COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED MANDIBULAR MOLARS RESTORED WITH DIRECT CONVENTIONAL COMPOSITE VERSUS COMPOSITE RESTORATION REINFORCED WITH HORIZONTAL FIBERGLASS POSTS: AN IN? VITRO STUDY

INTRODUCTION

Root canal therapy allows for the preservation of teeth that would otherwise be extracted. However, it compromises structural integrity as removal of tooth tissue during access, instrumentation, and restoration reduces stiffness and increases fracture risk. Despite high success rates in microbial control, the structural integrity of endodontically treated teeth remains a challenge[1,2]. Tooth fracture has been reported as a more frequent cause of tooth loss than reinfection[3], particularly when definitive full-coverage restorations are delayed due to financial or logistical constraints [1].

Immediate full coverage with or without a post and core is the best way to prevent fracture. Unfortunately, in many population areas, predominantly due to cost, this restoration is often delayed, leading to fracture of the tooth. A promising technique to enhance the mechanical integrity of these teeth involves the use of a composite restoration reinforced with glass fibers, particularly with fiberglass posts.

Several in-vitro studies have demonstrated that horizontally placed fiberglass posts, especially in the buccolingual orientation, significantly improve fracture resistance [4]. However, limited experimental evidence exists for mandibular molars, which are subjected to high occlusal loads and are clinically vulnerable[5].

This study aims to compare the fracture resistance of endodontically treated mandibular molars restored with conventional composite resin to those reinforced with horizontally placed fiberglass posts.

Subjects and Methods:

The current in -vvitro study was conducted at the Department of Conservative Dentistry and Endodontics, National Dental College And Hospital, Dera Bassi.

Sample Size Calculation : The sample size was calculated to be 15 samples in each group using the G*Power software v. 3.1.9.4 and the effect size to be measured (f) at 48%, power of the study was at 80%, and the alpha error at 5%. Thirty permanent mandibular molars, which were extracted for periodontal purposes, they were collected and were preserved in 0.1% thymol solution.

Sample preparation: Standard access cavities were prepared in mandibular molars and canals (mesiobuccal, mesiolingual, distal) were located and instrumented to their working lengths. Irrigation was with 3% sodium hypochlorite and 17% EDTA. The canals were all obturated with gutta-percha and AH Plus (Dentsply Sirona, Tulsa, OK) cement using warm vertical condensation. [Figure 1a].

According to the postendodoontic restoration used the samples were assigned at random to two primary groups:Group 1 (n = 15): Samples restored with direct composite resin (Ivoclar Tetric N Ceram) and Group 2 (n = 15): Samplesrestored with composite resin reinforced with horizontally placed fiberglass posts in the buccolingual direction.

In Group 2, standardized horizontal slots were created in the coronal dentin using a #1 drill [Figure 1b]. Fiberglass posts (0.8 mm diameter) were positioned horizontally [Figure 1c], acid - etched, bonded, and secured with flowable composite [Figure 1d]. The chamber was then incrementally restored with composite resin [Figure 1e].

Fracture Testing: All specimens were embedded in acrylic blocksbelow the cementoenamel junction (CEJ). They were stored in saline at 37°C for 24 hours. A universal testing machine applied compressive load at a crosshead speed of 1 mm/min until fracture occurred [Figure 2]. Maximum load to fracture (N) was

recorded.

<u>Statistical Analysis</u>:Statistical analysis was performed using SPSS version 22.0 (Armonk, NY: IBM Corp). Descriptive statistics (mean and standard deviation) were calculated for testing fracture resistance of different groups. Independent t-test was used to compare groups, with statistical significance set at P < 0.05.

Figure 1: Root canal therapy and restoration with horizontal posts: (a)Root canal treated sample, (b) Horizontal post space preparation in buccolingual direction, (c) Placement of horizontal fiberglass posts across buccolingual walls and cementation using flowable composite, (d) Restoration with packable composite resin covering horizontal posts, (e) Completed composite build-up after post placement

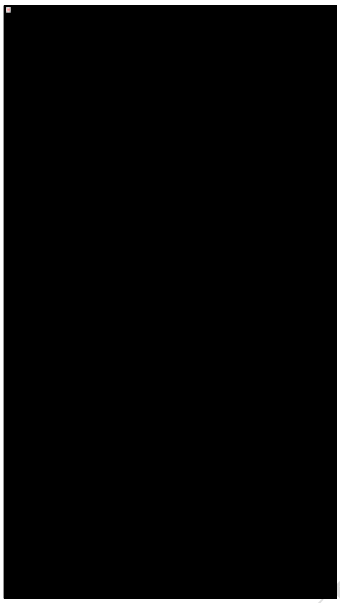

Figure 2: Specimen mounted in Universal Testing Machine for fracture resistance testing.

