

A Comparative Evaluation Of Fracture Resistance Of Endodontically Treated Teeth Using Conventional Glass Ionomer Cement, Resin Modified Glass Ionomer Cement, Nanohybrid Composite, Biodentin, Zirconomer, And Proroot Mineral Trioxide Aggregate As Intraorifice Barrier: An Invitro Study

Dr. Astha Dubey¹, Dr. Rana k Varghese^{*2}, Dr. Naveen Kumar Gupta³, Dr. Shreeya Jaiswal⁴, Dr. Ippar Priyanka Damodhar⁵, Dr. Abhilasha Bishwal⁶

¹postgraduate student, Department of Conservative Dentistry and Endodontics, New horizon dental college and research institute, sakri, bilaspur.

^{*2}prof and hod, dean, Department of Conservative Dentistry and Endodontics, New horizon dental college and research institute, sakri, bilaspur.

³reader, Department of Conservative Dentistry and Endodontics, New horizon dental college and research institute, sakri, bilaspur.

⁴postgraduate student, Department of Conservative Dentistry and Endodontics, New horizon dental college and research institute, sakri, bilaspur.

⁵postgraduate student, Department of Conservative Dentistry and Endodontics, New horizon dental college and research institute, sakri, bilaspur.

⁶postgraduate student, Department of Conservative Dentistry and Endodontics, New horizon dental college and research institute, sakri, bilaspur.

***Corresponding author:**

Dr. Rana k Varghese

Cite this paper as: Dr. Astha Dubey, Dr. Rana k Varghese, Dr. Naveen Kumar Gupta, Dr. Shreeya Jaiswal, Dr. Ippar Priyanka Damodhar, Dr. Abhilasha Bishwal, (2025) A Comparative Evaluation Of Fracture Resistance Of Endodontically Treated Teeth Using Conventional Glass Ionomer Cement, Resin Modified Glass Ionomer Cement, Nanohybrid Composite, Biodentin, Zirconomer, And Proroot Mineral Trioxide Aggregate As Intraorifice Barrier: An Invitro Study. *Journal of Neonatal Surgery*, 14 (32s), 5852-5873.

ABSTRACT

Aim: This study primarily aims to evaluate the effectiveness of various intraorifice barrier materials in enhancing the fracture resistance of endodontically treated teeth. It focuses on identifying the material that offers the greatest structural reinforcement and reduces the likelihood of fractures, thereby contributing valuable insights into the material properties that impact the longevity and durability of treated teeth. By providing evidence-based findings, the study also seeks to support dental professionals in selecting the most suitable intraorifice barrier materials for improved clinical outcomes.

Materials and methods: This in vitro study was conducted in the Department of Conservative Dentistry and Endodontics at New Horizon Dental College and Research Institute, Bilaspur, Chhattisgarh. A total of 105 freshly extracted human mandibular premolars, collected from patients aged 20–45 years, were used. Teeth were selected based on specific inclusion criteria—single-rooted premolars with single canals, extracted for periodontal reasons, and free from cracks, resorption, or abnormal root curvature. Ethical clearance was obtained prior to sample collection and experimentation. The teeth were cleaned, decoronated at the cemento-enamel junction, and root canals were prepared using hand files up to size #20 followed by Protaper Universal rotary files till F3 size using the crown-down technique. Irrigation was done with sodium hypochlorite, EDTA, and distilled water, and the canals were obturated using F3 gutta-percha and AH Plus sealer. After sealing, the samples were incubated at 37°C for 8 hours. For all groups except the control, 3 mm of coronal gutta-percha was removed to make space for the intraorifice barrier.

Results: This study evaluated the fracture resistance of endodontically treated mandibular premolars restored with different intraorifice barrier materials, including Conventional Glass Ionomer Cement (GIC), Resin-Modified Glass Ionomer Cement (RMGIC), Zirconomer, Nanohybrid Composite, Biodentine, and Mineral Trioxide Aggregate (MTA). The primary objective was to determine the most effective material in reinforcing root canal-treated teeth and preventing fractures. The findings revealed that Zirconomer and Biodentine exhibited the highest fracture resistance, followed by Nanohybrid Composite. Conventional GIC and RMGIC provided moderate reinforcement, while MTA demonstrated the lowest resistance. The control group, without any intraorifice barrier, exhibited the weakest structural integrity, underscoring the necessity of using

intraorifice barriers to enhance the mechanical strength of endodontically treated teeth. From a clinical perspective, Zirconomer and Biodentine are highly recommended for posterior teeth due to their superior strength and ability to withstand occlusal forces. Nanohybrid Composite serves as a viable option for anterior teeth, where esthetics is of a prime concern. conventional GIC and RMGIC offer the advantages of fluoride release, making them beneficial in cases where additional cariostatic effects are needed. MTA, despite its bioactive properties, showed limited mechanical reinforcement and may be best suited for applications, prioritizing biological sealing rather than fracture resistance. This study has certain limitations, as it was conducted in vitro, which does not fully replicate intraoral conditions such as occlusal forces, saliva exposure, and thermal changes. Additionally, the long-term durability and degradation of these materials over time were not assessed. Future research should focus on clinical trials under real-life conditions, along with the development of advanced bioactive materials that enhance both mechanical and biological properties

Conclusion: In conclusion, this study confirms that intraorifice barriers play a crucial role in enhancing the fracture resistance of endodontically treated teeth. Zirconomer, Biodentine, and Nanohybrid Composite emerged as the most effective materials, significantly improving tooth strength and longevity. Their routine incorporation into endodontic treatment protocols is essential for ensuring long-term success and structural stability of treated teeth. Further research should continue exploring material innovations and assessing their long-term clinical effectiveness.

Keywords: *endodontic, pulpal, composites*

1. INTRODUCTION

Endodontic treatment, or root canal therapy, is essential for saving teeth affected by pulpal and periapical diseases. However, endodontically treated teeth (ETT) are more prone to fractures due to factors like dentin dehydration, structural loss from treatment procedures, and internal stresses from instrumentation. These factors reduce the tooth's natural toughness and make restorative reinforcement crucial, especially in posterior teeth subjected to heavy occlusal forces. Intraorifice barriers have emerged as a potential solution for reinforcing the coronal third of the root, where stress concentration is highest.^{1,2,3,}

Intraorifice barriers serve dual roles—preventing microleakage and reinforcing tooth structure. Microleakage can allow bacterial reentry, compromising the treatment, while structural reinforcement helps distribute stress and prevent cracks. Introduced by Roghanizad and Jones, the concept has evolved, with various materials now being used to enhance both sealing ability and mechanical strength. For optimal results, materials with properties resembling natural dentin—such as similar modulus of elasticity and good bonding capabilities—are preferred.^{4,5,6,7}

Traditionally used materials include conventional glass ionomer cement (GIC) and resin-modified GIC (RMGIC), valued for their chemical bonding and antimicrobial properties. Newer materials like nanohybrid composites, Biodentin, Zirconomer, and mineral trioxide aggregate (MTA) offer superior mechanical properties, bonding strength, and biocompatibility. These innovations represent a shift toward biomimetic dentistry, which aims to restore both the function and biological integrity of teeth.^{8,9}

The current study aims to compare the fracture resistance of six intraorifice barrier materials—conventional GIC, RMGIC, nanohybrid composite, Biodentin, Zirconomer, and ProRoot MTA—using extracted mandibular premolars under simulated occlusal conditions. The objective is to determine which material provides the most effective reinforcement, thereby helping clinicians make evidence-based choices for restoring ETT.^{10,11}

By evaluating these materials, the study will provide insight into their mechanical behavior and interaction with dentin under stress, guiding restorative strategies for long-term tooth durability. Ultimately, the findings are expected to support better clinical decisions, enhancing the longevity and success of endodontic treatments.

