COMPARISON OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED CLASS II PREMOLAR TEETH RESTORED WITH DIFFERENT COMPOSITE RESTORATIONS: AN INVITRO STUDY

[1]Dr. Sowmya S, [2]Dr. Pradeep PR, [3]Dr. Ananthakrishna A, [4]Dr. Claudia Dayanandini, [5]Dr. Subhasmita Panda

[1]Post Graduate Student, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India.

[2]Principal and Professor, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India.

[3]Professor and HOD, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India.

[4]Post Graduate Student, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India.

[5]Post Graduate Student, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India.

ABSTRACT

Aims: The present study aimed to compare fracture resistance of endodontically treated class II premolar teeth restored with different composite restorations.

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Methodology: Sixty intact human premolars were selected for this study. All teeth received disto-occlusal preparation such that the buccolingual width was 3mm, mesiodistal width was 2mm and depth of the cavity was 4mm. A conservative endodontic access was done. The biomechanical preparation was done using hyflex CM rotary files upto apical size 30 with 6% taper. After preparation, canals were obturated with gutta percha using single cone technique. All teeth were etched with 37% phosphoric acid for 15seconds and washed with water for 15 seconds. The teeth were randomly divided into 6 groups (n=10 in each group) according to the type of the restorative material that was used Group A: Filtek P60 Group B: 3M ESPE Filtek Z250 XT Group C: Filtek bulkfill Group D: Tetric N-Ceram Bulkfill (Ivoclar) Group E: 3M Filtek Supreme Flowable Restorative underneath Filtek bulkfill Group F: Tetric N-Flow Bulkfill underneath Tetric N-Ceram bulkfill. All specimens were stored in an incubator at 37º C for 1week. The samples were subjected to universal testing machine at to determine fracture resistance.

Results: The highest fracture resistance was seen in teeth restored with 3M Filtek Supreme Flowable Restorative underneath Filtek bulkfill next by Tetric N-Flow Bulkfill underneath Tetric N-Ceram bulkfill, followed by Filtek bulkfill, Tetric N-Ceram Bulkfill, Filtek Z250 XT and least with Filtek P60. The statistical significance of these variations yielded a p-value of <0.001, indicating a highly significant difference among the groups.

Conclusion: This study concluded that, flowable composite underneath bulkfill improves fracture resistance of teeth when compared to only bulkfill. Highest fracture resistance is seen in Filtek Supreme Flowable Restorative underneath Filtek bulkfill, Tetric N-Flow Bulkfill underneath Tetric N-Ceram bulkfill followed by Filtek bulkfill, Tetric N-Ceram Bulkfill, Filtek Z250 XT, Filtek P60.

Keywords: *[Bulkfill composite, Flowable Composite, Filtek bulkfill, Tetric N-Ceram Bulkfill }*

INTRODUCTION

Endodontically treated teeth are more prone to fractures due to the removal of pulp tissue, leading to a 22% decline in moisture content and increased dentin brittleness. Structural compromises such as caries, access cavity preparation, instrumentation, and pre-existing fractures further weaken the tooth, making it more susceptible to fracture compared to vital teeth[1].

Effective coronal restoration and adequate support for the remaining tooth structure are critical for the long-term success of endodontic treatment. Premolars are especially vulnerable to cusp fractures due to their anatomy, unfavorable crown-to-root ratio, and exposure to shear and compressive forces[2-3].

Various materials like amalgam, GIC, and composite have been used to restore these teeth. Resin composites enhance fracture resistance by reinforcing remaining tooth structure. They gained popularity due to their superior aesthetics and minimal tooth destruction. The composite resin material was found to exhibit deeper strength and micromechanical interlocking[4].

Packable composites are widely used in posterior teeth due to their stiff viscosity and favorable handling similar to amalgam. These composites typically contain filler particles ranging from 0.4–1 µm[5].

Filtek Z250, a nanohybrid composite, offers high strength and durability. Its advanced formulation offers excellent mechanical properties and reliable clinical performance with reduced polymerization shrinkage due to its high filler content[5].

