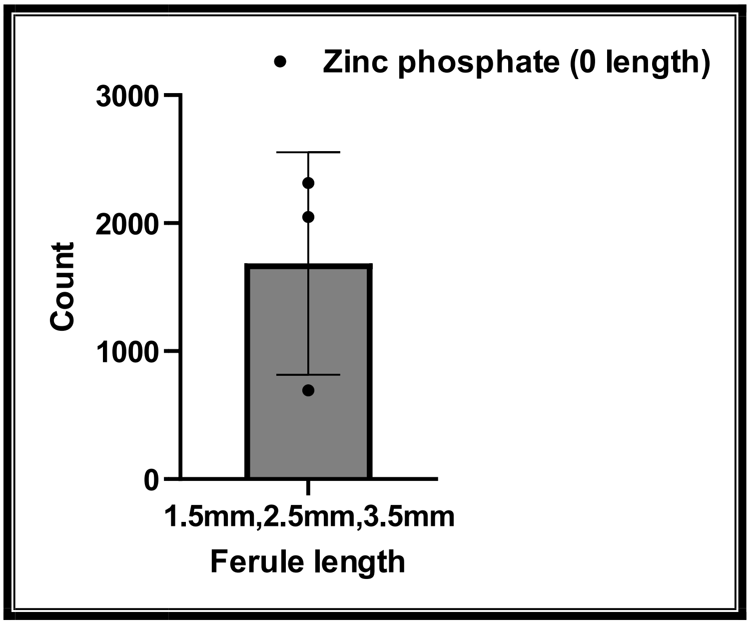


Figure (9): Zinc phosphate cement (0 length, on 1.5, 2.5, and 3.5)

Table (8): Group II (Flexi-Post) in composite resin (0 length, on 1.5, 2.5, and 3.5)

Ferrule Length	**Composite resin (0 length)**	**P**
1.5mm	742.13	0.0768 NS
2.5mm	1570.79	
3.5mm	3520.97	

Table (8) and Figure (9) showed no significant difference between Composite resin (0 length and other ferrule lengths (P>0.05).

Ferrule Length	**Composite resin (0 length)**	**P**
1.5mm	742.13	0.0768 NS
2.5mm	1570.79	
3.5mm	3520.97	

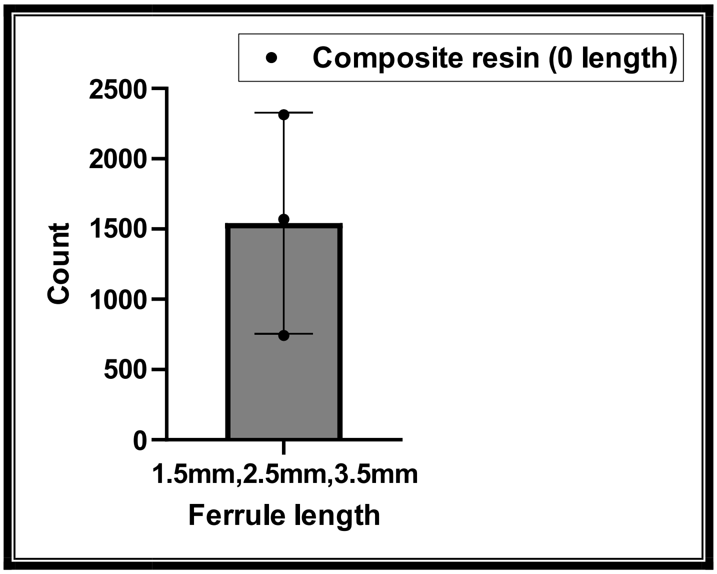


Figure (10): Composite resin (0 length, on 1.5, 2.5, and 3.5)

Table (9):Group I and Group II

Ferrule length	Zinc phosphate in group I	Zinc phosphate in group II	Composite resin in group I	Composite resin in group II
0	645.976	1076.34	1126.61	1216.32
1.5	1340.32	1660.97	1700.91	1958.45
2.5	2200.2	2694.56	2483	2887.11
3.5	2772.27	3200	3737.29	4411.43

Table (10): T-test results of Group I and Group II (P<0.01)

