ORIGINAL RESEARCH PAPER

Conservative Dentistry

TO EVALUATE THE FRACTURE RESISTANCE IN MANDIBULAR FIRST MOLARS RESTORED USING HORIZONTAL AND VERTICAL REINFORCEMENT TECHNIQUES - AN INVITRO STUDY

KEY WORDS: Root canal treated teeth; Horizontal glassfiber post; Vertical fiber post; Flowable composite; Dual-cure resin cement; Fracture resistance.

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ABSTRACT

Background: One of the most common post-endodontic therapy is glass fiber post combined with adhesively bonded resin composite restorations to enhance increase fracture resistance.The present study evaluated the fracture resistance of endodontically treated mandibular first molars restored with different fiber post orientations and restorative materials.**Aim:** To compare the fracture resistance of endodontically treated mandibular first molars restored with different fiber post orientations and restorative materials.**Materials and Methods:** Seventy extracted mandibular first molars were selected. Specimens were randomly allocated into seven experimental groups (n=10). Following root canal treatment, access opening and biomechanical preparation were performed. Horizontal fiber post placement was performed with or without a template technique, while vertical post placement was performed in the respective group. Restoration was completed using either flowable composite or dual-cure resin cement. Additional specimens with Class II (MOD) cavities restored with horizontal posts were evaluated. Fracture resistance was assessed using a universal testing machine, and fracture load values were statistically analyzed using one-way ANOVA followed by Bonferroni post hoc analysis (=0.05).**Results:** One-way ANOVA demonstrated a statistically significant difference in fracture resistance among the seven groups ($F=145.01$, $p<0.001$). The highest fracture resistance was observed in Class II cavities restored with horizontal fiber posts and flowable composite (1793.40 ± 75.23 N), followed by horizontal posts with template flowable composite (1473.20 ± 109.06 N) and Class II cavities restored with horizontal posts and dual-cure resin cement (1383.40 ± 182.88 N). The lowest fracture resistance was recorded in the vertical post with dual-cure resin cement group (793.40 ± 57.48 N). Bonferroni analysis revealed significant differences between most groups ($p<0.05$), with flowable composite demonstrating superior reinforcing ability compared with dual-cure resin cement.**Conclusion:** Within the limitations of this in vitro study, horizontal fiber post placement significantly enhanced the fracture resistance of endodontically treated mandibular first molars. The use of flowable composite as a reinforcing material provided higher fracture resistance compared with dual-cure resin cement, particularly in teeth with Class II cavity configurations.

INTRODUCTION

The principal objective of endodontic therapy is to conserve the natural tooth structure whenever possible.[1] ETT are at increased risk of fracture due to loss of coronal tooth by caries, excessive removal of dentin during therapeutic procedures, trauma, previous restorations, prolonged use of NaOCl and EDTA and endodontic over instrumentation, there is a direct relationship between the quantity of remaining tooth walls and fracture resistance.[2]

The loss of structural integrity of cusps and ridges and the complete removal from roof of the pulp chamber during endodontic access affect tooth function because of cusp deflection, which may lead to a increased risk of fractures.[3] The prognosis of root canal treated teeth is contingent not only on apical seal but also on the coronal sealing of the canal thereby reducing leakage of oral fluids and bacteria into the periradicular areas.[4]

Compared with indirect restorations such as metal or ceramic crowns and onlays, direct adhesive restorations are more conservative because they eliminate laboratory procedures and impression making while preserving greater amounts of sound tooth structure.[5] One of the major challenges in restoring deep carious lesions with mesio-distal extension is the significant reduction in fracture resistance compared to that of an intact tooth.[6] Previous studies have demonstrated that the loss of one marginal ridge decreases tooth rigidity by approximately 46%, while the loss of both marginal ridges reduces it by nearly 63%, thereby significantly compromising fracture resistance.[7]

Although numerous treatment modalities and restorative approaches are available in dental practice for coronal rehabilitation of teeth that have received endodontic treatment such as use of post and core, partial crowns, direct composite resins, and amalgam or ceramic restorations the selection of the best restoration is still debated. In addition to providing function, esthetic and marginal sealing, the chosen restoration needs to safeguard whatever is left of the tooth structure.[8] A widely used post-root canal procedure involves placing a glass fiber post combined with resin composite that is bonded adhesively, aimed at improving resistance to fractures.[9] The vertical post helps to retain the core severely mutilated teeth. However, owing to the biomechanical limitations associated with vertical post placement, these teeth are at greater risk of complications such as vertical root fractures, excessive loss of cervical dentin, and strip perforations in the furcation region. In contrast, placing horizontal fiber post is a more conservative technique that

preserves more tooth structure and can be performed in a relatively short clinical time.[10]

