International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 21s, 2025
https://theaspd.com/index.php

Optimizing Post-Endodontic Outcomes: A Review On Efficacy Of Intraorifice Barrier Materials In Endodontically Treated Teeth

Dr Manish Dongre[1], Dr Madhu Pujar[2], Dr Hemant T vagarali[3], Dr Mohammed Suhail Mirza[4], Dr Gunnam Anjany Chowdary[5], Dr Aishwarya Sinha[6]
[1]Maratha mandal dental college, Belagavi, dongremanish62@gmail.com
[2]Professor and Hod, Dept of conservative dentistry and endodontics, Maratha mandal dental college, Belagavi, Madhupujar.r@gmail.com
[3]Professor, Dept of conservative dentistry and endodontics, Maratha mandal dental college, Belagavi, hemantvagarali@gmail.com
[4]Assistant Professor, Dept of conservative dentistry and endodontics, Oxford dental college, Bengaluru, suhailmirza7@gmail.com
[5]MDS endodontics, anjanychowdary@gmail.com
[6]Assistant professor, Dept of conservative dentistry and endodontics, Kle dental college, Belagavi, dr.aishwaryasinhaendo@gmail.com

Abstract
The long-term success of endodontically treated teeth depends not only on proper canal disinfection and obturation but also on preventing coronal microleakage and preserving structural integrity. Intraorifice barriers (IOBs) are restorative materials placed within the coronal portion of the root canal system after obturation, serving to reinforce the cervical dentin and act as a secondary seal against microbial infiltration. This review explores the rationale, ideal properties, and clinical performance of various materials used as IOBs. Materials such as Biodentine, mineral trioxide aggregate (MTA), resin-modified glass ionomer cements (RMGICs), bulk-fill flowable composites(BFC), and resin-modified calcium silicate cements have demonstrated varying degrees of efficacy in reducing coronal leakage and enhancing fracture resistance. Biodentine offers superior mechanical properties and bioactivity; MTA provides excellent sealing but is technique sensitive. RMGICs offer fluoride release and ease of handling but may show lower fracture resistance. Bulk-fill flowable composites allow deep curing and good adaptation, while resin-modified calcium silicate cements like TheraCal LC combine biocompatibility with convenient light-curing. ParaCore, a dual-cure composite, exhibits high compressive strength and monoblock bonding when used with adhesives. Evidence suggests that IOBs not only enhance the longevity of endodontic treatment but also serve a protective role during intracoronal bleaching. However, material selection should consider handling characteristics, removal feasibility, and long-term stability. Further in vivo studies are necessary to standardize protocols and validate long-term clinical outcomes.
Keywords: *Intraorifice barrier, microleakage, structural integrity*

INTRODUCTION

The long-term success of endodontic treatment extends beyond the mere debridement and obturation of the root canal system. Increasing attention is being directed toward the post-treatment phase, particularly the restoration protocols employed after completion of root canal therapy, as these significantly influence the prognosis of endodontically treated teeth(1).

The structural integrity of these teeth is often compromised due to extensive caries, loss of tooth structure during access cavity preparation, and chemical alterations induced by endodontic irrigants and medicaments(2). As a result, they become more susceptible to fracture, especially in the absence of an adequate coronal restoration.

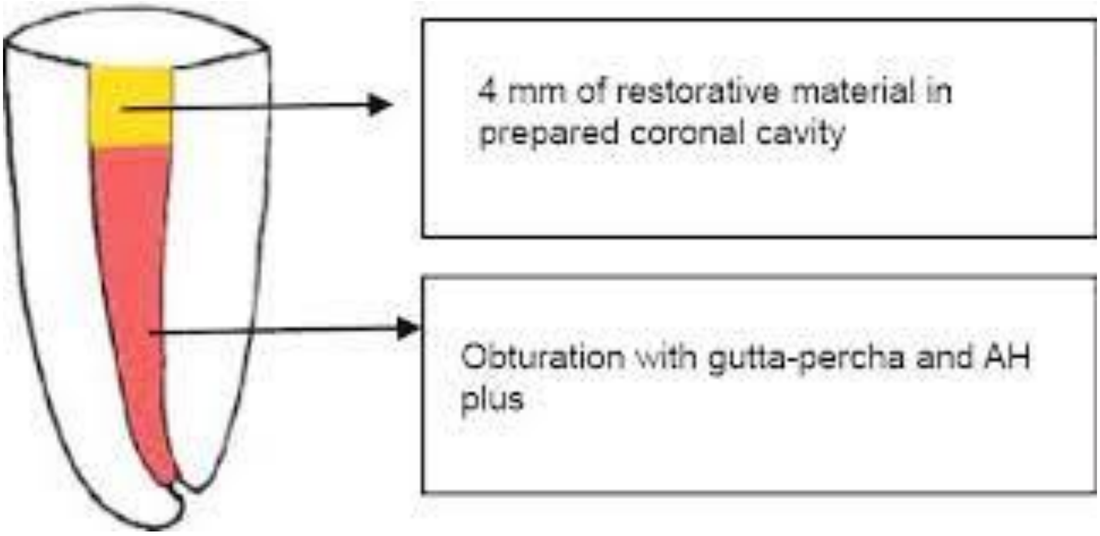
A critical area of clinical concern is the interface between the restorative material and the remaining dental hard tissues. This region, if inadequately sealed, can serve as a potential pathway for bacterial infiltration, leading to the recontamination of the root canal system and ultimately resulting in the failure of endodontic therapy. Numerous clinical and laboratory investigations have emphasized that a well-executed coronal seal is as essential as an apical seal in preventing microleakage and maintaining endodontic success(3).