Tukey's multiple comparisons tests	Mean Diff.	95.00% CI of diff.	Below threshold?	Summary	Adjusted P Value
Zinc phosphate in group I vs. Zinc phosphate in group II	-418.3	-592.5 to -244.0	Yes	**	0.0042
Zinc phosphate in group I vs. Composite resin	-522.3	-1261 to 216.6	No	ns	0.1197
Zinc phosphate in group I vs. Composite	-878.8	-2107 to	No	ns	0.1163

resin		349.5			
Zinc phosphate in group II vs. Composite resin	-104	-859.0 to 651.0	No	ns	0.9041
Zinc phosphate in group II vs. Composite resin	-460.5	-1678 to 757.1	No	ns	0.4085
Composite resin vs. Composite resin	-356.5	-953.7 to 240.7	No	ns	0.1756
Test details	Mean 1	Mean 2	Mean Diff.	SE of diff.	
Zinc phosphate in group I vs. Zinc phosphate in group II	1739	2158	-418.3	36.11	
Zinc phosphate in group I vs. Composite resin	1739	2262	-522.3	153.1	
Zinc phosphate in group I vs. Composite resin	1739	2618	-878.8	254.5	
Zinc phosphate in group II vs. Composite resin	2158	2262	-104	156.5	
Zinc phosphate in group II vs. Composite resin	2158	2618	-460.5	252.3	
Composite resin vs. Composite resin	2262	2618	-356.5	123.8	

A highly Significance difference has been noticed between Zinc phosphate in group 1 and group 2 at p=0.0042 (less than 0.01)

Nosignificant difference has been noticed between other parameters in both groups

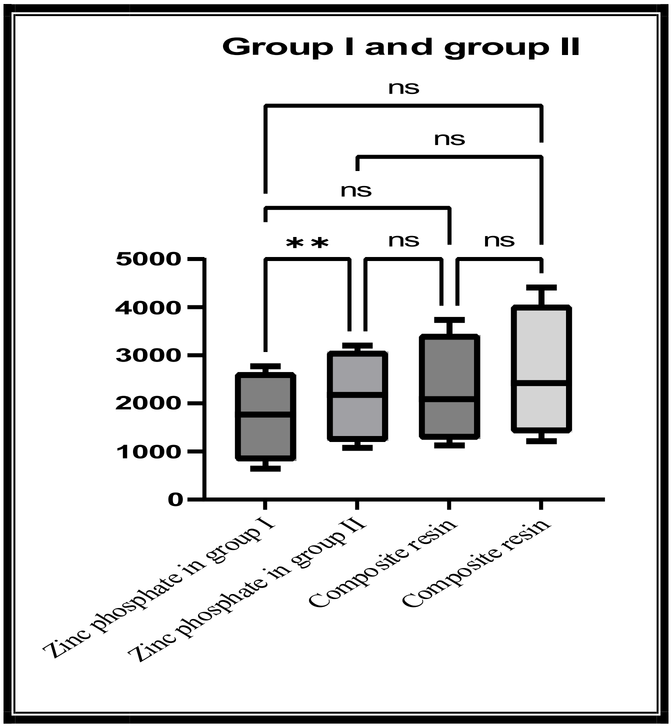


Figure (11): Group I and Group II

Table (11): Comparison between Cast-post and Flexi-post.

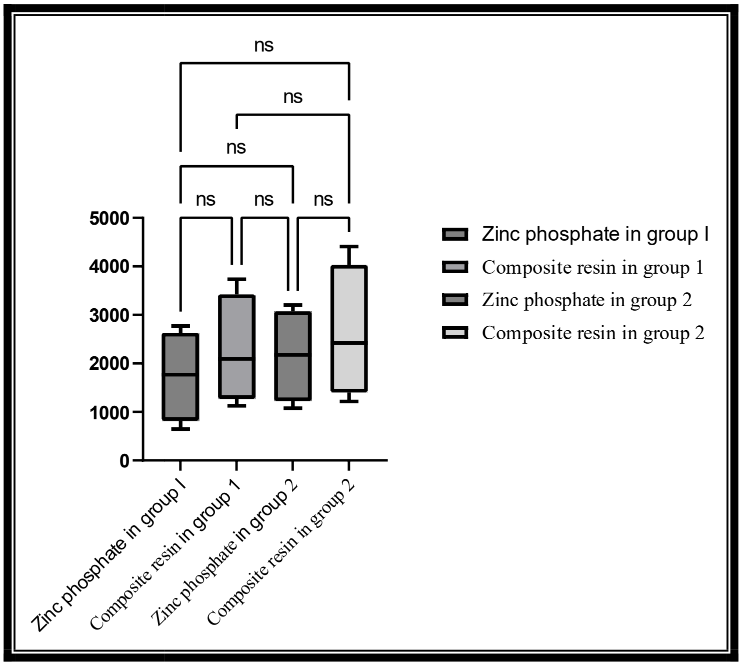
Group I Cast-post	0mm	1.5mm	2.5mm	3.5mm	Group II Flexi-post	0mm	1.5mm	2.5mm	3.5mm
Zinc phosphate	645.976	1340.32	2200.2	2772.27	Zinc phosphate	1076.34	1660.97	2694.56	3200
Composite resin	1126.61	1700.91	2483	3737.29	Composite resin	1216.32	1958.45	2887.11	4411.43

Group I Cast-post	0mm	1.5mm	2.5mm	3.5mm	Group II Flexi-post	0mm	1.5mm	2.5mm	3.5mm
Zinc phosphate	645.976	1340.32	2200.2	2772.27	Zinc phosphate	1076.34	1660.97	2694.56	3200
Composite resin	1126.61	1700.91	2483	3737.29	Composite resin	1216.32	1958.45	2887.11	4411.43

Figure (12): Comparison between Cast-post and Flexi-post.