MATERIALS AND METHODOLOGY

Ethical clearance was obtained before the study (Ref. Number: EC/IRB NO: MDC-R-088533). Seventy extracted human mandibular first molars were taken for the present in-vitro study (Figure 1). Teeth without caries, cracks, fractures, restorations, or developmental anomalies were included in the present study. Teeth exhibiting structural defects such as craze lines, attrition, abrasion, erosion, or root abnormalities were excluded. All specimens were debrided using an ultrasonic scaler and subsequently stored in normal saline until further use. (Figure 2).

GROUPING

Group IA: Horizontal fiber post placement (n = 40)
Subgroup IA1: Horizontal fiber post with template technique (n = 20)

IA1a: Horizontal fiber post with template technique + flowable composite (n = 10)

IA1b: Horizontal fiber post with template technique + dual-cure resin cement (n = 10)

Subgroup IA2: Horizontal fiber post without template technique (n = 20)

IA2a: Horizontal fiber post without template technique + flowable composite (n = 10)

IA2b: Horizontal fiber post without template technique + dual-cure resin cement (n = 10)

Group IB: Vertical fiber post placement (n = 10)

IB: Vertical fiber post + dual-cure resin cement (n = 10)

Group II: Teeth without RCT (Vital teeth) with Class II MOD cavity preparation (n = 20)

Standardized Class II mesio-occluso-distal (MOD) cavity preparations were completed, followed by the preparation of through-and-through buccolingual channels using a No. 2 round bur to facilitate horizontal fiber post placement.

Based on composite used they were divided into two sub groups

Subgroup IIA: Class II MOD cavity + horizontal fiber post + flowable composite (n = 10)

Subgroup IIB: Class II MOD cavity + horizontal fiber post + dual-cure resin cement (n = 10)

Root Canal Treatment

GROUP I A

During the procedure, endodontic access cavity was performed followed by identification of all canal orifices (Figure 3). The working length was determined and confirmed by intraoral periapical radiograph (Figure 4). Biomechanical preparation of the root canals was performed using the crown-down technique with 3% sodium hypochlorite and 17% EDTA as irrigating solutions (Figure 5). Obturation was subsequently completed using a bioceramic sealer in conjunction with a single-cone gutta-percha technique (Figure 6).

Subgroup IA1

A model mockup was fabricated to create a template that would help identify and precisely locate the post placement site. The predetermined post channels were prepared on the master cast, and the fit of the glass fiber posts was verified using the fabricated acrylic template. Following confirmation of the template adaptation, it was positioned intraorally to guide the preparation of buccolingual channels with a No. 2 round bur through the remaining tooth structure. Subsequently, two glass fiber posts were placed through the prepared channels, extending from the buccal surface to the lingual surface. (Figure 7)

Subgroup IA1a

Following conventional acid etching and primer application of the coronal chamber, flowable composite resin was injected into the canal orifices and evenly adapted over the pulpal floor (Figure 8).

Subgroup IA1b

After completing the standard acid etching and priming protocols for the coronal chamber, a Dual cure composite resin was applied and injected into the canal openings and over the pulpal floor (Figure 9).

The pulp chamber was subsequently restored with the respective composite resin to completely surround and stabilize the two horizontal fiber posts. Any excess portion of the posts projecting beyond the buccal and lingual surfaces was removed, and the restoration was finished and polished to obtain a smooth surface.

Subgroup IA2

Using a Vernier caliper, two equidistant reference points were marked on the middle third of the buccal and lingual surfaces of the tooth. Buccolingual channels were then prepared through the remaining tooth structure with a No. 2 round bur. Subsequently, two glass fiber posts were positioned through these channels, extending from the buccal to the lingual surface (Figure 10).

Subgroup IA2a

After completing the standard acid etching and priming protocols for the coronal chamber, a Flowable composite resin was applied and injected into the canal openings and over the pulpal floor (Figure 11).