This study primarily aims to evaluate the effectiveness of various intraorifice barrier materials in enhancing the fracture resistance of endodontically treated teeth. It focuses on identifying the material that offers the greatest structural reinforcement and reduces the likelihood of fractures, thereby contributing valuable insights into the material properties that impact the longevity and durability of treated teeth. By providing evidence-based findings, the study also seeks to support dental professionals in selecting the most suitable intraorifice barrier materials for improved clinical outcomes.



Photograph showing six types of intraorifice barrier materials used in the study

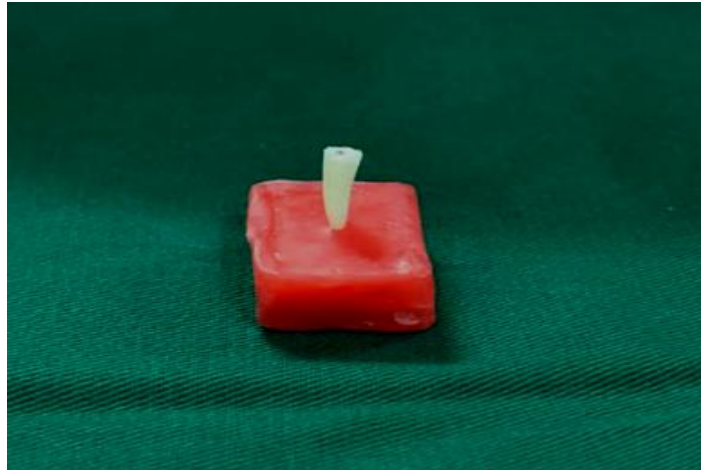


Photograph depicting sample resection

2. MATERIALS AND METHODS

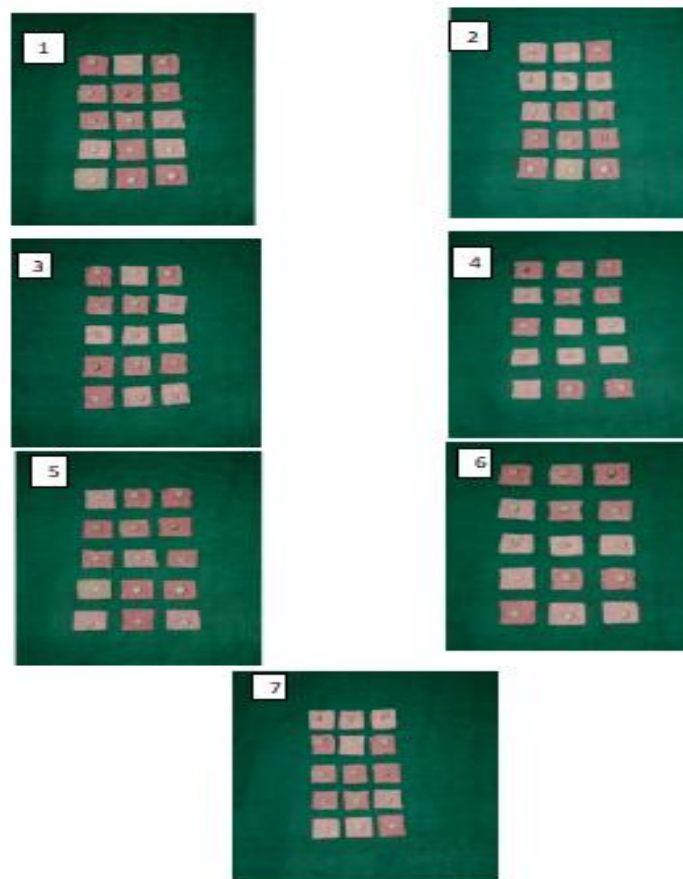
This in vitro study was conducted in the Department of Conservative Dentistry and Endodontics at New Horizon Dental College and Research Institute, Bilaspur, Chhattisgarh. A total of 105 freshly extracted human mandibular premolars, collected from patients aged 20–45 years, were used. Teeth were selected based on specific inclusion criteria—single-rooted premolars with single canals, extracted for periodontal reasons, and free from cracks, resorption, or abnormal root curvature. Ethical clearance was obtained prior to sample collection and experimentation.

The teeth were cleaned, decoronated at the cemento-enamel junction, and root canals were prepared using hand files up to size #20 followed by Protaper Universal rotary files till F3 size using the crown-down technique. Irrigation was done with sodium hypochlorite, EDTA, and distilled water, and the canals were obturated using F3 gutta-percha and AH Plus sealer. After sealing, the samples were incubated at 37°C for 8 hours. For all groups except the control, 3 mm of coronal gutta-percha was removed to make space for the intraorifice barrier.



Photograph showing decoronated specimen

The 105 teeth were divided into seven groups (15 samples each), based on the intraorifice barrier used: Group 1 (Conventional GIC), Group 2 (Resin-Modified GIC), Group 3 (Zirconomer), Group 4 (Nanohybrid Composite), Group 5 (Biodentine), Group 6 (ProRoot MTA), and Group 7 (Control, no barrier). Each barrier material was mixed and placed according to the manufacturer's instructions. Appropriate surface conditioning and curing steps were followed where required, and care was taken to ensure complete adaptation and setting of materials.