Posterior teeth endure high masticatory forces. Composite contraction stress can damage the marginal seal and result in microleakage[1]. This leads to microcracks and potential fractures. To overcome this, the incremental layering technique is used. However, this they require precise handling, additional time, and advanced skills since the composite must be applied in multiple layers. To simplify the procedure, bulk-fill resin composites were introduced, allowing single-layer placement[1,6-7].

Damanhoury and Platt (2014) reported that bulk-fill composites have 80% curing efficiency and lower shrinkage stress than incremental composites[1]. Tetric Evo-Ceram, a nano-hybrid bulk-fill, offers better depth of cure and creep resistance due to its optimized filler and matrix components[8]. Studies by Zorzin et al. and Fronza et al. confirm bulk-fills like Filtek Bulk Fill and Tetric N Ceram reduce shrinkage rates to 1.2–2.5% through stress-relieving monomers and high filler loads[9-10].

Despite their advantages, bulk-fills may exhibit poor adaptation to cavity walls. This can be improved by using a flowable composite liner[8]. Flowable composites, with smaller filler particles and low viscosity, adapt well to cavity anatomy and improve clinical performance when used beneath packable/hybrid composites[8,11]

Taha et al. demonstrated that using flowable composite as a base significantly enhances the fracture resistance of non-vital teeth[12]. This approach also reduces polymerization stress through the elastic bonding concept, improving durability and clinical outcomes[6].

Fracture toughness is a critical factor reflecting a material's ability to resist crack propagation. Evaluating bond strength under shear stress is necessary for accurate clinical insights. However, evidence on the fracture resistance of endodontically treated teeth restored with bulk-fill composites remains limited, necessitating further research[8].

So this study aims to "compare fracture resistance of endodontically treated class II premolar teeth restored with different composite restorations". [Packable (Filtek P60), Nanohybrid (3M ESPE Filtek Z250 XT), Bulkfill (Filtek bulkfill, Tetric N Cerum bulkfill), Flowable underneath bulkfill (3M Filtek Supreme Flowable Restorative underneath Filtek bulkfill, Tetric N-Flow Bulkfill underneath Tetric N-Ceram bulkfill]

Material and methods

The selected teeth were mounted in a self-cured acrylic resin blocks (1.5×1.5×1.5 cm) so that they remain 1 mm above the CEJ.

All teeth received disto-occlusal preparation such that the buccolingual width was 3mm, mesiodistal width was 2mm and depth of the cavity was 4mm measured from cavosurface margin of the palatal cusp. The cavosurface margins were prepared at 90°.

Conservative endodontic access were done on the pulp chamber wall using endo access bur and a straight-line access into the canal was gained, working length was set at 0.5 short of the apical foramen. The biomechanical preparation was done using hyflex CM nickel titanium rotary files upto apical size 30 with 6% taper and canals are irrigated with 0.9% saline solution and 3% NaoCl (sodium hypochlorite). After preparation, canals were obturated with gutta percha and AH-PLUS using single cone technique.

All teeth were etched with 37% phosphoric acid for 15seconds and washed with water for 15 seconds. A one-bottle adhesive system was then applied to the cavities with a microbrush and photopolymerised for 20 seconds.

The teeth were randomly divided into 6 groups (n=10 in each group) according to the type of the Restorative Material that was used

Group A: Teeth were restored with Filtek P60 (Packable/ microhybrid)

Group B: Teeth were restored with 3M ESPE Filtek Z250 XT (Nanohybrid)

Group C: Teeth were restored with Filtek bulkfill (3M ESPE)

Group D: Teeth were restored with Tetric N-Ceram Bulkfill (Ivoclar)

Group E: Teeth were restored with 3M Filtek Supreme Flowable Restorative underneath Filtek bulkfill (3M ESPE)

Group F: Teeth were restored with Tetric N-Flow Bulkfill underneath Tetric N-Ceram bulkfill.