Subgroup IA2b

After completing the standard acid etching and priming protocols for the coronal chamber, a Dual cure composite resin was applied and injected into the canal openings and over the pulpal floor.

The chamber was then filled with respective composite resins to restore the area surrounding the two horizontal posts. Excess portions of the posts that extended beyond the buccal and lingual surfaces were trimmed off, and the restoration was subsequently polished to a smooth finish (Figure 12).

Group IB

Sectional obturation was performed in the distal canal, after which the post space was prepared and a vertical fiber post was placed. (Figure 13).

In this sub group, after completing the standard acid etching and priming protocols for the coronal chamber, a dual-cure composite resin was applied and injected into the canal openings and over the pulpal floor.The chamber was then filled with dual cure composite resins to restore the area surrounding the post. Excess portions of the posts that extended beyond the occlusal surface were trimmed off, and the restoration was subsequently polished to a smooth finish (Figure 14).

Group II

In this group standardised class II cavities (MOD) were prepared with the help of No. 2 round bur followed by placement of two equidistant points with the help of vernier calliper on the middle third of buccal and lingual surfaces of

the tooth. Holes were drilled using no. 2 round bur through the remaining buccal and lingual walls. Two glass fiber posts were then inserted through these holes, extending from the buccal to the lingual aspect (Figure 15).

Subgroup II A
After completing the standard acid etching and priming bur through or the coronal chamber, a flowable composite resin was applied and injected into the canal openings and over the pulpal floor (Figure 16).

Subgroup II B
After completing the standard acid etching and priming protocols for the coronal chamber, a dual-cure composite resin was applied and injected into the canal openings and over the pulpal floor (Figure 17).

Fracture Resistance Testing
Each specimen was positioned in a universal testing machine and subjected to a compressive load applied parallel to its long axis. A standardized loading tip was used to apply the load continuously until fracture occurred. The fracture load for each specimen was recorded in Newtons (N) (Figure 18).

Figure 1

Figure 2

Figure 3

Figure 4

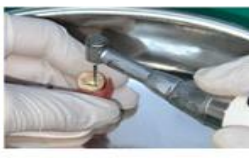


Figure 5

Figure 6

Figure 7

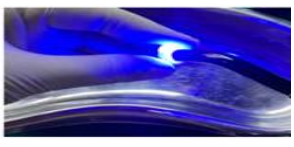


Figure 8

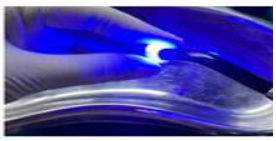


Figure 9

Figure 10

Figure 11

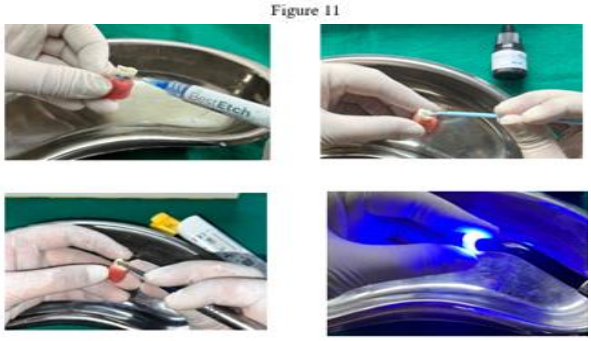


Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

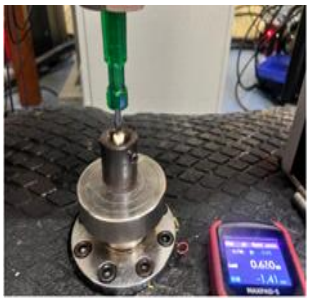


Figure 18

Statistical Analysis

The fracture load values were analyzed using IBM SPSS Statistics software version 26.0. Descriptive statistics including mean and standard deviation were calculated for each group. Normality of data distribution was assessed using the Shapiro–Wilk test. Since the data followed a normal distribution, intergroup comparison was performed using one-way analysis of variance (ANOVA). Post hoc comparisons were performed using the Bonferroni test. The level of statistical significance was set at $p \leq 0.05$.