Swartz et al. highlighted the importance of post-endodontic restoration, reporting that the failure rate of endodontically treated teeth was nearly doubled in the absence of an appropriate final restoration(4).

To enhance the coronal seal and reinforce the remaining tooth structure after root canal treatment, a technique was introduced involving the removal of approximately 3 mm of coronal gutta-percha and its

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 21s, 2025
https://theaspd.com/index.php

replacement with a restorative material placed at the canal orifice(5). This approach, now referred to as the intraorifice barrier technique, has attracted substantial interest for its ability to minimize coronal microleakage and improve the fracture resistance of endodontically treated teeth.

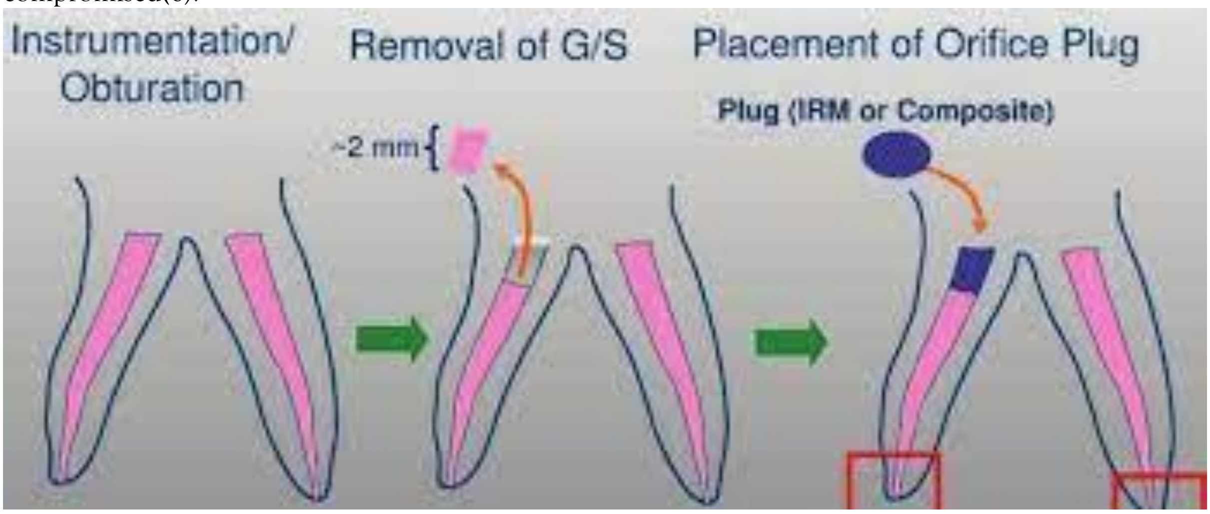


DISCUSSION:

What are intraorifice barriers?

Intraorifice barriers (IOBs) are restorative materials placed within the coronal portion of a root canal system—typically in the canal orifice—following endodontic obturation, with the primary aim of enhancing coronal sealing and preventing microleakage. The concept involves removing a short segment of coronal gutta-percha, usually 2–4 mm and replacing it with a material that offers superior sealing ability and mechanical strength.