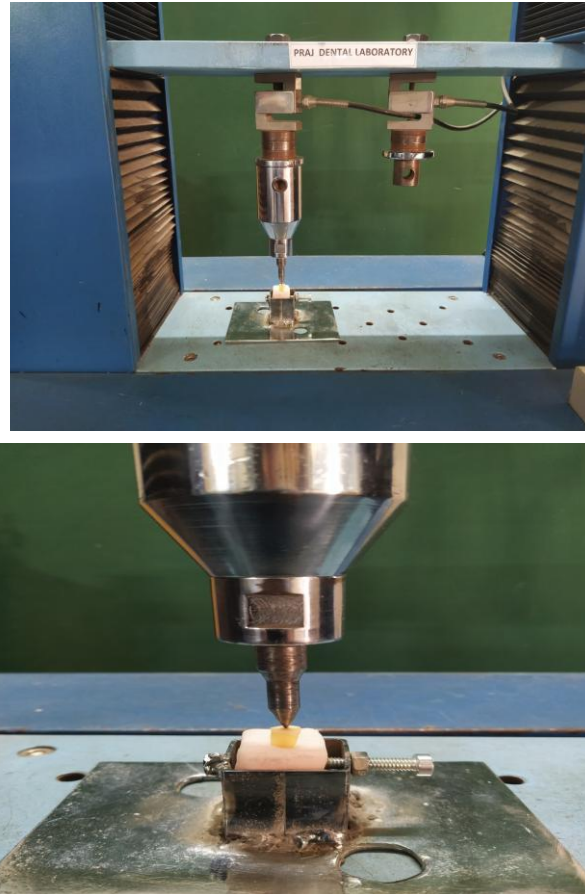


Photograph displaying 7 (seven) experimental groups with 15 (fifteen) samples each in every group

Group 1 - GIC, Group 2 - RMGIC, Group 3 - Zirconomer, Group 4 - Nanohybrid composite, Group 5 - Biodentin, Group 6 - MTA, Group 7 - Control group

After restoration, the teeth were embedded in self-cure acrylic blocks, exposing the coronal 9 mm of each root. They were then subjected to fracture testing using a universal testing machine. A stainless steel fixture applied compressive force vertically over the canal orifice at a crosshead speed of 1 mm/min until fracture occurred. The maximum force required to fracture each tooth was recorded in Newtons, allowing comparison of fracture resistance across all groups.

This detailed methodology ensured a standardized, controlled approach to evaluating how different intraorifice barrier materials influence the fracture resistance of endodontically treated mandibular premolars. The use of uniform instrumentation, obturation techniques, and testing procedures aimed to isolate the effect of the intraorifice material itself on fracture strength



Photograph showing placement of test materials / samples in the Universal Testing Machine

3. RESULTS

Table-1: Showing seven study groups were made containing 15 samples each as follows

GROUP-1	Conventional GIC (GC Gold Label 2 Universal restorative GIC)
GROUP-2	Resin Modified GIC (GC Gold Label 2 LC)
GROUP-3	Zirconia Reinforced Glass Ionomer (Zirconomer)
GROUP-4	Nanohybrid Composite (Filtek Z250 XT, 3M ESPE)
GROUP-5	Biodentine (Septodont, Saint Maur des Fosses, France)
GROUP-6	MTA (Proroot, Dentsply, Tulsa dental)
GROUP-7	Control group

Table-2: Showing fracture load values obtained from Group 1 samples consisting of 15 samples each

Group- 1: ConventionalGIC(GCGoldLabel2UniversalrestorativeGIC)		
Sr.No.	SampleNo.	FractureLoad(N)
1	No.1	378
2	No.2	396.5
3	No.3	301.2
4	No.4	379.16
5	No.5	326.45
6	No.6	367.62
7	No.7	319.34
8	No.8	330.63
9	No.9	383.05
10	No.10	311.62
11	No.11	385.08
12	No.12	390.15
13	No.13	388.97
14	No.14	382
15	No.15	370.3
AVERAGE		360.67

Table 3: Showing fracture load values of group 2 consisting of 15 samples

Group- 2 : Resin Modified GIC (GC Gold Label 2 LC)		
Sr. No.	Sample No.	Fracture Load (N)
1	No.1	325.4
2	No.2	316.6
3	No.3	303.8
4	No.4	324.29
5	No.5	319.56
6	No.6	304.72
7	No.7	309.52
8	No.8	324.75
9	No.9	305.37
10	No.10	316.87
11	No.11	306.18
12	No.12	311.33
13	No.13	309.79
14	No.14	310.4
15	No.15	304.85
AVERAGE		312.90

Table-4: Showing fracture load values of Group-3 consisting of 15 samples

Group- 3: Zirconia Reinforced Glass Ionomer (Zirconomer)		
Sr.No.	Sample No.	Fracture Load(N)
1	No.1	385
2	No.2	458.6
3	No.3	441.7
4	No.4	

		438.01
5	No.5	438.11
6	No.6	402.45
7	No.7	428.56
8	No.8	396.44
9	No.9	430.7
10	No.10	388.44
11	No.11	446.52
12	No.12	443.13
13	No.13	456.85
14	No.14	403.7
15	No.15	450.1
AVERAGE		427.30

Table-5: Showing fracture load values obtained from Group – 4 consisting of 15 samples

Group- 4: Nano hybrid Composite (FiltekZ250XT,3MESPE)		
Sr.No.	Sample No.	Fracture Load(N)
1	No.1	434.2
2	No.2	396.5
3	No.3	350.6
4	No.4	408.01

5	No.5	365.75
6	No.6	404.09
7	No.7	423.2
8	No.8	389.41
9	No.9	401.68
10	No.10	390.49
11	No.11	357.8
12	No.12	398.76
13	No.13	411.17
14	No.14	373.21
15	No.15	394.32
AVERAGE		393.27

Table-6: Showing fracture load values of Group-5 consisting of 15 samples

Group- 5: Biodentine(Septodont,SaintMaurdesFosses, France)		
Sr.No.	SampleNo.	FractureLoad(N)
1	No.1	408.6
2	No.2	376
3	No.3	428.5
4	No.4	424.15
5	No.5	377.82

6	No.6	381.77
7	No.7	422.46
8	No.8	400
9	No.9	378.22
10	No.10	419.35
11	No.11	389.9
12	No.12	417.19
13	No.13	381.01
14	No.14	423.1
15	No.15	402.1
AVERAGE		402.1

Table-7: Showing fracture load values of Group-6 consisting of 15 samples

Group- 6: MTA(Proroot,Dentsply,Tulsa dental)		
Sr.No.	SampleNo.	FractureLoad(N)
1	No.1	275.5
2	No.2	236.3
3	No.3	311.1
4	No.4	307.47
5	No.5	289.8
6	No.6	239.86
7	No.7	266.82
8	No.8	298.4
9	No.9	238.32
10	No.10	264.79
11	No.11	285.18

12	No.12	273
13	No.13	244.11
14	No.14	293.37
15	No.15	272.59
AVERAGE		273.10

Table 8: Showing fracture load values of Group-7consisting of 15 samples

Group - 7: Control group		
Sr.No.	Sample No.	Fracture Load(N)
1	No.1	182.5
2	No.2	151.3
3	No.3	202.2
4	No.4	181.59
5	No.5	163.7
6	No.6	201.24
7	No.7	152.03
8	No.8	191.23
9	No.9	156.19
10	No.10	154.07
11	No.11	166.57
12	No.12	194.69
13	No.13	201.14
14	No.14	171.75
15	No.15	162.42
AVERAGE=		175.50

