Original Article

Comparative evaluation of fracture resistance of endodontically treated teeth with wedge shaped non-carious cervical lesions using different types of esthetic post: An *in vitro* study

Mousumi Biswas, Dibyendu Mazumdar, B. Gengadharani, Kallol Kumar Saha, Binayak Saha, Debjani Saha

Department of Conservative Dentistry and Endodontics, Dr. R. Ahmed Dental College and Hospital, Kolkata, West Bengal, India

Abstract

Introduction: Background of the study: Conventionally, postcore and crown foundation systems have been employed for restoring endodontically treated teeth (ETT).

Aim: The aim of this study was to evaluate and compare the fracture resistance of ETT with wedge-shaped noncarious cervical lesions (NCCLs) using different types of esthetic posts.

Technique: Forty maxillary first premolars possessing two root canals have been randomly divided into four groups ($n = 10$). Thirty tooth specimens were used to generate buccal wedge-shaped NCCLs. Zirconia and prefabricated fiber posts have been cemented in Groups III and IV. In universal testing machine, the palatal cusp has been subjected to nonaxial compressive stress at 30° angle with crosshead speed of 0.5 mm/min till fracture occurred. (1) Group I – composite resin core (CRC), (2) Group II – NCCLs + CRC, (3) Group III – NCCLs + PFC + CRC, and (4) Group IV – NCCLs + custom-made zirconia post + CRC.

Results: A one-way analysis of variance/Kruskal–Wallis test was employed to compare the outcome variables between the study groups, which showed Group III's fracture resistance was noticeably greater than Group I. Finally, there has been a substantial difference ($P < 0.0001$) between Group IV and all other groups.

Conclusion: Maxillary premolars with NCCLs that were repaired endodontically utilizing PFCs showed higher fracture resistance than maxillary premolars without posts.

Keywords: Custom-made zirconia post; endodontically treated tooth; noncarious cervical caries; prefabricated fiber post

INTRODUCTION

In many cases, posts are necessary to properly preserve the core material in teeth that have suffered severe hard-tissue loss as a result of trauma or cavities. The crucial element for a successful outcome is the remaining tooth structure since they lack mechanical traits such as strength loss, fragility, and fracture susceptibility.[1,2] Posts are separated into two groups according to their composition: metallic and tooth colored. Custom-made and prefabricated posts are two other types of tooth-colored posts.[3,4] A catastrophic, irreparable fracture of tooth could result from the metallic post because of its higher modulus of elasticity than dentin.[5] Esthetics has a major impact on patient happiness. The need for endodontic posts and core materials with exceptional esthetics has increased due to the expanding usage of all ceramic dental restorations. Dentin and enamel

Address for correspondence:
Dr. B. Gengadharani,
Dr. R. Ahmed Dental College and Hospital, Kolkata,
West Bengal, India.
E-mail: gengadharani62@gmail.com

Date of submission : 16.01.2025
Review completed : 02.02.2025
Date of acceptance : 05.02.2025
Published : 03.03.2025

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jcde

DOI: 10.4103/JCDE.JCDE_46_25

How to cite this article: Biswas M, Mazumdar D, Gengadharani B, Saha KK, Saha B, Saha D. Comparative evaluation of fracture resistance of endodontically treated teeth with wedge shaped non-carious cervical lesions using different types of esthetic post: An *in vitro* study. J Conserv Dent Endod 2025;28:285-9.

that are undamaged have elastic modulus of about 15 GPa and 80 GPa, respectively.[6]

After the maxillary premolars were prepared with a buccal cervical lesion and root canal treatment the fracture resistance was reduced by 50% according to Pavita Tangsripongkul *et al*. study.[7] NCCLs, which are prevalent tooth anomalies with a high incidence (53%–72%), most frequently affect maxillary premolars.[8,9] NCCLs have two distinct morphological characteristics: saucer-shaped lesions and wedge-shaped lesions. As a result of pattern and direction of occlusal pressures following occlusal loading that emphasizes tensile stress at the deepest section of NCCLs, wedge-shaped lesions have been prevalent on buccal cervical surface of maxillary premolars.[10,11] Current research attempts at determining that NCCLs among other post systems affected fracture resistance with patterns of maxillary premolars that had received endodontic treatment.

MATERIALS AND METHODS

Sample selection

- Specimens: 40 intact human maxillary first premolars extracted for orthodontic reasons
- Storage: Physiological saline (0.9%) at room temperature
- Ethical approval: Institutional Ethical Committee, Ref No: EC/NEW/INST/2023/3191
- Grouping
  1. Group I: Composite resin core (CRC)
  2. Group II: NCCLs + CRC
  3. Group III: NCCLs + prefabricated fiber post + CRC
  4. Group IV: NCCLs + custom zirconia post + CRC.