Group I Cast-post	0mm	1.5mm	2.5mm	3.5mm	Group II Flexi-post	0mm	1.5mm	2.5mm	3.5mm
Zinc phosphate	645.976	1340.32	2200.2	2772.27	Zinc phosphate	1076.34	1660.97	2694.56	3200
Composite resin	1126.61	1700.91	2483	3737.29	Composite resin	1216.32	1958.45	2887.11	4411.43

Nosignificant difference has been noticed (ns)



From Table (12) and Figure (12), we revealed no significant variation between both groups (P>0.05

Discussion

Root-filled teeth provide difficulty when the adequate coronal structure of the tooth remains to sustain a restoration. Several post-and-core systems may be utilized to create a sturdy foundation for the final restoration[13].

In our research, the influence of the length of the ferrule on the resistance to fracture in root-filled teeth was determined by restoring the teeth with various types of posts (Flexi-post, cast post).Various types of zinc phosphate and composite resin for cementation were studied. The upper central incisors were picked and selected because of their optimal root shape and length. Their roots were straight, long and surrounded the circular root channel enough.

A material with great strength, stress distribution, and corrosion resistance must be used to construct the post [1,5,13].All of the chosen posts employed in this investigation have good strength and resistance to corrosion. The flexi-post was created to alleviate the old problem of the potential for the occurrence of fracture in the root, owing to the peculiar patent split-shank that absorbs stresses during insertion by progressively closing during installation while combining parallel and tapering designs to epically fit the natural architecture of the external root [6,9,14].

The maximum values for resistance to fracture were achieved with flexi-posts and cast posts bonded by zinc phosphate cement or composite resin at a ferrule length of 3.5 inches, according to the findings of this investigation, which was similar to multiple trials [7,12,15-19].This is likely due to the remaining ferrule length (dentinal tooth structure).As it enhances fracture resistance, ferrule length is crucial for restoring endodontically-treated teeth [12,20,21]. Moreover, this could be linked to the natural dentine, which is superior to any post and core in terms of fracture resistance as it disperses the stress to the surrounding structure. This needs vigilance during tooth preparation for endodontic post-insertion since the endodontically treated teeth' fracture resistance is strongly tied to the residual structure of the tooth and preventing its breakage and evenly dispersing occlusal stresses. [22].

In contrast, several investigations found no advantages to including the ferrule in the endodontic preparation of teeth [23-26]. Variations in their experimental procedures may account for this result.

Consensus holds that a correctly designed ferrule significantly lowers the non-vital teeth' incidence of fracture by strengthening the tooth and its exterior surface and spreading stresses that concentrate at the tooth's narrowest point across its circumference. Also, it helps preserve the integrity of the crown's cement seal. [22].

Our findings revealed that the minimum length of the ferrule should be (1.5 mm) in the root of the maxillary central incisor, coronal to the cementoenamel junction, to provide resistance to fracture; this was like multiple investigations [7,15].

The teeth repaired with flexi-posts and cemented with composite resin had the highest resistance to fracture among the post types evaluated in the current investigation; this is consistent with the findings and interpretation of another investigation[2,27,28].Additionally, it had the lowest resistance to fracture among teeth repaired with posts and cemented with zinc phosphate; this outcome was similar to other research [2,16,17]. These findings are mostly attributable to the tensile and compressive strength of the resin-luting cement technique, the resin cement's adhesive capacity, in addition to the elasticity and strength of dentin. This factor contributes to a reduction in potential stress and an increase in fracture resistance, possibly due to the buffer zone provided by the resin cement layer that causes the uniform stress distribution between the canal and the post. As a result, the space between the channel wall and the post is filled with resin; it acts as a resilient sealant for a degree of vertical displacement, causing an increase in fracture resistance [26].

Conclusion

The following conclusions may be taken, given the limitations of this in vitro trial:

• Restoration of root-filled teethbyflexipostsandcementedusingcompositeresinhad agreater fractureresistance.

in comparison with otherscementedwithzincphosphate.

- In root-filled teeth, enhancingthe ferrulelength(coronaldentinalstructure) enhanced the resistance tofracture.
- Restoration of root-filled teeth withflexipostandTicorehad greaterfracture resistance thanthe castpostanditscore.
- Root-filled teethrepairedwithcastpostandcementedusingcompositeresinhad agreaterfracture

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