The technique was first introduced by Roghanizad and Jones, who demonstrated that replacing 3 mm of coronal gutta-percha with bonded restorative materials significantly reduced coronal leakage, thereby improving the long-term prognosis of root canal treatment (5). Since then, intraorifice barriers have been widely studied for their ability to act as a second line of defense against microbial penetration, especially in situations where there is a delay in final coronal restoration or when temporary restorations may be compromised(6).



Rationale for Intraorifice Barriers in Intracoronal Bleaching

Discoloration of teeth is a common esthetic concern and can result from extrinsic, local intrinsic, or systemic intrinsic factors, or a combination of these. In the case of non-vital teeth, intrinsic factors such as trauma, intrapulpal hemorrhage, inadequate pulp tissue removal, residual endodontic materials, post-endodontic restorations, and root resorption are frequently implicated causes of discoloration(7).

Among the various esthetic management techniques available—including crowns, veneers, and composite resins—intracoronal bleaching has been widely recognized as a minimally invasive, safe, and conservative approach to improve the appearance of discolored endodontically treated teeth. Two primary techniques are commonly employed for intracoronal bleaching: the thermocatalytic method and the walking bleach technique. Owing to its lower risk of complications, particularly cervical root resorption, the walking bleach technique is generally the preferred method

Hydrogen peroxide (HP) and sodium perborate (SP) are the most frequently used bleaching agents. HP is usually applied directly at concentrations ranging from 30% to 35%, or it may be formed as a byproduct of the chemical breakdown of SP.

However, intracoronal bleaching using peroxides is not without risks. Hydrogen peroxide, due to its low molecular weight and high oxidative power, can easily penetrate the dentinal tubules and reach the cervical and periodontal tissues. This may create an acidic environment favorable for osteoclastic activity, thereby increasing the risk of invasive cervical resorption (ICR)(8). Furthermore, HP may also cause chemical alterations in dentin, increase dentin permeability, and weaken the mechanical properties of dental hard tissues, ultimately compromising the structural integrity of treated teeth(9).

Sodium perborate (SP) mixed with water and carbamide peroxide (CP) are potentially safer alternatives to hydrogen peroxide due to low peroxide diffusion into the radicular tissues(10). Additionally, carbamide peroxide (CP), a compound of HP and urea, is considered a safer alternative due to its controlled peroxide release and lower tissue diffusion(11).

To minimize these adverse effects, the use of a protective intraorifice barrier has been advocated. This technique involves sealing the coronal third of the root canal with a restorative material that acts as both a physical and chemical barrier, thereby reducing the diffusion of bleaching agents into the cervical region and protecting periradicular tissues(12). In addition to preventing chemical irritation, intraorifice barriers have also been shown to improve the fracture resistance of endodontically treated teeth by reinforcing weakened tooth structure.

Thus, the integration of intraorifice barriers during intracoronal bleaching procedures represents an important advancement in improving both the safety and efficacy of esthetic treatment protocols in non-vital, discolored teeth.

Ideal properties of intraorifice barrier include:

- Allow easy placement.
- Possess increased fracture resistance
- Should bond to the tooth structure.
- Provide effective seal against coronal microleakage.
- Should be easily distinguished from the natural tooth structure.
- Should not interfere with the final restoration of the access preparation.
- Exhibit dimensional stability.
- Should not stain the tooth.

Recent materials as intraorifice barriers:

Biodentine

Biodentine is a calcium silicate-based restorative material introduced as a dentin substitute due to its favorable physical and biological properties. Its application as an intraorifice barrier has been well-documented for improving the fracture resistance and sealing ability of endodontically treated teeth. Owing to its bioactivity and mechanical compatibility with dentin, Biodentine has gained popularity as an alternative to traditional materials such as mineral trioxide aggregate (13).

Advantages:

- **Dentin-like mechanical properties:** Compressive strength (~300 MPa) and modulus of elasticity (~22 GPa) closely match those of natural dentin, allowing efficient distribution of occlusal forces and reduced fracture risk(14).
- **Bioactivity:** Releases calcium and silicon ions, promoting the formation of tag-like structures in dentinal tubules and enhancing micromechanical bonding(13).
- **No polymerization shrinkage:** As a non-resin-based material, it avoids shrinkage-related gap formation, ensuring better marginal integrity.
- **Short setting time:** Sets within approximately 12 minutes, allowing for faster clinical workflow(15).

- **Excellent sealing ability:** Small particle size and uniform distribution improve dentinal penetration and sealing capacity.
- **Biocompatibility and slight expansion:** Offers good tissue compatibility and marginal sealing due to expansion during setting.