Artificial noncarious cervical lesion preparation

- Artificial wedges created on buccal cervical aspects of specimens in Groups II–IV using cylindrical diamond burs and high-speed handpieces with water coolant.
- Preparation criteria:
  1. Buccal vertical height: 3 mm
  2. Mesiodistal width from mesial to distal line angle
  3. Occlusal wall: 2 mm coronal to cementoenamel junction (CEJ)
  4. Gingival wall: 1 mm cervical to CEJ
  5. Root canal preparation
  6. Depth: Pulpal space exposure (1/3 of BL width at CEJ)
  7. Apex at CEJ level.

Standardized root canal treatment

1. Working length: 0.5 mm short of radiographic apex
2. Step-back technique (master apical file=#40)
3. Lateral condensation with gutta-percha (GP) and eugenol-free sealer
4. Restorative procedures.

Group I:
Endodontic access cavity had been filled with nanohybrid composite resin.

Group II:
Endodontic access cavity and NCCLs have been filled with composite resin.

Group III:
1. Post space prepared in palatal canal using Gates Glidden drill (#1 drill)
2. Apical 4 mm GP has been left for apical seal
3. PFC's apical end coated with resin cement before luting
4. Composite resin is used for orifice closure and access cavity repair.

Group IV:
1. Custom-made zirconia post cemented with resin cement after post space preparation
2. Restoration performed similarly to Group III.

Fracture resistance testing

- Equipment: Instron E3000 with 5 mm diameter stainless steel sphere crosshead
- Procedure:

Nonaxial static compressive load applied at 30°angle to tooth's long axis at 0.5 mm/min until breakage. Load applied on buccal slope of palatal cusp and central fossa [Figure 1].

Statistical analysis

Collected data have been tabulated in spreadsheet utilizing Microsoft Excel 2021; then, statistical analysis has been conducted employing IBM SPSS Statistics for Windows, Version 27.0 (Armonk, NY, USA: IBM Corp.). Nonparametric tests were performed for analyzing quantitative variables. Intergroup comparisons were carried out with one-way analysis of variance test. $P \leq 0.05$ has been considered a level of significance.

RESULTS

Group III exhibited the highest fracture resistance with a mean (±standard deviation [SD]) of 846 ± 8.43 N, ranging from 830 to 860 N. This was followed by Group I, which showed a fracture resistance of 666 ± 6.27 N (range: 657–675 N). Group II recorded a slightly lower fracture resistance of 651 ± 6.09 N (range: 642–661 N). Group IV had the lowest fracture

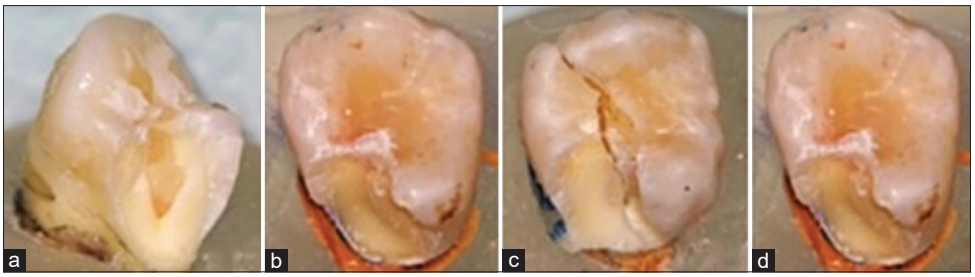


Figure 1: (a) Group I, (b) Group II, (c) Group III, and (d) Group IV specimens after testing in universal testing machine

Table 1: Descriptive statistics and comparison of fracture resistance (*N*) of endodontically treated teeth between the study groups

Study groups/parameter	Mean±SD	Minimum–maximum	*P*[a]
Group I: CRC (*n*=10)	666±6.27[A]	657–675	<0.0001*
Group II: NCCLS + CRC (*n*=10)	651±6.09[A]	642–661	
Group III: NCCLS + PFC (*n*=10)	846±8.43[B]	830–860	
Group IV: NCCLS + CZP + CRC (*n*=10)	429±23.5[C]	390–460	

*Statistically significant ($P \leq 0.05$), [a]Analyzed by the one-way ANOVA test. Different superscript letters indicate significant differences between the pairs. *n*: Sample size per group, CRC: Composite resin core, NCCL: Noncarious cervical lesions, PFP: Prefabricated fiber post, CZP: Custom-made zirconia post, SD: Standard deviation, ANOVA: Analysis of variance

Table 2: Pairwise comparisons

Tukey's multiple comparisons test	Mean difference	Adjusted *P* value
Group I versus Group II	15.54	0.0586
Group I versus Group III	−179.7	<0.0001
Group I versus Group IV	236.9	<0.0001
Group II versus Group III	−195.2	<0.0001
Group II versus Group IV	221.3	<0.0001
Group III versus Group IV	416.6	<0.0001

resistance, with a mean (± SD) of 429 ± 23.5 N, ranging from 390 to 460 N [Table 1].