All specimens were stored in an incubator at 37º C for 1week, at 100% relative humidity in deionized water before testing.The samples were subjected to universal testing machine to determine fracture resistance and fracture type (favourable or unfavourable). The test was performed at a speed of 1mm/min with a 5mm diameter round tip, parallel to the long axis of the tooth until a fracture occurred in the tooth or restoration.

STATISTICAL ANALYSIS

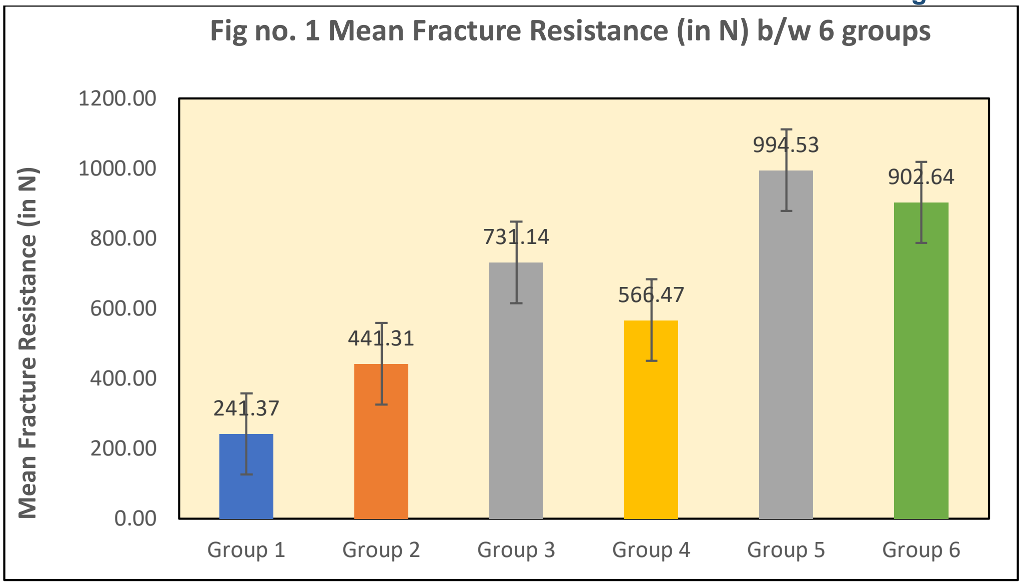
The sample size for the present study were estimated using GPower software (latest ver. 3.1.9.7; Heinrich-Heine-Universi-ta ̈t Du ̈sseldorf, Du ̈sseldorf, Germany). One-way ANOVA Test followed by Tukey’s post hoc test / Kruskal Wallis Test followed by Dunn’s post hoc test [Based on Data distribution] were used to compare the mean Fracture Resistance between 6 groups. The level of significance [P-Value] was set at P<0.05

Table no. 1 Comparison of mean Fracture Resistance (in N) b/w 6 groups using One-way ANOVA Test

Groups	N	Mean	SD	Min	Max	p-value
Group 1	10	241.37	89.25	115.4	372	<0.001*
Group 2	10	441.31	79.25	331.4	542.2	
Group 3	10	731.14	95.34	575.3	856.1	
Group 4	10	566.47	71.88	417.1	655.9	
Group 5	10	994.53	54.34	889.9	1076.4	
Group 6	10	902.64	83.21	767	995.7	

RESULTS

The mean fracture resistance values (N) and the standard deviations of each group are given in Table 1. Group 5 (3M Filtek Supreme Flowable Restorative underneath Filtek bulkfill) exhibited significantly higher fracture resistance compared to other groups followed closely by Group 6 (Tetric N-Flow Bulkfill underneath Tetric N-Ceram bulkfill). Group 3 (Filtek bulkfill) demonstrated moderate resistance, with Group 4 (Tetric N-Ceram Bulkfill) and Group 2 (Filtek Z250 XT) exhibiting lower values. Group 1 (Filtek P60) had the least fracture resistance among all groups.