RESULTS

One-way ANOVA revealed a statistically significant difference in mean fracture load among the seven experimental groups ($F = 145.01$, $p < 0.001$), indicating that the type of post orientation, restorative material, and cavity configuration had a significant influence on fracture resistance. The highest mean fracture load was observed in Class II cavities restored with a horizontal post and flowable composite (Group IIA; 1793.40 ± 75.23 N), followed by horizontal post with template flowable composite (Group IA1a; 1473.20 ± 109.06 N) and Class II cavities with horizontal post and dual-cure resin cement (Group IIB; 1383.40 ± 182.88 N). In contrast, the lowest fracture resistance was recorded in the vertical post with dual-cure resin cement group (Group IB; 793.40 ± 57.48 N) and horizontal post with template dual-cure resin (Group IA1b; 824.20 ± 56.78 N).

Post hoc Bonferroni analysis demonstrated that Group IA1a showed significantly higher fracture load than Groups IA1b, IA2a, IA2b, and IB ($p < 0.001$), while no statistically significant difference was noted between Group IA1a and Group II B ($p = 0.882$), suggesting comparable performance between these two configurations. Group II A exhibited significantly higher fracture resistance than all other groups ($p < 0.001$), including Group II B, confirming the superior reinforcing effect of flowable composite in Class II cavities with horizontal post placement. Comparisons involving Group IA1B and Group I B showed no significant difference ($p = 1.000$), indicating similarly low fracture resistance when dual-cure resin cement was used with either horizontal (template) or vertical post placement. Overall, the pairwise comparisons consistently demonstrated that flowable composite groups outperformed dual-cure resin cement groups, and horizontal post placement provided greater fracture resistance than vertical post placement. Additionally, the presence of Class II cavity configuration further enhanced fracture load, particularly when combined with flowable composite, highlighting the synergistic effect of cavity design, post orientation, and restorative material on fracture resistance.

Comparison of fracture load

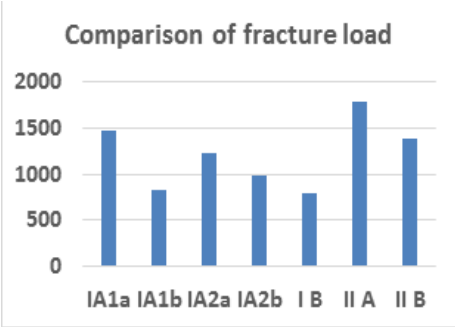
Group	Mean	SD	F-value	p-value
Horizontal Post with Template Flowable Composite (IA1a)	1473.20	109.06	145.01	<0.001*
Horizontal Post with Template Dual-Cure Resin (IA1b)	824.20	56.78		
Horizontal Post Without Template Flowable (IA2a)	1224.00	69.27		
Horizontal Post Without Template Dual Cure Resin Cement (IA2b)	982.50	56.24		
Vertical Post with Dual Cure Resin Cement (IB)	793.40	57.48		
Class II Cavities - Horizontal Post with Flowable Composite (II A)	1793.40	75.23		
Class II Cavities – Horizontal Post with Dual Cure Resin Cement (II B)	1383.40	182.88		

One-way ANOVA test; *indicates a significant difference at $p \leq 0.05$

Pairwise comparison of fracture load

Pairwise comparisons	Mean difference	p-value
IA1a vs IA1b	649	<0.001*
IA1a vs IA2a	249.2	<0.001*
IA1a vs IA2b	490.7	<0.001*
IA1a vs IB	679.8	<0.001*
IA1a vs II A	-320.2	<0.001*
IA1a vs II B	89.8	0.882
IA1b vs IA2a	-399.8	<0.001*
IA1b vs IA2b	-158.3	0.011*
IA1b vs IB	30.8	1.000
IA1b vs II A	-969.2	<0.001*
IA1b vs II B	-559.2	<0.001*
IA2a vs IA2b	241.5	<0.001*
IA2a vs IB	430.6	<0.001*
IA2a vs II A	-569.4	<0.001*
IA2a vs II B	-159.4	0.01*
IA2b vs IB	189.1	0.001*
IA2b vs II A	-810.9	<0.001*
IA2b vs II B	-400.9	<0.001*
IB vs II A	-1000	<0.001*
IB vs II B	-590	<0.001*
II A vs II B	410	<0.001*