Group III's fracture resistance has been significantly higher than that of all other groups, according to pairwise comparisons ($P < 0.0001$). Although there was not significant difference within Groups I and II ($P = 0.0586$), Group I demonstrated considerably stronger resistance than Group IV ($P < 0.0001$). Resistance had been much higher in Group II than in Group IV ($P < 0.0001$) while significantly lower than in Group III ($P < 0.0001$). Finally, there has been substantial difference ($P < 0.0001$) between Group IV and all other groups [Table 2].

DISCUSSION

Maxillary premolars are frequently affected by NCCLs, which are prevalent dental anomalies with an incidence rate of 53%–72%.[10] According to morphology NCCLS are classified into wedge shaped and saucer shaped. wedge shaped being more common in maxillary premolars due to pattern of occlusal force.[11] Age-related alterations to the mechanical strength of dentine are known to occur due to the increased risk of sclerotic dentine formation.[12] Fracture resistance of endodontically treated teeth mainly depends on remaining tooth structure. This also reduce catastrophic fracture of endodontically treated tooth.[13]

It has been suggested that the same elastic modulus (18 GPa) of the root dentine and fiber post can reduce stress concentration and bring the stress distribution closer together.[14] The current study examined two fiber post systems: PFCs and custom-made zirconia posts, which were cemented into the tooth specimens' palatal canals [Figure 2]. Interestingly, even though maxillary premolars exhibited a reduced fracture resistance when fiber posts have been inserted into palatal canal, manner of failure had significantly greater advantage in Group III (i.e., restorable fracture). This functioned as a monoblock, distributing forces along long axis of post and providing roots with strong resistance to shatter under occlusal forces.[14]

However, when evaluating endodontically treated maxillary premolars with NCCLs that contained posts in palatal canal or both canals, additional research observed an insignificant enhancement in fracture resistance.

Graph 1 represents this study has already shown that maxillary premolars with NCCL that have had endodontic treatment and have fiber post and custom-made zirconia post in the palatal canal (Group III and Group IV) have a different level of fracture resistance than their counterparts without NCCLs and post (CRC). A flowable resin composite has been utilized to reconstruct NCCL. Bioceramic sealer was used for better sealing property.[15]

Flowable resin composites often exhibit a reduced modulus of elasticity and viscosity in comparison with nanohybrid variants due to their diminished filler loading (about 37%–53%). Additional advantages include decreased void formation and improved marginal adaptability as compared to other resin composites.[16,17]

Nonaxial compressive loading, which replicates the damaging lateral occlusal stress on functional (palatal) cusp following occlusal loading, is predominant loading method

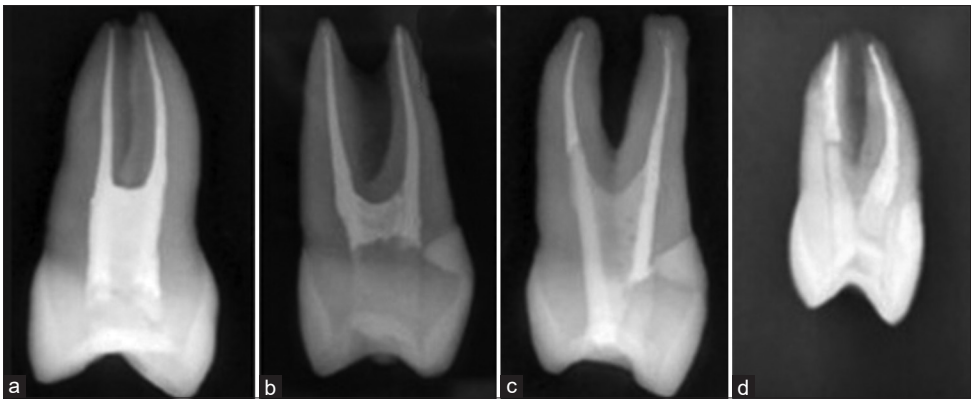
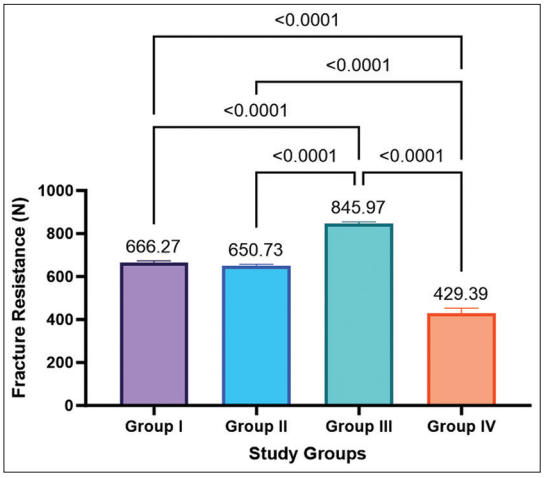