DISCUSSION

A complete or partial break in a material caused by excessive force is called a fracture[13]. One crucial feature of dental materials is their ability to withstand fractures, which depends on resisting crack propagation from internal flaws. These flaws act as stress concentrators, leading to bulk fractures or marginal microfractures[14].

Posterior teeth bear the highest occlusal loads. Restorations disrupting enamel integrity, especially those covering more than one-third of the intercuspal distance, reduce fracture resistance and increase cusp fracture risk[15]. Premolars are particularly susceptible to fractures due to their position in the arch, prominent cusps, and fragile root anatomy, making post-placement inadvisable. These cuspal fractures in premolars highlight the need for materials with high fracture toughness after endodontic treatment, thus making fracture resistance a critical parameter for restoration longevity[16].

Studies report a 5% reduction in fracture resistance from endodontic procedures and 20% from occlusal cavity preparation. Taha et al. found teeth without proximal walls had a 60% lower fracture resistance. Access cavity preparation further weaken teeth[1,17]. Therefore, restorative materials must resist these dynamic stresses to ensure long-term post-endodontic success[18].

Also endodontically treated teeth have reduced structural integrity and a diminished long term prognosis than vital teeth. Traditionally, posts, cores, and full-coverage crowns were used to reinforce such teeth[19]. Contemporary minimally invasive dentistry now favors repairing rather than replacing restorations when feasible—e.g., minor fractures, intact margins, or localized secondary caries[20]. Adhesive direct restorations without posts have gained support for enhancing cuspal stiffness while preserving structure[1].

Mannocci et al. recommended direct composite restorations to restore function and aesthetics while minimizing tissue removal[6]. Kahler et al. confirmed composite resins offer mechanical properties similar to intact teeth, making them a reliable choice for endodontically treated teeth. Composite resins are preferred due to their adhesive nature, allowing minimal cavity prep and internal reinforcement[21].

In this study, Group 5 (3M Filtek Supreme Flowable under Filtek Bulk Fill, 1076.4 N) had higher fracture load than Tetric N-Flow under Tetric N-Ceram (995.7 N). This is because Flowable composites are more flexible due to lower filler content, improving wettability and adaptation. These act as flexible intermediate layer that may help dissipate stresses generated during the polymerization of large composite restorations, increasing fracture resistance. Their elastic modulus is similar to dentin, which enhances the fracture resistance[5]. Gabriela Ciavoi et al. confirmed base materials under adhesive restorations enhanced fracture strength.
Also high filler content of composites results in higher modulus and offer greater resistance to deformation. The increased filler content in Filtek Bulk Fill enhances its depth of cure by reducing the volume of the resin matrix available for polymerization. This leads to increased surface hardness and reduced polymerization shrinkage and ultimately increase fracture resistance.[22]

In this study, the fracture load of teeth in Group 6 restored with Tetric N-Flow Bulkfill under Tetric N-Ceram Bulkfill (1076.4 N) was higher than that of Group 3 with Filtek Bulkfill (856.1 N) (Refer Table 2). Tetric Evo-Flow Bulk Fill shows polymerization shrinkage stress that is lower or comparable than conventional composites, making it suitable as a flowable liner beneath bulk-fill. Its flexibility allows plastic deformation and energy absorption, reducing the risk of catastrophic failure. Its excellent adaptation to both tooth structure and bulk-fill composite enables it to function as a monolithic unit. Also the advanced filler system consists of barium aluminum silicate glass, Isofiller (glass fillers with ytterbium fluoride in a prepolymerized matrix), ytterbium fluoride, and spherical mixed oxides—has a refractive index matching the resin matrix, improving translucency despite high filler content. Additionally, the use of Ixoderin, a highly reactive dibenzoyl germanium-based light initiator, enhances depth of cure. These combined properties contributed to the superior fracture resistance observed in Group 5[8].