Disadvantages:

- **Technique sensitivity:** Sealing effectiveness may be influenced by handling technique and clinical conditions
- **Difficult to Remove in Retreatment**: Biodentine integrates well into dentinal tubules and hardens similarly to natural dentin, making it difficult to distinguish and remove during retreatment procedures.

Commercially available as:

- Biodentine® (Septodont, Saint-Maur-des-Fossés, France)

RMGIC

Resin-Modified Glass Ionomer Cements (RMGICs), such as Vitremer, have gained recognition as effective intraorifice barrier materials due to their combination of favorable mechanical properties and chemical adhesion to dentin. RMGICs exhibit a dual-curing mechanism, involving both the traditional acid-base reaction of conventional glass ionomers and light-activated polymerization via methacrylate groups. This hybrid setting mechanism enhances their handling characteristics and mechanical stability. RMGICs have shown moderate reinforcement of root dentin and significantly improved outcomes when compared to no barrier placement. While they may not consistently outperform all materials—particularly composite resins—they remain useful in clinical scenarios where fluoride release, ease of handling, and moisture tolerance are critical [8].

Advantages

- **Elastic modulus (10–14 GPa):** Closely resembles natural dentin (14–16 GPa), promoting effective stress distribution and reinforcement(16).
- **Flexural strength (~60 MPa):** Provides sufficient mechanical strength to reinforce the cervical area of the root.
- **Chemical bonding to dentin:** Ionic interactions contribute to a strong dentin-cement interface.
- **Dual-curing mechanism:** Combines acid-base and light-activated polymerization for enhanced physical performance(17).
- **Water sorption and setting expansion:** Improve adaptation and sealing at the dentin interface(16).
- **Improved bonding with primer:** Surface preconditioning enhances marginal adaptation(17).
- **Fluoride release and moisture tolerance:** Useful for anticariogenic benefits and in less ideal clinical environments.

Disadvantages:

- **Polymerization shrinkage:** Light-activated curing may lead to contraction and marginal gaps.
- **Lower fracture resistance:** Performs less favorably than composite resin in some fracture resistance studies.
- **Technique sensitivity:** Requires appropriate curing and handling to achieve optimal outcomes.

Commercially available as:

- **Vitremer™** (3M ESPE, St. Paul, MN, USA)
- **Fuji II LC®** (GC Corporation, Tokyo, Japan)
- **Ketac Nano™** (3M ESPE, St. Paul, MN, USA)

Mineral Trioxide Aggregate (MTA)

Mineral Trioxide Aggregate (MTA), a calcium silicate-based bioceramic, has been extensively investigated for use as an intraorifice barrier (IOB) due to its superior sealing properties, bioactivity, and biocompatibility. MTA is particularly effective in endodontically treated teeth requiring internal bleaching, where prevention of cervical root resorption and microleakage is critical.

MTA demonstrates excellent sealing ability owing to its **hygroscopic expansion** during setting and **formation of hydroxyapatite** at the dentin-material interface(18,19). These properties allow MTA to diffuse and adapt well into moist dentinal tubules, enhancing the seal in cases involving bleaching agents . Studies have confirmed that both **gray and white MTA** reduce microleakage, with gray MTA demonstrating **greater expansion and sealing ability** than white MTA due to its mineral content and setting behavior(20).

Advantages:

- **Excellent sealing capacity:** Hygroscopic expansion and hydroxyapatite formation enhance adaptation and seal against leakage(18).
- **Reduced microleakage in bleaching cases:** Especially suitable when internal bleaching agents are used(19).
- **High biocompatibility and osteoinductivity:** Promotes periapical healing and hard tissue formation(20).
- **Antibacterial and alkaline properties:** Creates an unfavorable environment for microbial proliferation.
- **Hydrophilic nature:** Sets in the presence of moisture, making it ideal for root canal environments.
- **Formation of bioactive layer:** Leaches calcium, phosphate, and oxygen, encouraging dentin remineralization and tissue regeneration.