Figure 2: Radiographic images of the experimental specimens as (a) Group I, (b) Group II, (c) Group III, and (d) Group IV



Graph 1: Comparison of fracture resistance (*n*) between the study groups

employed in current research. Future research should incorporate both cyclic loading and thermal stress to more precisely replicating impacts of aging and masticatory function on the specimens, as recently and thoroughly discussed.

Before being tested, the tooth specimens in our study were kept at room temperature in saline, which would have had an unknown effect on their behavior and mechanical properties. Specimens ought to be preserved at 37°C with humidity levels similar to those in oral cavity to reduce any potential confounding effects.

This study results indicated that endodontically treated maxillary premolars with NCCLs repaired with direct composite resin (Group II) exhibited fracture resistance equivalent to those without NCCLs (CRC).

It is interesting to note that the implantation of a PFC (Group III) showed significantly better fracture resistance when compared to those restored without a post (Group II) which was consistent with research conducted by Bazzo *et al*.[18] and Pruthi *et al*.[19] According to the study done by Habibzadeh *et al*., fracture resistance of ETT with prefabricated fiber post was better.[20] This could be explained on the fact that the modulus of elasticity of prefabricated fiber post is same as radicular dentine and also that fiber posts absorb the stress to some extent, and the amount of stress delivered to root dentine is comparatively less.[20] However, the outcome for the custom-made zirconia post (Group IV) was different. The latter could be explained by zirconia post's higher modulus of elasticity, which is more than radicular dentin.[20] Based on the study conducted by Leung *et al*., restoration of ETT with NCCLs using prefabricated fiber post has higher fracture resistance than those without post.[21] The highest percentage of undesired fracture patterns have been discovered in the tooth specimens of Group IV, indicating that utilizing custom-made zirconia post restoration for endodontically treated maxillary premolars could yield detrimental effects.

Long-term survival of ETT depends mainly on the appropriate post endodontic restoration according to the condition of root canal-treated tooth. Hence, selecting suitable restorative material when needed reinforced by post and core that can distribute force adequately in this case PFC which shows higher fracture resistance can be used.[22]

CONCLUSION

Following root canal therapy, maxillary premolars exhibiting an NCCL might have fracture resistance comparable to that of teeth without NCCL provided they are adequately repaired. There were notable variations in the pattern and fracture resistance between the usage of custom-made zirconia posts and PFCs. Those with a PFC demonstrated a higher fracture resistance than those without one. Moreover, in terms of fracture, ETT with custom-made zirconia post had unfavorable fracture and had the least fracture resistance. Root canal anchoring is crucial in prosthetic therapy and dental restoration, and it remains as major concerns in future. It is essential to understand