Group 3 (Filtek Bulk Fill) exhibited higher fracture load than Group 4 (Tetric N-Ceram, 655.9 N) due to its higher filler content and nanocluster technology. Filtek Bulk Fill contains silica/zirconia nanocluster fillers (20 nm for silica, 4–11 nm for zirconia), which enhance mechanical properties, durability, and load-bearing capacity. Its higher compressive strength (300 MPa) also contributes to its superior fracture resistance. Additionally, Filtek Bulk Fill incorporates true nano-filler technology, two innovative methacrylates, and 1,12-dodecane dimethacrylate (DDMA) that relieve stress during polymerization. A high molecular weight aromatic urethane dimethacrylate reduces volumetric shrinkage, while addition-fragmentation monomers introduce a third reactive site that fragments under curing stress, enhancing overall material performance.

Group 4 teeth restored with Tetric N-Ceram Bulk Fill (655.9 N) showed higher fracture load than those with Filtek Z250 XT (542.2 N). Tetric EvoCeram Bulk Fill contains a BisEMA and UDMA matrix (21 vol%) with a filler mix of barium aluminum-silicate glass (61%), isofiller ytterbium fluoride, and spherical mixed oxide (17%). Tetric EvoCeram have advanced filler technology, including the patented light initiator Ivocerin, which is more reactive than conventional initiators and allows 4 mm polymerization in just 10 seconds. This rapid curing reduces shrinkage stress. Additionally, its glass fillers, with a low elastic modulus of 71 GPa, act like microscopic springs to absorb and distribute stress, enhancing restoration durability and increasing fracture resistance compared to Filtek Z250 XT[24].

In this study, the fracture load of teeth restored with Filtek Z250 XT (Group 2) (542.2 N) was higher than that of teeth restored with Filtek P60 (Group 1) (372.0 N). Teeth restored with Filtek Z250 XT (Group 2, 542.2 N) showed higher fracture load than those with Filtek P60 (Group 1, 372.0 N), due to differences in filler content and composition. Filtek Z250 XT has higher filler loading and uses small to medium round zirconium fillers, improving bonding surface area and mechanical strength. The presence of aromatic monomers like Bis-GMA and Bis-EMA enhances cross-linking and reduces cyclization, contributing to superior strength, durability, and compressive resistance[25].

In this study, Filtek P60 showed the lowest fracture load (372.0 N) among all experimental groups. As a packable posterior composite with 60–70% filler volume and compressive strength of 360–380 MPa, it aims to reduce polymerization shrinkage. However, its relatively low filler content compromises mechanical performance. Its resin matrix (BisGMA, BisEMA, UDMA, TEGDMA) and ZrO_2/SiO_2 fillers (0.01–3.5 µm) contribute to higher resin volume, increasing shrinkage and internal stress. This weakens the bond to tooth structure, reducing load resistance and increasing fracture susceptibility[16].

This study also assessed fracture types, classifying them as favourable or unfavourable. Most specimens showed unfavourable fractures where the fracture line is below the cementoenamel junction (CEJ), rendering them non-restorable. These results align with findings by Hande Kemaloglu et al. and Aws H. Atiyah et al., who also reported a predominance of non-restorable fractures[24].

Extrapolating the results of this study directly to clinical practice is challenging due to certain limitations as this study was conducted on freshly extracted, intact teeth, unlike typical clinical cases where endodontically treated teeth are often compromised or previously restored. Intraoral factors—such as thermal and chemical changes, and variations in occlusal force—also affect fracture resistance but are hard to replicate in vitro. Hence, long-term clinical studies are needed to evaluate the effectiveness of composites in post-endodontic restorations[7,24].

CONCLUSION

Loss of tooth structure, whether at the coronal or radicular level, significantly influences the structural integrity of endodontically treated teeth. The highest mean fracture resistance was observed in specimens restored with a flowable bulk-fill composite underneath a bulk-fill composite. This was followed by restorations using bulk-fill composites (Filtek Bulk Fill and Tetric N-Ceram Bulk Fill). Nanohybrid composite (Filtek Z250 XT) demonstrated moderate fracture resistance, while the lowest resistance was recorded in teeth restored with a packable composite resin (Filtek P60).

