Original Article

Fracture resistance of postendodontic restoration using self-adhesive bioactive resin and a bulk-fill composite with or without resin-impregnated glass fibers: An *in vitro* study

Aishika Paul, Rohit Dubey, Sonal B. Joshi, Anand C. Patil, Pranjali S. Narvekar

Department of Conservative Dentistry and Endodontics, KLE Academy of Higher Education and Research, KLE VK Institute of Dental Sciences, Belagavi, Karnataka, India

Abstract

Context: Due to advancements in adhesive technology and the introduction of fiber reinforcement, there has been a paradigm shift towards a more minimally invasive approach in coronal restoration of endodontically treated teeth.

Aims: This research aimed to evaluate and compare fracture resistance of postendodontic restoration using a self-adhesive bioactive resin and a bulk-fill composite with or without resin-impregnated glass fibers.

Materials and Methods: Mesio-occlusal-distal cavities were prepared on 80 extracted human maxillary premolars. Root canal treatment was completed following standard access cavity preparation. Then, the teeth were divided into two groups based on the composite used for postendodontic restoration. Group I: Bulk-fill composite (Tetric N-Ceram). Group II: Activa BioActive. Group I and Group II were then divided into two subgroups depending on fiber incorporation ($n = 20$). Subgroup IA: Bulk-fill composite. Subgroup IB: Bulk-fill composite with fiber incorporation. Subgroup IIA: Activa BioActive. Subgroup IIB: Activa BioActive with fiber incorporation. The force required to fracture the teeth was recorded using the universal testing machine.

Statistical Analysis Used: Two-way ANOVA and Tukey's multiple *post hoc* test.

Results: Activa BioActive with fiber incorporation showed the highest mean fracture resistance (988.52N). Bulk-fill composite without fiber incorporation had the least mean fracture resistance (669.87N).

Conclusions: Activa BioActive bulk-fill restorative material when used with the incorporation of resin-impregnated glass fibers can be a preferred material of choice for restoring endodontically treated teeth.

Keywords: Activa bioactive; bulk-fill composite; fracture resistance; interlig; postendodontic restoration; resin-impregnated glass fibers; self-adhesive bioactive resin; Tetric N-Ceram

INTRODUCTION

Dentinoenamel complex (DEC) is a functional interphase which prevents crack propagation by providing crack tip shielding.[1] Imbeni *et al*. reported that the DEC toughness is about 75% lower than dentin but five to ten times greater than enamel.[2] Hence, a restorative technique that is based on the knowledge and comprehension of the biomechanical

Address for correspondence:
Dr. Pranjali S. Narvekar,
Department of Conservative Dentistry and Endodontics, KLE VK Institute of Dental Sciences, JNMC Campus, Nehru Nagar, Belagavi - 590 010, Karnataka, India.
E-mail: pranjalinarvekar25@gmail.com

Date of submission : 06.07.2024
Review completed : 24.07.2024
Date of acceptance : 06.08.2024
Published : 07.09.2024

Access this article online	
Quick Response Code:	Website: https://journals.lww.com/jcde
	DOI: 10.4103/JCDE.JCDE_428_24

How to cite this article: Paul A, Dubey R, Joshi SB, Patil AC, Narvekar PS. Fracture resistance of postendodontic restoration using self-adhesive bioactive resin and a bulk-fill composite with or without resin-impregnated glass fibers: An *in vitro* study. J Conserv Dent Endod 2024;27:908-12.

characteristics of the DEC is essential for the restoration of structurally compromised teeth.[1]

Coronal restorations of endodontically treated teeth add to the challenge. The advent of bulk-fill composite has simplified the restorative process in large cavities.[3] Activa BioActive is a novel, flowable, resin-based composite, which is hydrophilic, self-adhesive resin with a better bond strength.[4] It incorporates components of glass ionomer and patented rubberized resin, which has shock-absorbing property.[5] They require shorter clinical time and have decreased stress from polymerization.[3]

Newer techniques enable maximizing the bond and minimizing shrinkage stresses allowing the restoration to mimic the optical and functional properties of the natural tooth.[1] Integration of polyethylene or glass fibers into increments of composite has regained attention for restoring structurally compromised teeth that require more amount of composite.[1] Sadr *et al*. in their study concluded that placing a fiber-reinforced increment close to the hybrid layer of a deep restoration reduced gap formation and behaved as a shrinkage stress breaker, thus protecting the bonding interface.[6]

The combination of resin-impregnated glass fibers and Activa BioActive-restorative in deep restorations has not been evaluated yet. The current study investigated the fracture resistance of endodontically treated premolars restored with Activa BioActive resin with and without glass fiber reinforcement (Interlig, Angelus, Brazil) when compared with restoration using conventional bulk-fill (Tetric N-Ceram) composite with and without fiber reinforcement.