the principles and processes behind the development of strong interfaces in root canal posts and dentin to provide long-lasting results for ETT repaired with a crown.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Maroulakos G, Nagy WW, Kontogiorgos ED. Fracture resistance of compromised endodontically treated teeth restored with bonded post and cores: An *in vitro* study. J Prosthet Dent 2015;114:390-7.
2. Soliman M, Alshamrani L, Yahya B, Alajlan G, Aldegheishem A, Eldwakhly E. Monolithic endocrown versus hybrid intraradicular post/core/crown restorations for endodontically treated teeth; cross-sectional study. Saudi J Biol Sci 2021;28:6523-31.
3. Al Khaldi FF. Post placement and restoration of endodontically treated teeth: A review. Int J Med Dev Ctries 2020;4:534.
4. Singh SV, Chandra A, Pandit IK. A new classification of post and core. Indian J Restor Dent 2015;4:56-8.
5. Hennig CL, Stöcker A, Nitzsche A, Marquetand J, Jacobs C, Jahn F. Influence of root post materials and aging on fracture strength and marginal gap quality of ceramic crowns-an *in vitro* study. Materials (Basel) 2023;16:3985.
6. Kumar P, Rao RN. Three-dimensional finite element analysis of stress distribution in a tooth restored with metal and fiber posts of varying diameters: An *in-vitro* study. J Conserv Dent Endod 2015;18:100-4.
7. Tangsripongkul P, Jearanaiphaisarn T. Resin composite core and fiber post improved the fracture parameters of endodontically treated maxillary premolars with wedge-shaped cervical lesions. J Endod 2020;46:1733-7.
8. Fei X, Wang Z, Zhong W, Li Y, Miao Y, Zhang L, *et al.* Fracture resistance and stress distribution of repairing endodontically treated maxillary first premolars with severe non-carious cervical lesions. Dent Mater J 2018;37:789-97.
9. Yoshizaki KT, Francisconi-Dos-Rios LF, Sobral MA, Aranha AC, Mendes FM, Scaramucci T. Clinical features and factors associated with non-carious cervical lesions and dentin hypersensitivity. J Oral Rehabil 2017;44:112-8.
10. Yang J, Cai D, Wang F, He D, Ma L, Jin Y, *et al.* Non-carious cervical lesions (NCCLs) in a random sampling community population and the association of NCCLs with occlusive wear. J Oral Rehabil 2016;43:960-6.
11. Hayashi M, Kubo S, Pereira PN, Ikeda M, Takagaki T, Nikaido T, *et al.* Progression of non-carious cervical lesions: 3D morphological analysis. Clin Oral Investig 2022;26:575-83.
12. Montoya C, Arango-Santander S, Peláez-Vargas A, Arola D, Ossa EA. Effect of aging on the microstructure, hardness and chemical composition of dentin. Arch Oral Biol 2015;60:1811-20.
13. Haridoss S, Rajendran M, Swaminathan K, Anbarasi, Sharma A, Elumalai V. Impact of pericervical dentin on fracture resistance of endodontically treated posterior permanent teeth: A systematic review and meta-analysis. J Contemp Dent Pract 2024;25:372-85.
14. Priyanka B, Parvathaneni KP, Raju TB, Seshadri A, Dondapati GD. Comparative evaluation of fracture resistance of wide and flared endodontically treated teeth with new techniques of postplacement – An *in vitro* study. J Conserv Dent Endod 2024;27:1141-5.
15. Kaul S, Kumar A, Badiyani BK, Sukhtankar L, Madhumitha M, Kumar A. Comparison of sealing ability of bioceramic sealer, AH plus, and GuttaFlow in conservatively prepared curved root canals obturated with single-cone technique: An *in vitro* study. J Pharm Bioallied Sci 2021;13:S857-60.
16. Baroudi K, Rodrigues JC. Flowable resin composites: A systematic review and clinical considerations. J Clin Diagn Res 2015;9:E18-24.
17. Szesz A, Parreiras S, Martini E, Reis A, Loguercio A. Effect of flowable composites on the clinical performance of non-carious cervical lesions: A systematic review and meta-analysis. J Dent 2017;65:11-21.
18. Bazzo JF, Pedriali MB, Guiraldo RD, Berger SB, Moura SK, de de Carvalho RV. Push-out bond strength of different translucent fiber posts cemented with self-adhesive resin cement. J Conserv Dent 2016;19:583-6.
19. Pruthi V, Talwar S, Nawal RR, Pruthi PJ, Choudhary S, Yadav S. Evaluation of retention and fracture resistance of different fiber reinforced posts: An *in vitro* study. J Conserv Dent 2018;21:157-61.
20. Habibzadeh S, Rajati HR, Hajmiragha H, Esmailzadeh S, Kharazifard M. Fracture resistances of zirconia, cast Ni-Cr, and fiber-glass composite posts under all-ceramic crowns in endodontically treated premolars. J Adv Prosthodont 2017;9:170-5.
21. Leung WS, Lee AH, Liu C, Hu M, Chang JW, Neelakantan P, *et al.* Fracture resistance of endodontically treated maxillary premolars with non-carious cervical lesions restored with different post systems. Eur Endod J 2023;8:65-71.
22. Thakur A, Ramarao S. A comparative evaluation of fracture resistance of endodontically treated premolar teeth reinforced with different prefabricated and custom-made fiber-reinforced post system with two different post lengths: An *in vitro* study. J Conserv Dent 2019;22:376-80.