Post hoc Bonferroni test; *indicates a significant difference at $p \leq 0.05$



DISCUSSION

The tooth is particularly susceptible to fracture during the interval between endodontic therapy and placement of the definitive restoration. In Class II MOD cavities, inadequate cuspal support may compromise the structural integrity of the tooth by promoting microcrack formation and cuspal flexure. Therefore, providing effective cuspal reinforcement is essential for improving the tooth's resistance to fracture. Immediate reinforcement of the tooth using horizontal posts following endodontic treatment, while maintaining the rubber dam in place, may reduce the likelihood of post-treatment fractures. Fiber posts are considered suitable because of their favourable mechanical properties. Teeth that have undergone endodontic treatment can be reinforced with horizontal fiber posts extending from the buccal to the lingual wall, thereby enhancing structural stability.[10]

Horizontal post reinforces MOD cavities by increasing the fracture resistance of premolars and molars compared with unrestored MOD cavity preparations, composite-restored MOD cavities, and teeth restored with conventional root canal posts. Root canal posts provide only retention without offering structural support, making horizontal posts preferable when the aim is to fortify the prepared tooth cavity and restoration against fracture.[8]

Mechanically, the junction between the vertical post, core foundation and definitive crown often carries certain intrinsic risks. Creating and the placement of vertical posts may produce vertical stresses that result in microcracks, fracture lines, or strip perforations, excessive removal of extra dentin in crucial regions can further compromise the tooth's strength. Hence, subjected to horizontal fracture.[10]

The advantages of using horizontal posts are minimally invasive, as the posts are inserted through at a depth of less than 1 mm of dentin.[1]In the current study teeth which are restored with vertical posts shows less fracture resistance when compared with the teeth which are rehabilitated using horizontal post.

Salameh et al (2006) and Scotti et al (2016), reported that when compared with a direct composite restoration, conventional direct composite restoration with fiber post significantly increased fracture resistance.[11,12]Bromberg et al (2016) and Borges et al (2021) applied two horizontal posts for molars; one runs through the mesial axial wall and the other through the distal axial wall; these two posts reported a marked improvement in fracture resistance.[2,9]

Rana et al (2023) in a case report used template method for placement of horizontal post, which was used in the template group IA1aof thisstudy.[1]the teeth restored using template shows highest fracture resistance compared to teeth rehabilitated without template in this study.

In the current study, the diameter of holes created for insertion of the post was kept less than 1 mm, which maintained the structural integrity of the tooth and enhanced its ability to bear functional loads. Using a horizontal post may temporarily help patients who cannot afford full-coverage crowns after root canal therapy.

Eventually, the horizontal post-core complex can provide adequate retention.In the present study cementation of the posts was done with the help of dual cure composite in groups IA1b, IA2b, IB, IIB .Dual-cure composites have been developed to achieve good cure beyond the conventional 2-mm depth regardless of light attenuation, while maintaining the advantage of on command setting offered by photoactivation (Candace B.Windle et al., 2022).[13]

Flowable composites have been used since 1995. Previously used flowable composites had less filler content, and as a result of their perceived mechanical limitation, they have traditionally been used clinically for restorations with minimal occlusal loading.[14]

Consequently, advanced flowable composite materials were produced for clinical restoration of occlusal cavity with excellent anatomy-forming properties, abrasion resistance, good strength, and expanded clinical application for the occlusal cavity (Walter Dukic et al.,2021).[14]

So in the current study flowable composite was used for cementation and restoration of teeth in groups IA1a, IA2a, IIA2a.The findings of the present study demonstrated that horizontal fiber posts luted with flowable composite exhibited superior fracture resistance compared with those luted using dual-cure resin cement.

Karzoun et al (2015) evaluated the fracture resistance on endodontically treated premolar teeth restored in a variety of ways found that the incorporation of a single buccolingually oriented horizontal glass fiber post within the core build-up almost doubled the fracture resistance when compared with a core restored using composite resin alone.[15]Mergulhao et al. (2019) Reported that the addition of horizontal posts, when used in composite restorations, significantly lessen thereby reducing the likelihood of catastrophic fractures in endodontically treated teeth (ETT).[16]

Abdulrab et al. (2023) reported that reinforcement with horizontal fiber posts significantly enhanced the fracture resistance of endodontically treated teeth.[17]Alghauli et al (2025) stated that Endodontically treated teeth (ETT) demonstrated better outcomes when both horizontal posts and composite restorations were used together compared to composite restoration alone and compared with unrestored cavities or composite restorations without support.[8]

CONCLUSION

Within the limitations of this in vitro study, horizontal fibre post placement significantly enhanced the fracture resistance of endodontically treated mandibular first molars. The use of flowable composite as the reinforcing material resulted in greater fracture resistance than dual-cure resin cement, with the most favourable outcomes observed in teeth restored using the template-guided technique.