Results:

Group Distribution of Samples

As shown in [Table 1], the distribution of samples was done across the experimental groups. Each group comprised 15 specimens, resulting in a total sample size of 30. Group I included teeth restored with direct conventional composite resin, while Group II consisted of teeth restored with composite reinforced using horizontal fiberglass posts.

Comparing the mean fracture resistance values among the groups

As shown in [Table 2], the mean fracture resistance values Group 1 (conventional composite resin) demonstrated a mean fracture resistance of 890.45 ± 115.32with values ranging from 720 N to 1080 N, whereas Group 2 (horizontal fiberglass post reinforced composite) showed a significantly higher mean fracture resistance of 1245.67 ± 135.28Nranging from 1020 N to 1480 N. The difference between the groups was statistically significant ($p < 0.001$), indicating that horizontal fiberglass post reinforcement substantially improved fracture resistance.

Multiple comparison of mean difference between groups

According to [Table 3], the results of the independent*t*-test used for intergroup comparison. The mean difference in fracture resistance between the two groups was 355.22 N, with a *t*-value of 7.15. This difference was found to be highly significant ($p < 0.001$), further confirming that Group II performed significantly better than Group I in resisting fracture forces.

Mode of Fracture Distribution

The mode of fracture distribution is depicted in [Table 4]. In Group I, the majority of specimens (73.3%) exhibited non-restorable fractures occurring below the cementoenamel junction (CEJ), whereas only 26.7% of specimens had restorable fractures above the CEJ. In contrast, Group II demonstrated a favorable pattern, with 73.3% of fractures being restorable and only 26.7% being non-restorable. The difference in fracture patterns between the groups was statistically significant

(p<0.05), indicating that horizontal fiberglass post reinforcement not only increased strength but also shifted fracture patterns toward more clinically manageable outcomes.

A concise summary of the key findings is provided by [Table 5]. Compared to direct composite restoration, composite reinforced with horizontal fiberglass posts exhibited higher fracture resistance, a greater proportion of restorable fractures, and reduced risk of catastrophic, non-restorable failures. Clinically, these results suggest that the use of horizontal fiberglass posts can enhance structural integrity and improve the prognosis of endodontically treated teeth subjected to occlusal forces.

Table 1: Group Distribution of Samples

Group	Restoration Technique	Sample Size (n)
Group I	Direct Conventional Composite	15
Group II	Composite Reinforced with Horizontal Fiberglass Posts	15
Total	—	30

Table 2: Mean Fracture Resistance (in Newtons) of Different Groups

Group	Mean ± SD (N)	Minimum (N)	Maximum (N)
Group I: Direct Composite	890.45 ± 115.32	720	1080
Group II: Composite + Horizontal Fiberglass Posts	1245.67 ± 135.28	1020	1480
p-value	**< 0.001**	—	—

Table 3: Intergroup Comparison (Independent t-test)

Comparison	Mean Difference (N)	t-value	p-value	Significance
Group I vs. Group II	355.22	7.15	<0.001	Highly Significant

Table 4: Mode of Fracture Distribution

Group	Restorable Fractures (Above CEJ)	Non-restorable Fractures (Below CEJ)	% Restorable
Group I: Direct Composite	4 (26.7%)	11 (73.3%)	26.7%
Group II: Composite + Horizontal Fiberglass Posts	11 (73.3%)	4 (26.7%)	73.3%
Chi-square value	—	—	**p < 0.05 (Significant)**

Table 5: Summary of Results

Outcome Measure	Group I (Direct Composite)	Group II (Composite + Fiber)	Interpretation
Mean Fracture Resistance (N)	Lower	Higher	Fiber reinforcement improved resistance
Failure Mode	Mostly non-restorable	Mostly restorable	Fiber reinforcement promoted favorable fractures
Clinical Implication	Weaker, higher extraction risk	Stronger, repairable failures	Fiber reinforcement recommended

Discussion:

The long-term success of endodontically treated teeth depends not only on the elimination of infection but also on the restoration of structural integrity and resistance to fracture. Tooth fracture after root canal therapy has been recognized as one of the most important reasons for tooth loss[6,8], sometimes surpassing the risk of endodontic reinfection [9]. In this context, restorative strategies that can reinforce the remaining tooth structure are crucial to preserve function, esthetics, and longevity.