Reference

1.Atalay C, Yazici AR, Horuztepe A, Nagas E, Ertan A, Ozgunaltay G. Fracture Resistance of Endodontically Treated Teeth Restored With Bulk Fill, Bulk Fill Flowable, Fiber-reinforced, and Conventional Resin Composite. Oper Dent. 2016 Sep-Oct;41(5):E131-E140. doi: 10.2341/15-320-L. Epub 2016 Jun 28. PMID: 27352045.

2.R M Ahmed, Doaa & Ghobashy, Ahmed & Banna, Mai. (2017). MICROLEAKAGE AND FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH BULK-FILL RESTORATIVE MATERIALS. Egyptian dental journal. 63. 839-849. 10.21608/edj.2017.75204.

3.Mergulhão VA, de Mendonça LS, de Albuquerque MS, Braz R. Fracture Resistance of Endodontically Treated Maxillary Premolars Restored With Different Methods. Oper Dent. 2019 Jan/Feb;44(1):E1-E11. doi: 10.2341/17-262-L. PMID: 30715998.

4.Preethy NA, Jeevanandan G, Govindaraju L, Subramanian E. Comparison of Shear Bond Strength of Three Commercially Available Esthetic Restorative Composite Materials: An In Vitro Study. Int J Clin Pediatr Dent. 2020 Nov-Dec;13(6):635-639. doi: 10.5005/jp-journals-10005-1849. PMID: 33976488; PMCID: PMC8060938.

5.Ozgünaltay G, Görücü J. Fracture resistance of class II packable composite restorations with and without flowable liners. J Oral Rehabil. 2005 Feb;32(2):111-5. doi: 10.1111/j.1365-2842.2004.01364.x. PMID: 15641976.

6.Renuka M. Evaluation of fracture resistance of two new nano hybrid composites with and without SDR Liner- An in vitro study. http://www.jamdsr.com/. Medarametla Renuka; 2020 [cited 2025 May 25]. Available from: http://www.jamdsr.com/

7.Atalay, Cansu & Yazici, Ayse & Horuztepe, Aynur & Nagas, Emre. (2022). The Effect of Endodontic Treatment and Thermocycling on Cuspal Deflection of Teeth Restored with Different Direct Resin Composites. Conservative Dentistry and Endodontic Journal. 6. 38-44. 10.5005/jp-journals-10048-0105.

8.Susila, Anand & Aruna Kumari, Veronica & Manimaran, Manivannan & Sai, Shamini. (2022). Fracture Resistance of Teeth Restored by Layered and Nonlayered Composite Resin. Journal of Operative Dentistry & Endodontics. 6. 62-64. 10.5005/jp-journals-10047-0114.

9.Zorzin J, Maier E, Harre S, Fey T, Belli R, Lohbauer U, Petschelt A, Taschner M. Bulk-fill resin composites: polymerization properties and extended light curing. Dent Mater. 2015 Mar;31(3):293-301. doi: 10.1016/j.dental.2014.12.010. Epub 2015 Jan 9. PMID: 25582061.

10.Fronza BM, Rueggeberg FA, Braga RR, Mogilevych B, Soares LE, Martin AA, Ambrosano G, Giannini M. Monomer conversion, microhardness, internal marginal adaptation, and shrinkage stress of bulk-fill resin composites. Dent Mater. 2015 Dec;31(12):1542-51. doi: 10.1016/j.dental.2015.10.001. Epub 2015 Nov 20. PMID: 26608118.

11.Taher NM. Mechanical properties of flowable composites. Saudi Dent J 2001;13(1):20–24.

12. Taha, N.A.; Maghaireh, G.A.; Ghannam, A.S.; Palamara, J.E. Effect of bulk-fill base material on fracture strength of root-filled teeth restored with laminate resin composite restorations. J. Dent. 2017, 63, 60–64.