MATERIALS AND METHODS

Eighty extracted human maxillary premolar teeth, with closed apex, without any caries, restorations, or fractures were used in this study. Scaling of samples was done followed by disinfection with 0.1% thymol solution and stored in 0.9% saline till use.

Preparation of mesio-occlusal-distal (MOD) cavities was done with a straight fissure diamond bur (SF-21, Mani, Japan). The cavity dimensions were standardized, occlusal isthmus was one-third (1/3rd) of the intercuspal distance, the width of the proximal box was two-thirds (2/3rd) of the buccopalatal width, and height of the proximal box was such that gingival floor was 1 mm above cemento-enamel junction (CEJ). Preparation of the access cavity was done using an Endo Access bur no. 2 (Dentsply) under high speed. The working length was determined, 1 mm short of where 10 K file (Mani, Japan) exited the foramen. Canals were prepared with Protaper Universal nickel–titanium rotary files (Dentsply Maillefer, Switzerland) till F4 and 3% of sodium hypochlorite (Vishal, Dentocare) as an irrigant after each instrument was used. 2 mL of 17% EDTA (Ammdent Canalarge) for 1 min was used as a final irrigant. F4 gutta-percha cone (Diadent Group International, Korea) and Apexit Plus Sealer (Ivoclar Vivadent) were used for the obturation of canals. The chamber was cleaned and sealed with resin-modified GIC (GC Gold Label 2 Lc). Teeth were stored at 37°C in 100% relative humidity for 1 week.

After incubation, teeth were divided into two groups based on the restorative material used for postendodontic restoration.

- Group I: Bulk-fill composite
- Group II: Activa BioActive.

Group I and Group II were then divided into two subgroups depending on fiber incorporation ($n = 20$ in each).

- Subgroup IA: Bulk-fill composite
- Subgroup IB: Bulk-fill composite with fiber incorporation
- Subgroup IIA: Activa BioActive
- Subgroup II2B: Activa BioActive with fiber incorporation.

The cavities were dried; 37% phosphoric acid gel (Eco-Etch, Ivoclar) was used for etching the walls for 15 s, followed by 15 s of rinsing with water. The cavities were blot-dried, Tetric N-Bond (Ivoclar Vivadent, 5th-generation bonding agent) was applied for 20 s, air-dried for 5 s, and light cured for 20 s with QTH light-curing unit.

In Subgroup IA, Bulk-fill composite (Tetric N-Ceram, Ivoclar Vivadent) was used for restoration with one increment up to 4 mm thickness, then light cured for 20 s after each increment.

In Subgroup IIA, the cavities were filled with Activa BioActive (Pulpdent) with one increment up to 4 mm thickness, then light cured for 20 s after each increment.

Subgroup IB and IIB: Wallpapering technique was incorporated where dentin walls were reinforced with preimpregnated glass fibers.

- Two strands of preimpregnated glass fiber (Interlig, Angelus, Brazil) of 4 mm wide and 11 mm in length were cut
- Fibers were coated with a thin layer of flowable resin composite (Tetric N-Ceram) before insertion in the cavity.

Cut fibers were adapted to the cavity walls, on the buccal and palatal wall with composite spatula and cured for 20 s. The fiber extension on proximal walls overlapped about 1–1.5 mm over each other.

Following which, Subgroup IB was restored using bulk-fill composite and Subgroup IIB was restored using Activa BioActive in a similar way like Subgroup IA and IIA re-spectively.

The force required to fracture the teeth was recorded using the universal testing machine with the load applied parallel to the cusps and with a spherical crosshead having diameter 6 mm, at a speed of 1 mm/min.

Statistics

Statistical analysis was done using the two-way ANOVA and Tukey's multiple *post hoc* test.

RESULTS

Figure 1 shows the comparison of two groups (I and II) and two subgroups (A and B) with mean fracture resistance.

The results of this study showed that Subgroup IIB, Activa BioActive with fiber incorporation showed the highest mean fracture resistance (1259.87N) followed by Subgroup IIA, Activa BioActive without fiber incorporation (988.52N). Subgroup IB, Bulk-fill composite with fiber incorporation (877.00N) followed by Subgroup IA, Bulk-fill composite without fiber incorporation (669.87) having the least mean fracture resistance [depicted in Figure 1].

Table 1 gives the comparison of two groups (I and II) and two subgroups (A and B) with mean fracture resistance by the two-way ANOVA.