Table 9: Showing comparison of fracture resistance between the various groups

STUDY GROUPS	FRACTURE RESISTANCE (MEAN $\pm$ SD)
Group-1 : Conventional GIC	360.67 $\pm$ 32.75
Group- 2 : RMGIC	312.9 $\pm$ 7.78
Group- 3 : Zirconomer	427.22 $\pm$ 25.18
Group- 4 : Nanohybrid Composite	393.28 $\pm$ 23.3
Group- 5 : Biodentine	402.01 $\pm$ 19.75
Group- 6 : MTA	273.11 $\pm$ 24.96
Group- 7 : Control	175.51 $\pm$ 19.1

Table-10: ANOVA table

Source variation	Sum of squares (SS)	df	Mean SS	F-value	P value
Between groups	702111.18	6	117,018.5312	222.14	<0.001 HS
Within groups	51623.42	98	526.7696		
Total	753734.61	104			

Table-11: Showing Tukey's Honest Significant Difference Post Hoc Test Results

Treatment pair	Tukey HSD Q statistic	p-value
Group- 1 vs Group- 2	8.0618	0.001
Group- 1 vs Group- 3	11.2299	0.001
Group- 1 vs Group- 4	5.5027	0.003
Group- 1 vs Group- 5	6.9764	0.001
Group- 1 vs Group- 6	14.7759	0.001
Group- 1 vs Group- 7	31.2455	0.001
Group- 2 vs Group- 3	19.2917	0.001
Group- 2 vs Group- 4	13.5645	0.001
Group- 2 vs Group- 5	15.0383	0.001
Group- 2 vs Group- 6	6.7141	0.001
Group- 2 vs Group- 7	23.1837	0.001
Group- 3 vs Group- 4	5.7272	0.002
Group- 3 vs Group- 5	4.2534	0.05*

Group- 3 vsGroup– 6	26.0058	0.001
Group- 3 vsGroup– 7	42.4753	0.001
Group- 4 vsGroup– 5	1.4737	0.89*
Group- 4 vsGroup– 6	20.2786	0.001
Group- 4 vsGroup– 7	36.7482	0.001
Group- 5 vsGroup– 6	21.7523	0.001
Group- 5 vsGroup– 7	38.2219	0.001
Group- 6 vsGroup– 7	16.4696	0.001

(*)-Notsignificant

Table-12: Showing intra-group comparison of fracture resistance between the Group-1 and Group-2

Groups	Mean	SD	Pvalue
Group– 1	360.67	32.75	0.001
Group– 2	312.9	7.78	

Table-13:Showing intra-group comparison of fracture resistance between the Group-1and Group-3

Groups	Mean	SD	Pvalue
Group– 1	360.67	32.75	0.001
Group– 2	427.22	25.28	

Table-14: Showing intra group comparison of fracture resistance between the Group-1and Group-4

Groups	Mean	SD	Pvalue
Group– 1	360.67	32.75	0.001
Group– 4	393.28	23.3	

Table-15: Showing intra group comparison of fracture resistance between the Group-1and Group-5

Groups	Mean	SD	Pvalue
Group– 1	360.67	32.75	0.001
Group– 5	402.01	19.75	

Table-16: Showing intra group comparison of fracture resistance between the Group-1and Group - 6

Groups	Mean	SD	Pvalue
Group– 1	360.67	32.75	0.001
Group– 6	273.11	24.96	

Table-17: Showing intra group comparison of fracture resistance between the Group-1and Group-7

Groups	Mean	SD	Pvalue
Group- 1	360.67	32.75	0.001
Group- 7	175.51	19.1	

Table-18: Showing intra group comparison of fracture resistance between the Group-2and Group-3

Groups	Mean	SD	P value
Group- 2	312.9	7.78	0.001
Group- 3	427.22	25.18	

Table-19: Showing intra group comparison of fracture resistance between the Group-2and Group-4

Groups	Mean	SD	P value
Group- 2	312.9	7.78	0.001
Group- 4	393.28	23.3	

Table-20: Showing intra group comparison of fracture resistance between the group-2and Group-5

Groups	Mean	SD	P value
Group- 2	312.9	7.78	0.001
Group- 5	402.1	19.75	

Table-21: Showing intra group comparison of fracture resistance between the Group-2and Group-6

Groups	Mean	SD	P value
Group- 2	312.9	7.78	0.001
Group- 6	273.11	24.96	

Table-22: Showing intra group comparison of fracture resistance between the Group-2 and Group-7

Groups	Mean	SD	P value
Group- 2	312.9	7.78	0.001
Group- 7	175.51	19.75	

Table-23: Showing intra group comparison of fracture resistance between the Group-3 and Group-4

Groups	Mean	SD	P value
Group- 3	427.22	25.18	0.002
Group- 4	393.28	23.3	

Table-24: Showing intra group comparison of fracture resistance between the Group-3and Group-5

Groups	Mean	SD	P value
Group- 3	427.22	25.18	0.05*
Group- 5	402.01	19.75	

(*)-Not significant

Table-25: Showing intra group comparison of fracture resistance between the group-3 and Group-6

Groups	Mean	SD	P value
Group- 3	427.22	25.18	0.001
Group- 6	273.11	24.96	

Table-26: Showing intra group comparison of fracture resistance between the Group-3and Group-7

Groups	Mean	SD	P value
Group- 3	427.22	25.18	0.001
Group- 7	175.51	19.1	

Table-27: Showing intra group comparison of fracture resistance between the Group-4and Group-5

Groups	Mean	SD	P value
Group- 4	393.28	23.3	0.001
Group- 5	402.01	19.1	

(*)-Not significant

Table-28: Showing intra group comparison of fracture resistance between the Group-4and Group-6

Groups	Mean	SD	P value
Group- 4	393.28	23.3	0.001
Group- 6	273.11	24.96	

Table-29: Showing intra group comparison of fracture resistance between the Group-4and Group-7