REFERENCES

1. Rana V et al. Horizontal post – An innovative method to rehabilitate endodontically treated teeth. IP Ann Prosthodont Restor Dent. 2023;9(1):53–58.
2. Bromberg CR, Alves CB, Stona D, Spohr AM, Rodrigues-Junior SA, Melara R, Burnett LH Jr. Fracture resistance of endodontically treated molars restored with horizontal fiberglass posts or indirect techniques. J Am Dent Assoc. 2016 Dec;147(12):952-958.
3. Kneib Ferri, M., Bonato Luisi, S., Burnett Junior, L. H. ., Melara, R., & Fontoura de Melo, T. A. (2021). Effect of horizontal position of fiber post placement on fracture resistance and location in endodontically treated premolars with a MOD preparation. Giornale Italiano Di Endodonzia, 35(2).
4. Richard T. Restoration of endodontically treated teeth: criteria and technique considerations. Quintessence international. 2014;45:557-67.
5. Kumari M, Pandey P, Bharti R, Verma P, Jyothi M. Rehabilitation of weak marginal ridges in endodontically treated teeth: enhancing strength and longevity with horizontal fibre post IP Indian J Conserv Endod. 2025;10(2):118–120
6. Sharma S, Ramesh S, Rayapudi J. Biomechanical Performance of Mandibular Molars with Deep Mesio-Occlusal-Distal Cavities Rehabilitated with Horizontal Posts: A 3D Finite Element Analysis. International Journal of Dentistry. 2023;2023(1):3379373.
7. Daokar, Sadashiv & Ranjalkar et al. (2024). Enhancing Fracture Resistance in Coronal Structure of Endodontically Treated Teeth by Placing Horizontal Posts in Buccolingual Direction: Case Report. International Journal of Innovative Science and Research Technology (IJISRT). 995-999.
8. Alghauli MA, Alqutaibi AY, Al-Gabri RS, Baik AA, Mahrous AM, Bafail A, Saker S. Effectiveness of horizontal posts to support MOD cavities compared with other restorative approaches in endodontically treated teeth: systematic review with meta-analysis of laboratory studies. BMC Oral Health. 2025 May 21;25(1):743.
9. Borges AL, Grangeiro MT, De Andrade GS, De Melo RM, Baroudi K, Silva-Concilio LR, Tribst JP. Stress concentration of endodontically treated molars restored with transfixed glass fiber post: 3D-finite element analysis. Materials. 2021, 29;14(15):4249.
10. Sahng G. et al. A Novel Approach to Fracture Resistance Using Horizontal Posts after Endodontic Therapy: A Case Report and Review of Literature,

Journal of Endodontics, Volume 46, Issue 4, 2020, Pages:545-550.
11. Scotti N et al. Effects of fiber-glass-reinforced composite restorations on fracture resistance of ETT molars. J Dent. 2016;53:82–87.
12. Salameh Z et al. Fracture resistance of endodontically treated molars restored with resin composites with or without fiber posts. J Endod. 2006;32(8):752–755.
13. Windle CB, Hill AE, Tantbirojn D, Versluis A. Dual-cure dental composites: can light curing interfere with conversion? J Mech Behav Biomed Mater. 2022 Aug;132:105289.
14. Dukic W, Majic M, Prica N, Oreski I. Clinical Evaluation of Flowable Composite Materials in Permanent Molars Small Class I Restorations: 3-Year Double Blind Clinical Study. Materials (Basel). 2021 Jul 31;14(15):4283.
15. Karzoun W et al. Fracture strength of endodontically treated maxillary premolars supported by a horizontal glass fiber post: An in vitro study. J Endod. 2015;41(6):907–912.
16. Mergulhao VA et al. Fracture resistance of endodontically treated maxillary premolars restored with different methods. Oper Dent. 2019;44(1):1–11.
17. Abdulrab S, Geerts G, Al-Maweri SA, Alhajj MN, Alhadainy H, Ba-Hattab R. The influence of horizontal glass fiber posts on fracture strength and fracture pattern of endodontically treated teeth: A systematic review and meta-analysis of in vitro studies. J Prosthodont. 2023;32(6):469-481.