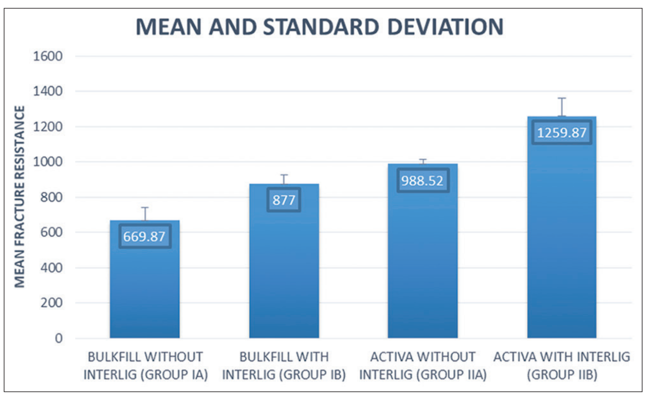

Figure 1: Comparison of two groups (1 and 2) and two subgroups (A and B) with mean fracture resistance

A significant difference was observed between the groups ($P = 0.000^*$).

Table 2 depicts the results of Tukey's multiple *post hoc* analysis procedure for comparison between two Groups I and II and two Subgroups A and B.

There was a highly statistically significant difference between each of the groups with respect to mean fracture resistance ($P = 0.000^*$).

DISCUSSION

Endodontically treated teeth are more prone to fracture as a result of increased loss of tooth structure due to caries or removal of previous restorations and due to the absence of a pulp chamber roof.[7] Preservation of endodontically treated teeth with no catastrophic fracture in the maintenance phase hence is a challenge.

Teeth, which require larger or cusp replacement restorations like most endodontically treated teeth, are most commonly opted for both, indirect composite resin or ceramic inlay/onlay restorations.[8]

The current advanced composite resins and the use of modern adhesive systems have made it possible to use direct composite restoration techniques for the rehabilitation of endodontically treated teeth. Bonded restorations allow the preservation of sound tooth structure, and functional stresses are better distributed across the bonding interface increasing the fracture resistance of the tooth.[9]

To achieve stress reduction, in direct composites, fiber reinforcement is considered a biomimetic approach to restore endodontically treated teeth. The fibers may act as an internal splint changing the dynamics of shrinkage stresses at the bonding tooth-restoration interface, thus increasing the flexural strength of the restoration.[10,11] The design of the fiber also prevents crack propagation.[12] Thus, the stress-reduced direct composite (SRDC) technique can be considered as a treatment alternative to indirect restorations.

In this study, premolar teeth were chosen as they are more likely to undergo lateral stresses which are destructive in

Table 1: Comparison of two groups (I and II) and two subgroups (A and B) with mean fracture resistance by two-way ANOVA

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	*F*	*P*
Main effects					
Groups	1	3,626,002.51	1,208,667.50	252.604	0.000*
Subgroups	2	1,165,315.88	582,657.94	121.772	0.000*
Two-way interaction effects					
Groups × Subgroups	1	72,020,561.63	7,202,056.63	15,051.852	0.0001*
Error	76	363,647.11	4784.830		
Total	80	76,010,211.25			

$^*P<0.05$

Table 2: Pairwise comparison of two groups (I and II) and two subgroups (A and B) with mean fracture resistance by Tukey's multiple *post hoc* procedures

Groups with subgroups	Bulk-fill without fiber incorporation (Group IA)	Bulk-fill with fiber incorporation (Group IB)	Activa bioactive without fiber incorporation (Group IIA)	Activa bioactive with fiber incorporation (Group IIB)
Mean	669.87	877.00	988.52	1259.87
SD	73.99	51.24	28.13	101.22
Bulk-fill without fiber incorporation (Group IA)	-			
Bulk-fill with fiber incorporation (Group IB)	$P=0.000$*	-		
Activa bioactive without fiber incorporation (Group IIA)	$P=0.000$*	$P=0.000$*	-	
Activa bioactive with fiber incorporation (Group IIB)	$P=0.000$*	$P=0.000$*	$P=0.000$*	-

*$P<0.05$. SD: Standard deviation

nature.[13] Reinforcement of self-adhesive bioactive resin, Activa BioActive, with preimpregnated glass fibers (Interlig) showed the highest fracture resistance compared to other groups, which was in accordance with Kemaloglu *et al*. Their study concluded increased fracture strength in groups where composite restorations were reinforced with fibers as compared to no fiber reinforcement or unrestored cavities.[14]

Activa BioActive composite is a flowable, resin-based bioactive restorative material with minimal polymerization shrinkage stress of about 1.7% and a greater depth of curing up to 4 mm.[15] Hence, it can be used as a bulk-fill material for restoring large cavities. Its greater fracture resistance could be due to its low modulus of elasticity which allows greater deformability under occlusal stresses, especially in load-bearing areas.[16]