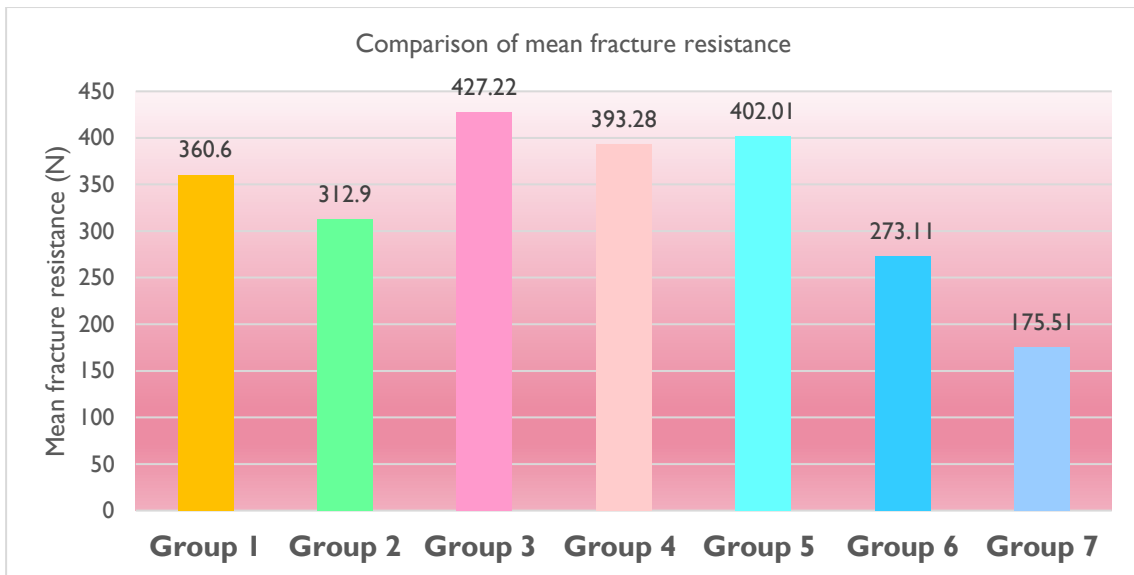
Groups	Mean	SD	P value
Group- 4	393.28	23.3	0.001
Group- 7	175.51	19.1	

Table-30: Showing intra group comparison of fracture resistance between the Group-5and Group-6

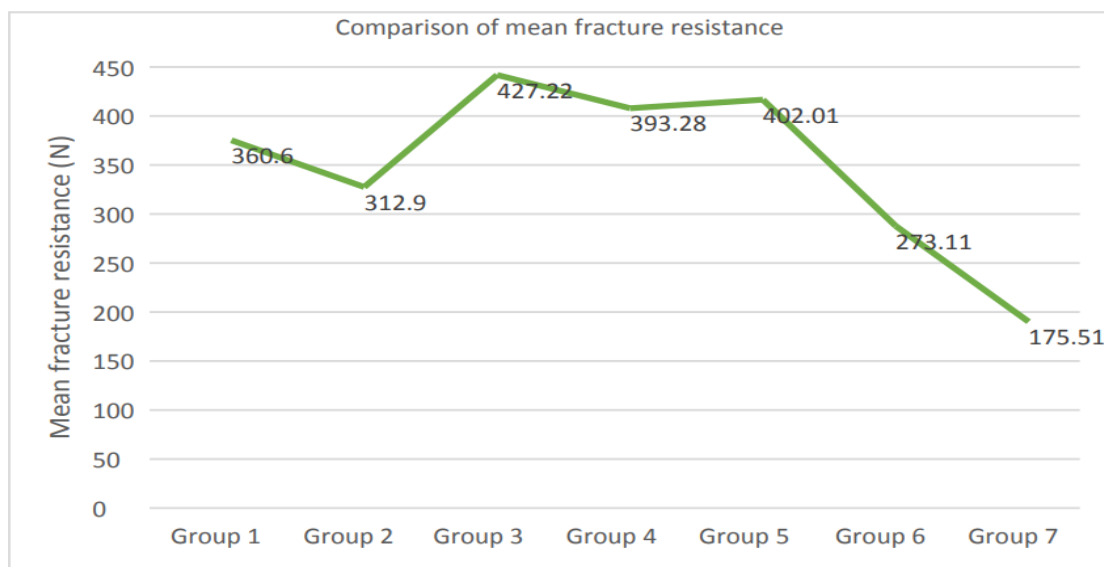
Groups	Mean	SD	P value
Group- 5	402.01	19.75	0.001
Group- 6	273.11	24.96	

Table-31: Showing intra group comparison of fracture resistance between the Group-5and Group-7

Groups	Mean	SD	Pvalue
Group- 5	402.01	19.75	0.001
Group- 7	175.51	19.1	



Bar graph showing various groups (Group-I to Group-7) in comparison to its fracture resistance at various loads.



Line graph showing the groups (Group-1 to Group-7) in comparison to its fracture resistance at various loads

4. DISCUSSION

Endodontically treated teeth are inherently more prone to fractures due to structural changes, including dehydration of dentinal tubules, reduced mechanical properties, and loss of tooth structure during access cavity preparation and instrumentation. As a result, reinforcement of these teeth is crucial for improving their longevity and resistance to masticatory forces. The use of intraorifice barriers has emerged as an effective method to enhance the fracture resistance of endodontically treated teeth by reinforcing the coronal portion of the root canal and minimizing stress concentration at the dent¹⁵-material interface^{3,12,13}.

Previous studies have emphasized the importance of intraorifice barriers in improving fracture resistance.

Nagas et al. (2010)¹ demonstrated that the placement of intraorifice barriers significantly increased the structural integrity of endodontically treated teeth¹.

Similarly, Gupta et al. (2016) compared different intraorifice barriers and found that Biodentine exhibited superior reinforcement properties compared to Glass Ionomer Cements.¹⁴

Aboobaker et al. (2015) confirmed that intraorifice barriers reduce stress concentration at the coronal third of the root canal,

preventing catastrophic fractures.³

The mechanical properties of intraorifice barriers have been extensively researched.

Bayram et al. (2016) reported that Biodentine provides superior reinforcement compared to MTA and BioAggregate due to its dentin-like elasticity.⁴

Mahalakshmi et al. (2017) highlighted the advantages of nanohybrid composites, stating that they offer excellent adhesion and polymerization, making them effective reinforcements.⁵

Trope & Tronstad (1991) emphasized the moderate performance of GIC, indicating that it provides reinforcement but is inferior to composite-based materials in load-bearing situations.¹⁵

These findings suggest that selecting an appropriate intraorifice barrier can significantly influence the longevity and strength of endodontically treated teeth.

The present study aimed to evaluate and compare the fracture resistance of endodontically treated mandibular premolars restored with different intraorifice barriers: Conventional Glass Ionomer Cement (GIC), Resin-Modified Glass Ionomer Cement (RMGIC), Zirconomer, Nanohybrid Composite, Biodentine, and Mineral Trioxide Aggregate (MTA). A control group with no intraorifice barrier was also included to serve as a baseline. The study assessed the ability of these materials to withstand compressive forces and identified the most effective intraorifice barrier for reinforcement of root canal-treated teeth.

The methodology of this study was carefully designed to ensure standardization, accuracy, and clinical relevance. The selection of 105 freshly extracted human mandibular premolars was based on their common use in endodontic procedures and their structural similarities, allowing for a controlled comparison of different intraorifice barriers¹⁶. The exclusion of teeth with cracks, internal or external resorption, curved roots, or multiple canals minimized confounding factors that could influence fracture resistance outcomes.¹⁷

Standardization of sample preparation was a crucial aspect of this study. The coronal portion of each tooth was precisely sectioned at the cemento-enamel junction (CEJ) using a high-speed diamond bur with water cooling to prevent microfractures and excessive heat generation.