The present in-vitro study compared the fracture resistance of mandibular molars restored with direct composite restorations versus those reinforced with horizontally placed fiberglass posts. The findings clearly indicated that the incorporation of horizontal fiberglass posts significantly enhanced fracture resistance when compared to conventional composite restorations. This improvement can be attributed to several biomechanical and material-related factors.

Composite resins, while highly esthetic and conservative, have a higher modulus of elasticity compared to dentin. This mismatch may lead to concentration of occlusal forces at the junction of tooth and restorative material, ultimately predisposing the tooth to fracture under repeated functional loading [12]. By contrast, fiberglass posts possess an elastic modulus similar to dentin, allowing them to act as a stress distributor rather than a stress concentrator [13].

The concept of reinforcement through horizontal post placement[7] relies on a “monoblock effect” in which dentin, adhesive, composite, and the post act as a single unit, dissipating stress across the restoration more evenly [9]. This biomechanical harmony helps prevent catastrophic root fractures and promotes favorable, repairable fractures above the cementoenamel junction (CEJ). The current results showed that horizontally reinforced groups demonstrated higher resistance to load application and exhibited fracture patterns that were more restorable clinically, consistent with findings of Santos et al. [14] and Soares et al. [15].

Our findings are consistent with Plotino et al. [10], who highlighted that restorative design, especially conservative approaches that retain dentin, directly affects fracture resistance of endodontically treated teeth. Garoushi et al. [11]demonstrated the clinical potential of fiber-reinforced composites in the restoration of severely damaged anterior teeth, further reinforcing the idea that fibers can significantly enhance the structural performance of weakened teeth.

Similarly, Marchi et al. [12] found that the type of filling technique and restorative composite used can significantly alter fracture strength. Their study highlighted the importance of material choice and demonstrated that fiber incorporation could mitigate the adverse effects of structural loss after endodontic treatment.Mannocci et al. [13]emphasized that quartz fiber posts contributed to higher resistance under fatigue loading compared to metallic or ceramic posts, due to their dentin-like flexibility. This corroborates our study's outcome that fiber-based reinforcement provides biomechanical compatibility.

Santos et al. [14] warned that while fiber posts may increase overall resistance, they can also alter stress distribution in ways that influence fracture mode. In our study, the reinforcement provided by horizontal posts led to favorable fracture patterns, supporting their utility as a conservative reinforcement strategy.Soares et al. [15]also emphasized the role of periodontal ligament simulation and stress distribution in fracture testing, underlining that the behavior of restorative systems is highly dependent on the supporting structures. Though our study did not simulate periodontal ligament properties, the observed trends remain relevant to the clinical setting.

Schmitter et al. [16] investigated upper premolars with class II composite restorations and concluded that reinforced restorations provided better fracture resistance than conventional composites. The present study aligns with these results, extending their relevance to mandibular molars, which endure even greater masticatory forces.

Horizontal fiberglass posts likely improve fracture resistance by better stress distribution at the dentin–composite interface—a finding echoed in prior research[17].

Research indicates that placing horizontal posts significantly increases fracture strength compared with MOD composite restorations, especially when paired with fiber-reinforced materials, bringing performance closer to that of intact teeth[18]. Further, the choice of ferrule design plays a critical role. Findings emphasize that even a minimal ferrule of 1.5–2 mm can dramatically improve fracture resistance in endodontically treated teeth[19]. Another study characterized the interaction between post placement and fracture location, noting that horizontal fiber posts generally increase resistance and that their position (e.g., slightly below the crown's middle third) influences failure mode[20]. Yet another investigation into the use of glass fiber–reinforced posts combined with resin-modified glass ionomer cement revealed a notable increase in fracture resistance compared to traditional post systems[21].

A critical observation of the present study was the difference in failure modes. Conventional composite restorations showed a higher incidence of catastrophic, non-restorable root fractures extending below the CEJ. Such fractures usually necessitate extraction, thereby jeopardizing tooth survival. In contrast, fiber-reinforced restorations tended to fail coronally or in a more favorable manner that could be managed clinically with subsequent restoration, consistent with previous literature[8,14].

CONCLUSION

Within the limitations of this in-vitro study design, the use of horizontal fiberglass posts may significantly enhance the fracture resistance of endodontically treated mandibular molars. Clinical studies with long-term follow-up are warranted to confirm the utility of this conservative and economical reinforcement method.