Lardani *et al*. found no statistically significant difference in retention and fracture of restoration filled with SDR bulk-fill and newly introduced Activa BioActive composite resin for restoring primary molars.[15] Shafiei *et al*. concluded that flowable bulk-fill composite resin with fiber had a similar reinforcing effect as packable bulk-fill and had the benefit of better adaptation.[7] Similar results were obtained by Toz *et al*. concluding that bulk-fill flowable resin in endodontically treated teeth exhibited higher fracture resistance than bulk-fill resin composites.[16]

Inserting fibers in the composite resin decreases the composite mass which decreases volumetric shrinkage due to the presence of a smaller organic matrix, thus decreasing microleakage. The fibers also resist pull-away forces on the edges of restoration toward the curing light.[17]

Interlig by Angelus was used in our study. Interlig is braided glass fibers, preimpregnated with light-cured composite resin.[18] The placement of glass fibers helps in the distribution of shrinkage stresses, thus resulting in improved occlusal load bearing.[19] The fibers perform similarly to DEC, when adapted directly against cavity walls, aid dentin and enamel to work together in harmony with the restorative composite.[20] Wallpapering walls of the cavity with fibers resist occlusal vertical loading by absorbing lateral forces,[11] causing minimal and repairable damage on the tooth-restoration complex.[21]

Luthria *et al*. concluded in their study that Interlig (glass fiber) reinforcement showed higher fracture resistance than Ribbond (polyethylene fiber) reinforcement. They stated the inferior results of Ribbond could be due to nonuniform manual wetting with unfilled resin, reducing adhesion of fibers to resin matrix.[18] In a study by Ozel and Soyman, glass fiber-reinforced composites exhibited lower volumetric polymerization shrinkage than polyethylene fiber-reinforced composites.[22]

A resultant unique structure is possible to achieve with flowable composite resin and fibers with the formation of chemical bond between the flowable resin, fibers, and the restorative resin positively influencing the use of fiber in the fracture resistance.[7]

Tetric N-Ceram, bulk-fill material, has a sculptable consistency and can be applied in a single increment of 4-mm thickness.[23] The presence of gap formation at the interface of the paste-based composite and the fibers might explain its lower fracture resistance.[3]

In case of failure, fiber reinforcement leads the tooth towards fracture modes that are more favorable (fractures above CEJ).[20]

Favorable mode of failure further allows the possibility of restoring the tooth using treatment like post-and-core and a full-coverage prosthesis, without compromising the entire tooth.

Yet, when the biomechanical integrity of the tooth is lost, where the functional (<2 mm) and nonfunctional (<3 mm) cusps are compromised, bonded direct restorations are not indicated. Such a structurally compromised tooth should be restored with an indirect restoration.[24]

This is an *in vitro* study and very few clinical trials have studied the long-term performance of SRDC restorations. As a future prospective, there is scope for further *in vivo* studies and randomized clinical trials with long-term follow-ups to study the efficacy of bulk-fill composites with fiber reinforcement, their survival rate, and thus their application in intraoral conditions.

CONCLUSIONS

Although reinforcing a compromised endodontically treated tooth is challenging, using resin-impregnated glass fibers along with flowable, bulk-fill composite resin enhances the strength of endodontically treated teeth compared to conventional restoration.