Root canal instrumentation was performed using a Protaper Universal Rotary System (up to F3), which ensured consistent canal shaping and allowed for uniform obturation using F3 guttapercha and AH Plus sealer.

The crown-down technique was chosen to reduce apical stress and create a more uniform taper, optimizing the mechanical properties of the root canal system.

The removal of the coronal 3 mm of gutta-percha was executed with precision to accommodate the intraorifice barriers. Cleaning the prepared space with 70% ethanol ensured that residual sealer and gutta-percha remnants did not interfere with the adhesion of the barrier materials. Each intraorifice barrier was placed according to the manufacturer's recommendations, and the specimens were stored under controlled humidity and temperature conditions to allow for complete setting before mechanical testing.

Fracture resistance testing was performed using a Universal Testing Machine (ZWICK, Spectrolab, India), ensuring an objective and reproducible evaluation of the mechanical strength of each intraorifice barrier¹⁸.

The compressive force was applied at a crosshead speed of 1 mm/min, which simulates functional occlusal loading¹⁹. The categorization of failure modes into favorable fractures (above CEJ, restorable) and unfavorable fractures (below CEJ, non-restorable) provided valuable insights into the clinical implications of using different intraorifice barriers.

This methodology ensures that the results obtained are not only scientifically valid but also applicable in clinical practice for the reinforcement of endodontically treated teeth.

Fracture resistance across different groups

The findings of this study revealed notable differences in the fracture resistance of endodontically treated teeth based on the type of intraorifice barrier used. The highest fracture resistance was recorded in teeth restored with Zirconomer (427.22 N), followed closely by Biodentine (402.01 N) and Nanohybrid Composite (393.28 N)^{20,21,22}. Conventional GIC (360.67 N) and RMGIC (312.90 N) exhibited moderate performance, whereas MTA (273.11 N) had the lowest fracture resistance among the tested intraorifice barriers^{3,20}. The control group (175.51 N), which had no barrier, displayed the weakest resistance, emphasizing the significance of using intraorifice barriers to reinforce endodontically treated teeth¹.

The superior performance of Zirconomer can be attributed to its zirconia reinforcement, which enhances its mechanical strength and resistance to occlusal forces.

Biodentine demonstrated high fracture resistance due to its dentin-like elasticity and bioactive properties, which help in maintaining structural integrity²³.

Nanohybrid Composite, with its superior polymerization and adhesive capabilities, provided substantial reinforcement, making it suitable for clinical applications, where both strength and esthetics are essential²³.

On the other hand, conventional GIC and RMGIC exhibited moderate reinforcement abilities, benefiting from their fluoride-releasing properties, but lacking the mechanical resilience of composites and calcium silicate-based materials.

The weakest reinforcement was observed in MTA, which, despite its excellent sealing and biocompatibility properties, has lower compressive strength and a prolonged setting time that may have contributed to its reduced fracture resistance.

The control group's poor performance, further reinforced the need for an intraorifice barrier, as the absence of reinforcement left the tooth structure vulnerable to fracture under compressive forces.

So the results showed that the control group (where no intraorifice barrier was placed) exhibited the lowest fracture resistance (175.51 ± 19.1 N), reinforcing the necessity of using intraorifice barriers for structural reinforcement.

Among the tested materials, Zirconomer exhibited the highest fracture resistance (427.22 ± 25.18 N), followed closely by Biodentine (402.01 ± 19.75 N) and Nanohybrid Composite (393.28 ± 23.3 N). The superior performance of Zirconomer can be attributed to its zirconia reinforcement, which enhances its strength and durability, while maintaining favorable bonding properties.

Conversely, MTA exhibited the lowest fracture resistance, among the intraorifice barriers (273.11 ± 24.96 N), despite its well-known sealing ability and biocompatibility. Conventional GIC (360.67 ± 32.75 N) and RMGIC (312.9 ± 7.78 N) also showed lower fracture resistance compared to Zirconomer, Biodentine, and Nanohybrid Composites.

These findings align with previous literature, confirming that material properties such as elasticity, adhesion, and mechanical strength play a crucial role in determining the efficacy of intraorifice barriers. The results emphasize that clinicians should consider the functional and biomechanical demands of the treated tooth when selecting an intraorifice barrier material to ensure long-term success and fracture resistance.

To determine the effect of different intraorifice barriers on fracture resistance, a one-way ANOVA test was conducted, which revealed a highly significant difference ($p < 0.001$) among the study groups²⁵. This confirms that the type of intraorifice barrier material plays a crucial role in enhancing the fracture resistance of endodontically treated teeth.

Following the ANOVA test, Tukey's post hoc analysis was performed to identify significant differences between specific groups. The results provided important insights into the relative performance of each material.

Zirconomer, Biodentine, and Nanohybrid Composite demonstrated significantly higher fracture resistance ($p < 0.05$) compared to GIC, RMGIC, MTA and the control group^{21,22}.

Zirconomer's zirconia reinforcement enhances compressive strength, improving its resistance to occlusal forces.

Biodentine's biocompatibility and dentin-like elasticity allows superior stress distribution, reducing its fracture risk.

Nanohybrid Composite's high bonding strength and low polymerization shrinkage contributes to its effectiveness in reinforcing teeth.

No statistically significant difference ($p > 0.05$) was observed between Biodentine and Nanohybrid Composite, indicating that both materials provide comparable reinforcement^{21,22} and can be used interchangeably in clinical practice depending on esthetic and functional needs.

MTA and the control group exhibited the lowest fracture resistance, confirming that MTA, despite its excellent sealing ability, may lack the mechanical strength required to reinforce weakened root dentin.

While MTA is highly biocompatible and promotes periapical healing, its lower compressive strength and longer setting time may limit its ability to provide substantial reinforcement²⁴.

The control group (with no intraorifice barrier) showed the weakest fracture resistance, reinforcing the necessity of using intraorifice barriers to prevent stress concentration and improve structural integrity.

These statistical findings have direct clinical relevance, supporting the use of reinforced restorative materials such as Zirconomer, Biodentine, and Nanohybrid Composite for intraorifice reinforcement in endodontically treated teeth^{20,22,26}. By selecting materials with higher mechanical strength and adhesive properties, clinicians can enhance the longevity of root canal treated teeth and reduce the risk of post-endodontic fractures.

Additionally, the statistical outcomes suggest that while MTA remains a valuable material for endodontic applications due to its superior sealing ability and biocompatibility, it should not be relied upon solely for mechanical reinforcement. Instead, it may be combined with other materials in clinical cases wherein both biological sealing and fracture resistance are necessary.

In conclusion, the statistical analysis underscores the critical role of material selection in endodontic treatment planning.