References:

1. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod. 1989;15:512-6.
2. Aquilino SA, Caplan DJ. Relationship between crown placement and the survival of endodontically treated teeth. J Prosthet Dent. 2002;87:256-63.
3. Boren DL, Jonasson P, Kvist T. Long-term survival of endodontically treated teeth at a public dental specialist clinic. J Endod. 2015;41:176-81.
4. Beltrao MC, Spohr AM, Oshima HM, Mota E, Burnett L. Fracture strength of endodontically treated molars transfixed horizontally by a fiberglass post. Am J Dent. 2009;22:9-13.
5. Karzoun W, Abdulkarim A, Samran A, Kern M. Fracture strength of endodontically treated maxillary premolars supported by a horizontal glass fiber post: an in vitro study. J Endod. 2015;41:907-12.
6. Bromberg CR, Alves CB, Stona D, Spohr A, Rodrigues-Junior S, Melara R. Fracture resistance of endodontically treated molars restored with horizontal fiberglass posts or indirect techniques. J Am Dent Assoc. 2016;147:952-8.
7. Scotti N, Forniglia A, Tempesta RM, Comba A, Pasqualini D, Alovisi M, et al. Effects of fiber-glass reinforced composite restorations on fracture resistance and failure mode of endodontically treated molars. J Dent. 2016;53:82-7.
8. Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent. 2002;87:431-7.
9. Belli S, Eraslan O, Eskitascioglu G, Karbhari V. Monoblock: a review of the concept and its applicability to root canal fillings. Int Endod J. 2011;44:775-81.
10. Plotino G, Grande NM, Isufi A, Ioppolo P, Pedulla E, Bedini R, et al. Fracture strength of endodontically treated teeth with different access cavity designs. J Endod. 2017;43:995-1000.
11. Garoushi S, Vallittu P, Lassila L. Direct restoration of severely damaged incisors using short fiber-reinforced composite resin. Dent Traumatol. 2009;25:595-9.
12. Marchi GM, Paulillo LA, Pimenta LA, Lima F. Effect of different filling techniques and resin composites on the fracture strength of roots after endodontic treatment. J Oral Rehabil. 2003;30:162-8.

Comment [D1]: Follow the punctuation marks carefully. Do not include unnecessary bibliographic elements such as issue number, month of publication, etc. Include names of six authors followed by et al if there are more than six authors.

13. Kurtz JS, Perdigão J, Geraldeli S, Hodges JS, Bowles WR. Bond strengths of four adhesives to dentin using a two-step etch-and-rinse technique. Oper Dent. 2003;28:441-7.
14. Santos MJ, Behr M, Martins LR. Influence of ferrule, post system, and length on fracture resistance of endodontically treated teeth. Quintessence Int. 2010;41:585-94.
15. Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of root embedment material and periodontal ligament simulation on fracture resistance tests. Braz Oral Res. 2008;22:211-6.
16. Schmitter M, Rammelsberg P, Gabbert O. Influence of clinical baseline findings on the survival of 2 post systems: a randomized clinical trial. Int J Prosthodont. 2010;23:223-30
17. Shah EH, Shetty P, Aggarwal S, Sawant S, Shinde R, Bhol R. Effect of fibre-reinforced composite as a post-obturation restorative material on fracture resistance: A systematic review. J Conserv Dent. 2021; posted online.
18. Belli S, Erdemir A, Yildirim C. Reinforcement effect of polyethylene fibre in root-filled teeth: comparison of two restoration techniques. J Conserv Dent. 2011;14:136-42.
19. Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Conserv Dent. 2002;5:431-7.
20. Singh S, Chhabra N, Sharma P, Tiku M. Does ferrule thickness influence resistance to fracture in endodontically treated teeth? An in vitro study. J Conserv Dent. 2018:307-12.
21. Bhandari A, Karthik KS, Nandakumar K, Jain AR. Fracture resistance of endodontically treated teeth restored with glass fiber posts using three different post space preparation techniques: An in vitro study. J Conserv Dent. 2019;22:376-80.

Acknowledgement:

I would like to express my heartfelt gratitude to the Almighty for His abundant blessings, guidance, and strength throughout this work.

I am deeply thankful to my parents for their unconditional love, constant encouragement, and endless support, which have been my greatest source of inspiration.

I extend my sincere thanks to my teachers for their invaluable guidance, motivation, and mentorship. Their dedication and knowledge have shaped my learning and helped me accomplish this work successfully.