13. Hada YS, Panwar S. Comparison of the fracture resistance of three different recent composite systems in large Class II mesio-occlusal distal cavities: An in vitro study. J Conserv Dent. 2019 May-Jun;22(3):287-291. doi: 10.4103/JCD.JCD_225_18. PMID: 31367115; PMCID: PMC6632638.

14.Mohamed Sameer Mohamed Megahed. Fracture Resistance of Maxillary Premolar Teeth Restored with Bulk Fill Resin Composite: In-vitro Study. Ashraf Ibrahim Ali Nadia, editor. Mansoura Journal of Dentistry. 2020;7(26):56–60.

15.Keskin, Gül & Gündoğar, Zübeyde & Tek, Gün. (2020). Fracture Resistance of Teeth Restored with Bulk-Fill and Fiber-Reinforced Composites in Class II Cavities. Odovtos - International Journal of Dental Sciences. 23. 239-249. 10.15517/ijds.2021.45159.

16.Kaur B, Gupta S, Grover R, Sadana G, Gupta T, Mehra M. Comparative Evaluation of Fracture Resistance of Endodontically Treated Teeth Restored with Different Core Build-up Materials: An In Vitro Study. Int J Clin Pediatr Dent. 2021 Jan-Feb;14(1):51-58. doi: 10.5005/jp-journals-10005-1901. PMID: 34326584; PMCID: PMC8311759.

17.Hansen EK, Asmussen E, Christiansen NC. In vivo fractures of endodontically treated posterior teeth restored with amalgam. Dent Traumatol. 1990;6:49-55.

18.Randow K, Glantz P: On cantilever loading of vital and non-vital teeth. Acta Odnt Scand(1986);44: 271 7.

19.Alaajam, Wafa & Al Moaleem, Mohammed & Shariff, Mansoor & Bds,. (2013). Restoration of Endodontically Treated Teeth: Materials Review. Cairo dental journal.

20.De Jesus Tavarez RR, Almeida Júnior LJDS, Guará TCG, Ribeiro IS, Maia Filho EM, Firoozmand LM. Shear bond strength of different surface treatments in bulk fill, microhybrid, and nanoparticle repair resins.

Clin Cosmet Investig Dent. 2017 Jul 3;9:61-66. doi: 10.2147/CCIDE.S135416. PMID: 28721100; PMCID: PMC5501442.

21.Taha DG, Abdel-Samad AA, Mahmoud SH. Fracture resistance of maxillary premolars with class II MOD cavities restored with Ormocer, Nanofilled, and Nanoceramic composite restorative systems. Quintessence Int. 2011 Jul-Aug;42(7):579-87. PMID: 21716986.

22.Kikuti WY, Chaves FO, Di Hipolito V, Rodrigues FP, & D'Alpino PHP (2012) Fracture resistance of teeth restored with different resin-based restorative systems Brazilian Oral Research 26(3) 275-281.

23.Hada YS, Panwar S. Comparison of the fracture resistance of three different recent composite systems in large Class II mesio-occlusal distal cavities: An in vitro study. J Conserv Dent. 2019 May-Jun;22(3):287-291. doi: 10.4103/JCD.JCD_225_18. PMID: 31367115; PMCID: PMC6632638.

24.Asopa S, Mandava J, Chalasani U, Anwarullah A, Ravi R. Fracture resistance of endodontically treated molars restored with resin composites. Indian J Conserv Endod. 2017 Jul;2(3):89-97.

25.Rakhee Ramdas, jayasree S, Ramesh Kumar, Prashant Balan, Rajeesh MK, Abdu Semeer Palottil (2017). Comparative Evaluation of Compressive And Flexural Strength of Newer Nanocomposite Materials with Conventional Hybrid Composites-An Invitro Study. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), 16(12), 65-69. https://www.europub.co.uk/articles/-A-250724