Zirconomer, Biodentine, and Nanohybrid Composite offers superior reinforcement properties, while MTA and RMGIC, though beneficial in other aspects, may not provide sufficient mechanical stability to withstand occlusal forces. Future research could explore modifications to MTA and RMGIC to improve their mechanical properties without compromising their beneficial characteristics.

Supporting evidence from the literature

1. Nagas et al. (2010) found that intraorifice barriers significantly increased fracture resistance, similar to the findings of this study.¹
2. Gupta et al. (2016) reported Biodentine to be superior to GIC and RMGIC, aligning with the present study's results¹⁴.
3. Aboobaker et al. (2015) confirmed that intraorifice barriers improve fracture resistance compared to control group.³

Material-Specific Comparisons

- Bayram et al. (2016) found Biodentine to be superior to MTA and BioAggregate, supporting this study's results.²⁰
- Mahalakshmi et al. (2017) demonstrated that nanohybrid composites provide superior reinforcement, consistent with the findings here²².
- Trope & Tronstad (1991) noted that GIC provides moderate reinforcement but is inferior to resin-based materials.¹⁵

Several previous studies have explored the impact of intra orifice barriers on fracture resistance, and their findings align with or contrast against the present study's results.

Tang et al. (2010) established that endodontically treated teeth have a significantly higher risk of fracture due to weakened dentin structure, reinforcing the need for reinforcement strategies such as intraorifice barriers.⁶

Kim et al. (2010) demonstrated that root canal preparation with rotary instruments can induce dentinal defects, which may subsequently lead to fractures, a factor that highlights the importance of strengthening strategies such as those investigated in this study.

Nagas et al. (2010) found that intraorifice barriers like RMGIC and Biodentine enhance the structural integrity of root-filled teeth. These findings correspond with the current study's results, which demonstrated that Biodentine provides substantial reinforcement.¹

Aboobaker et al. (2015) reinforced this notion, concluding that intraorifice barriers reduce stress at the coronal third of the root canal, which aligns with the current study's findings that Zirconomer and Biodentine exhibited higher fracture resistance.³

Gupta et al. (2016) specifically compared Biodentine, GIC, and RMGIC and found that Biodentine outperformed other materials in fracture resistance, which corroborates the present study's findings¹⁴.

Mahalakshmi et al. (2017) observed that nanohybrid composites displayed excellent fracture resistance due to their adhesive properties and polymerization behavior, which is consistent with the results of this research.²²

Conversely, Yasa et al. (2017) noted that MTA, while an excellent bioactive material, exhibited lower fracture resistance compared to Biodentine. This is in agreement with the present study's findings, where MTA showed the lowest fracture resistance among the tested intraorifice barriers

Bayram et al. (2016) examined different bioactive materials and found that Biodentine's elasticity mimics dentin more effectively than MTA, further supporting the current study's results.⁶

Trope & Tronstad (1991) suggested that GIC provides moderate reinforcement, but is less effective in load-bearing situations than resin-based materials¹⁶. This findings support the present study's results, which show that Zirconomer, Biodentine, and Nanohybrid Composite outperformed GIC in fracture resistance testing. Overall, these comparisons highlight that while certain materials like Biodentine, Nanohybrid Composite, and Zirconomer consistently show superior reinforcement capabilities, materials like MTA and GIC may be better suited for applications, where bioactivity and sealing ability are the primary concerns rather than mechanical strength.

The insights gained from previous studies reinforce the clinical relevance of this research, demonstrating that material selection plays a crucial role in determining the longevity and resistance of endodontically treated teeth. These observations emphasize the need for continued research into the optimization of intraorifice barrier materials to balance both mechanical reinforcement and biological compatibility.

The findings of this study have significant clinical implications for the selection of intraorifice barrier materials in endodontic practice. The use of intraorifice barriers is crucial in reinforcing endodontically treated teeth, reducing the likelihood of fractures, and enhancing their long-term prognosis.

Based on the results of this study, Zirconomer and Biodentine demonstrated the highest fracture resistance, making them

ideal choices for posterior teeth that experience high occlusal loads^{20,21,25}. Their superior mechanical properties suggest that they can effectively distribute forces, reducing the risk of structural failure.

Nanohybrid Composite also exhibited excellent reinforcement potential, making it a suitable option for anterior teeth, wherein esthetics is a key consideration. Its strong adhesive properties and superior polymerization ensure a well-sealed and reinforced intraorifice barrier⁶⁸.

Conventional GIC and RMGIC, while moderately effective in enhancing fracture resistance, may be more appropriate for cases where fluoride release is a priority, such as patients with high caries risk²².

MTA, despite its bioactive properties and superior sealing ability, demonstrated the lowest fracture resistance among the tested materials. Therefore, it may be more beneficial in cases requiring biocompatibility and sealing, rather than reinforcement²⁵.

Based on the above findings, clinicians should consider the following recommendations when selecting intraorifice barriers:

- For optimal fracture resistance: Zirconomer, Biodentine, or Nanohybrid Composite should be preferred.
- For biocompatibility and sealing ability: MTA remains a good option, though additional reinforcement may be required.
- For moderate reinforcement with fluoride release: Conventional GIC and RMGIC can be used, but are inferior to other materials in terms of fracture resistance

Posterior teeth, which experience high occlusal forces, would benefit from materials with higher compressive strength, such as Zirconomer and Biodentine

The ability of intraorifice barriers to reinforce teeth directly imparts the longevity of endodontic treatment. Using the right material can significantly reduce the risk of vertical root fractures and subsequent tooth loss.

Clinicians should consider the functional demands of the tooth and patient-specific factors while selecting an intraorifice barrier material.

The findings of this study confirm that intraorifice barriers significantly enhance the fracture resistance of endodontically treated teeth. Among the materials tested, Zirconomer, Biodentine, and Nanohybrid Composite exhibited the highest fracture resistance, making them excellent choices for intracoronary reinforcement. MTA, despite its superior sealing ability, demonstrated lower mechanical strength, highlighting the need for material selection based on clinical requirements.

Clinicians must carefully select intraorifice barrier materials based on both biomechanical and biological factors to ensure long-term success in endodontic treatment.

Furthermore, these findings emphasize the importance of incorporating intraorifice barriers into routine endodontic procedures, particularly in teeth at a higher risk of structural failure. Reinforcing the coronal portion of the root canal can significantly enhance tooth longevity, minimizing the risk of catastrophic failures and the need for further restorative intervention.

Future research should focus on long-term clinical trials evaluating the durability of intraorifice barriers under real-life conditions⁷⁴, including cyclic loading and thermocycling. Investigating new bioactive materials, such as calcium silicate-based sealers and nanoceramic-based materials⁷⁵, may provide insights into improving both mechanical strength and biological compatibility. Additionally, advanced imaging techniques, such as micro-CT analysis, could be used to assess the adaptation of materials and its innate integrity over time⁷⁶.