Thus, it can be concluded, within the limitations of this study, that the newly introduced Activa BioActive bulk-fill restorative material when used with the incorporation of resin-impregnated glass fibers can be a preferred material of choice for restoring endodontically treated teeth.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Deliperi S, Alleman D, Rudo D. Stress-reduced direct composites for the restoration of structurally compromised teeth: Fiber design according to the "wallpapering" technique. Oper Dent 2017;42:233-43.
2. Imbeni V, Kruzic JJ, Marshall GW, Marshall SJ, Ritchie RO. The dentin-enamel junction and the fracture of human teeth. Nat Mater 2005;4:229-32.
3. Aggarwal N, Jain A, Gupta H, Abrol A, Singh C, Rapgay T. The comparative evaluation of depth of cure of bulk-fill composites – An *in vitro* study. J Conserv Dent 2019;22:371-5.
4. Rifai H, Qasim S, Mahdi S, Lambert MJ, Zarazir R, Amenta F, *et al*. *In-vitro* evaluation of the shear bond strength and fluoride release of a new bioactive dental composite material. J Clin Exp Dent 2022;14:e55-63.
5. Bansal R, Burgess J, Lawson NC. Wear of an enhanced resin-modified glass-ionomer restorative material. Am J Dent 2016;29:171-4.
6. Sadr A, Bakhtiari B, Hayashi J, Luong MN, Chen YW, Chyz G, *et al*. Effects of fiber reinforcement on adaptation and bond strength of a bulk-fill composite in deep preparations. Dent Mater 2020;36:527-34.
7. Shafiei F, Dehghanian P, Ghaderi N, Doozandeh M. Fracture resistance of endodontically treated premolars restored with bulk-fill composite resins: The effect of fiber reinforcement. Dent Res J (Isfahan) 2021;18:60.
8. Deliperi S, Bardwell DN. Clinical evaluation of direct cuspal coverage with posterior composite resin restorations. J Esthet Restor Dent 2006;18:256-65.
9. Sagsen B, Aslan B. Effect of bonded restorations on the fracture resistance of root filled teeth. Int Endod J 2006;39:900-4.
10. Belli S, Erdemir A, Ozcopur M, Eskitascioglu G. The effect of fibre insertion on fracture resistance of root filled molar teeth with MOD preparations restored with composite. Int Endod J 2005;38:73-80.
11. Valizadeh S, Ranjbar Omrani L, Deliperi S, Sadeghi Mahounak F. Restoration of a nonvital tooth with fiber reinforce composite (wallpapering technique). Case Rep Dent 2020.
12. Abouelleil H, Pradelle N, Villat C, Attik N, Colon P, Grosgogeat B. Comparison of mechanical properties of a new fiber reinforced composite and bulk filling composites. Restor Dent Endod 2015;40:262-70.
13. Cavel WT, Kelsey WP, Blankenau RJ. An *in vivo* study of cuspal fracture. J Prosthet Dent 1985;53:38-42.
14. Kemaloglu H, Emin Kaval M, Turkun M, Micoogullari Kurt S. Effect of novel restoration techniques on the fracture resistance of teeth treated endodontically: An *in vitro* study. Dent Mater J 2015;34:618-22.
15. Lardani L, Derchi G, Marchio V, Carli E. One-year clinical performance of activa™ bioactive-restorative composite in primary molars. Children (Basel) 2022;9:433.
16. Toz T, Tuncer S, Öztürk Bozkurt F, Kara Tuncer A, Gözükara Bağ H. The effect of bulk-fill flowable composites on the fracture resistance and cuspal deflection of endodontically treated premolars. J Adh Sci Technol 2015;29:1581-92.
17. Mangoush E, Garoushi S, Lassila L, Vallittu PK, Säilynoja E. Effect of fiber reinforcement type on the performance of large posterior restorations: A review of *in vitro* studies. Polymers (Basel) 2021;13:3682.
18. Luthria A, Srirekha A, Hegde J, Karale R, Tyagi S, Bhaskaran S. The reinforcement effect of polyethylene fibre and composite impregnated glass fibre on fracture resistance of endodontically treated teeth: An *in vitro* study. J Conserv Dent 2012;15:372-6.
19. Jafari Navimipour E, Ebrahimi Chaharom ME, Alizadeh Oskoee P, Mohammadi N, Bahari M, Firouzmandi M. Fracture resistance of endodontically-treated maxillary premolars restored with composite resin along with glass fiber insertion in different positions. J Dent Res Dent Clin Dent Prospects 2012;6:125-30.
20. Khan S, Sitlani M, Pandey S, Singh S. K, Mishra P, Narang A. To Study Fracture Resistance of Interligtm Glass Fiber Orientation and Placement on Large Class II Cavities in Maxillary Premolars: An in Vitro Study. Enviro Dental Journal 2022;4.
21. Selvaraj H, Krithikadatta J, Shrivastava D, Onazi MA, Algarni HA, Munaga S, *et al*. Systematic review fracture resistance of endodontically treated posterior teeth restored with fiber reinforced composites- a systematic review. BMC Oral Health 2023;23:566.
22. Ozel E, Soyman M. Effect of fiber nets, application techniques and flowable composites on microleakage and the effect of fiber nets on polymerization shrinkage in class II MOD cavities. Oper Dent 2009;34:174-80.
23. Hirata R, Kabbach W, de Andrade OS, Bonfante EA, Giannini M, Coelho PG. Bulk fill composites: An anatomic sculpting technique. J Esthet Restor Dent 2015;27:335-43.
24. Griffis E, Abd Alraheam I, Boushell L, Donovan T, Fasbinder D, Sulaiman TA. Tooth-cusp preservation with lithium disilicate onlay restorations: A fatigue resistance study. J Esthet Restor Dent 2022;34:512-8.