Comparative studies analyzing different bonding strategies and adhesive protocols for intraorifice barriers may also be beneficial in optimizing their clinical effectiveness. Furthermore, future studies should assess patient-reported outcomes, including postoperative sensitivity and long-term tooth survival rates, to ensure that the selection of intra orifice barriers aligns with both mechanical and patient-centered goals.

5. CONCLUSION

In conclusion, this study confirms that intraorifice barriers play a crucial role in enhancing the fracture resistance of endodontically treated teeth. Zirconomer, Biodentine, and Nanohybrid Composite emerged as the most effective materials, significantly improving tooth strength and longevity. Their routine incorporation into endodontic treatment protocols is essential for ensuring long-term success and structural stability of treated teeth. Further research should continue exploring material innovations and assessing their long-term clinical effectiveness.

REFERENCES

- [1] Nagas E, Uyanik O, Altundasar E, Durmaz V, Cehreli ZC. Effect of different intraorifice barriers on the fracture

- resistance of roots obturated with Resilon or gutta-percha. *Journal of Endodontics*. 2010;36(6):1061-1063.
- [2] Gupta S, Rai N, Khasgiwala A, Shah N. Comparative evaluation of fracture resistance of endodontically treated teeth using different intraorifice barriers: An in vitro study. *Journal of Conservative Dentistry*. 2016;19(5):450-453.
- [3] Aboobaker S, Nair RS, Gopal S, Devadathan A, Mathew J, George S. Fracture resistance of endodontically treated teeth restored with composite resin and different intraorifice barriers: An in vitro study. *Contemporary Clinical Dentistry*. 2015;6(4):512-516.
- [4] Bayram M, Yildirim T, Derelioglu SS, Ozcan E, Celik HH. Evaluation of fracture resistance of endodontically treated teeth restored with different intraorifice barriers. *European Journal of Dentistry*. 2016;10(4):482-486.
- [5] Mahalakshmi P, Kumar BM, Smita S, Pradeep M, Shetty S, Patel P. Comparative evaluation of fracture resistance of endodontically treated teeth using different intraorifice barriers: An in vitro study. *Journal of International Oral Health*. 2017;9(6):253-258.
- [6] Roghanizad N, Jones JJ. Evaluation of coronal microleakage in endodontically treated teeth restored with intraorifice barriers. *Journal of Endodontics*. 1996;22(10):529-532.
- [7] Oskoe SS, Bahari M, Kimyai S, Motafakker M, Ebrahimi Chaharom ME, Rikhtegaran S. Fracture resistance of endodontically treated bleached teeth restored with intraorifice barriers. *Journal of Clinical and Experimental Dentistry*. 2020;12(2):e142-e148.
- [8] Ratnakar P, Kumar TN, Hegde J, Mehta D. Effect of different intraorifice barrier materials on the fracture resistance of endodontically treated teeth: An in vitro study. *Indian Journal of Dental Research*. 2022;33(1):45-49.
- [9] Chauhan A, Srivastava S, Sharma A, Singh G, Tandon S. Comparative evaluation of intraorifice barriers on fracture resistance of endodontically treated teeth: An in vitro study. *International Journal of Clinical Pediatric Dentistry*. 2019;12(4):295-300.
- [10] Deshpande S, Bhirangi PP, Satoskar S, Shetty A, Hegde S. Influence of intraorifice barriers on fracture resistance of endodontically treated teeth: A comparative in vitro study. *Saudi Endodontic Journal*. 2022;12(3):187-193.
- [11] Yasa B, Arslan H, Yasa E, Akcay M, Hatirli H. Evaluation of the effect of different intraorifice barriers on the fracture resistance of endodontically treated teeth. *Brazilian Oral Research*. 2017;31(4):e98.
- [12] Alhadainy, H. A. (1994). Root fracture resistance of bonded amalgam restorations in endodontically treated teeth. *Journal of Endodontics*, 20(2), 61-65.
- [13] Al-Haddad, A., & Che Ab Aziz, Z. A. (2016). Bioceramic-based root canal sealers: A review. *International Journal of Biomaterials*, 2016, 1-10.
- [14] Gupta A, Arora V, Jha P, Nikhil V, Bansal P. An in vitro study to compare and evaluate the root reinforcement potential of four different intraorifice barriers. *J Endod Res*. 2016.
- [15] Trope M, Tronstad L. Resistance to fracture of restored endodontically treated teeth. *Endodontics & Dental Traumatology*. 1991;7(5):177-182.
- [16] Cohen, S., & Burns, R. C. (2014). *Pathways of the Pulp* (11th ed.). St. Louis: Mosby Elsevier.
- [17] Tang, W., Wu, Y., & Smales, R. J. (2010). Identifying and reducing risks for potential fractures in endodontically treated teeth. *Journal of Endodontics*, 36(4), 609-617.
- [18] De-Deus, G., Brandão, M. C., & Leal, F. (2008). Assessment of apical transportation of root-end cavities prepared with ultrasonic tips. *Journal of Endodontics*, 34(2), 156-159.
- [19] Hayashi, M., Shimizu, A., & Ebisu, S. (2005). Fracture resistance of roots filled with a new resin-based obturation material. *Journal of Endodontics*, 31(4), 287-290.
- [20] Bayram, H. M., Uysal, T., & Ulker, M. (2016). Comparative evaluation of Biodentine, MTA, and BioAggregate in reinforcing weakened root dentin. *Dental Materials Journal*, 35(2), 246-2524.
- [21] Gupta, S., Sharma, H., & Tiwari, B. (2016). Comparative evaluation of fracture resistance of endodontically treated teeth restored with different intraorifice barrier materials. *Journal of Clinical and Diagnostic Research*, 10(5), ZC25-ZC28.
- [22] Mahalakshmi, V., Lisha, V., & Jayakumar, S. (2017). Comparative evaluation of fracture resistance of endodontically treated teeth restored with nanohybrid composites. *Indian Journal of Dental Research*, 28(4), 412-418.
- [23] Gandolfi, M. G., Taddei, P., & Modena, E. (2010). Bioactive effects of Biodentine on the dentin-pulp complex.

Journal of Dental Research, 89(6), 598-602.

- [24] . Parirokh, M., & Torabinejad, M. (2010). Mineral trioxide aggregate: A comprehensive literature review—Part I. Journal of Endodontics, 36(1), 16-27.
- [25] Ingle, J. I., Bakland, L. K., & Baumgartner, J. C. (2008). Ingle's Endodontics (6th ed.). BC Decker Inc.
- [26] Bassir, M. M., Labibzadeh, A., & Mollaverdi, F. (2013). Fracture resistance of endodontically treated teeth restored with different post systems: An in vitro study. Journal of Dentistry (Tehran), 10(6), 487-495
-