Disadvantages:

- **Long setting time:** Requires extended moisture application (up to 2–3 hours) to achieve full setting.
- **Poor handling properties:** Granular consistency and difficulty in placement can complicate clinical application.
- **Tooth discoloration potential:** Particularly in its gray formulation, which may affect esthetic outcomes.
- **Challenging removal:** Once set, MTA is difficult to retrieve or revise.
- **Inconsistent results under functional load:** Demonstrated lower fracture resistance compared to other IOBs like RMGIC and composites in some studies(18,19)

Commercially available as:

- **ProRoot® MTA** (Dentsply Sirona, Tulsa, OK, USA)
- **MTA Angelus®** (Angelus, Londrina, Brazil)
- **EndoCem® MTA** (Maruchi, Wonju, Republic of Korea)

Bulk-Fill Flowable Composite

Bulk-fill flowable composites have emerged as an advanced restorative material that combines ease of use, deeper polymerization capacity, and adequate mechanical properties. When used as intraorifice barriers (IOBs) in endodontically treated teeth.

Bulk Fill composites differ from traditional composites in their ability to be placed in **increments of up to 4–5 mm**, owing to **improved translucency** and **photo-initiator systems** that ensure adequate curing depth.

Advantages:

- **Deep curing capability:** Allows placement in single increments up to 4 mm without compromising polymerization, which simplifies application in the root canal orifice.
- **Reduced polymerization shrinkage stress:** Modifications in the resin matrix, such as the inclusion of stress relieving monomers, significantly reduce cuspal deflection and stress on dentin walls(21).
- **Improved adaptation to dentin:** High flowability enhances adaptation to internal canal walls and reduces the risk of voids and marginal gaps.
- **Good mechanical properties:** Despite being flowable, bulk-fill materials exhibit improved compressive strength and elastic modulus compared to conventional flowables, approaching the performance of traditional posterior composites(22).
- **Layer-free application:** Eliminates the need for multiple increments, reducing the risk of interfacial contamination and void formation during placement.
- **Esthetic and radiopaque:** Most formulations are radiopaque and offer shade compatibility for esthetic restorations when needed.

Disadvantages:

- **Lower filler content (~60–68% by weight):** While enhancing flowability, it may reduce wear resistance and flexural strength compared to packable composites(23).
- **Potential microleakage under high stress:** Although minimized, polymerization stress may still pose a risk at the dentin interface in areas with limited elastic buffering.

- **Limited long-term data as IOB:** Although promising, there is a paucity of long-term clinical evidence supporting bulk-fill flowable composites as a standard IOB material.

Commercially available as:
- **SureFil® SDR® flow+** (Dentsply Sirona, Konstanz, Germany)
- **Filtek™ Bulk Fill Flowable Restorative** (3M ESPE, St. Paul, MN, USA)
- **Tetric EvoFlow® Bulk Fill** (Ivoclar Vivadent, Schaan, Liechtenstein)

Resin modified calcium silicate cement

Resin-modified, light-cured calcium silicate-based cements are originally designed for pulp capping procedures. It combines the bioactivity of traditional calcium silicate cements with the handling advantages of resin materials. Compared to conventional materials like **MTA** and **Biodentine**, **Resin modified calcium slicate cement** demonstrates **rapid photopolymerization**, **improved mechanical properties**, and **reduced solubility**, making it a potential candidate for use as an intraorifice barrier(24). Laboratory evaluations have shown that **Resin modified calcium slicate cement** has **higher compressive and flexural strength** than other calcium silicate cements and maintains **good bonding capability** under varied pH conditions(25,26).

In a recent in vitro study, **TheraCal LC combined with Clearfil™ SE Bond**, a two-step self-etch adhesive, significantly **increased fracture resistance** in endodontically treated teeth. This enhancement is attributed to **micromechanical retention**, improved **stress distribution**, and **penetration of calcium silicate into dentin**, reinforcing the root structure(27).

Advantages:
- **Rapid setting** via light activation, allowing immediate clinical progression.
- **High compressive and flexural strength** compared to MTA and Biodentine.
- **Improved marginal sealing** and dentin bonding when used with adhesives.
- **Good mechanical and chemical stability** under various pH and moisture conditions.

Disadvantages:
- **Polymerization shrinkage** due to resin matrix may compromise marginal integrity.
- **Dependent on adhesives** for optimal sealing and reinforcement.
- **Limited long-term clinical data** compared to extensively studied materials like MTA or Biodentine.

Commercially available as:
- **TheraCal LC®** (Bisco, Inc., Schaumburg, IL, USA)
- **TheraCal PT®** (Bisco, Inc., Schaumburg, IL, USA)

Paracore

ParaCore (Coltène/Whaledent) is a **dual-cured, fluoride-containing, radiopaque composite** that contains methacrylate monomers (Bis-GMA, UDMA, TEGDMA, TMPTMA), barium glass, amorphous silica, and sodium fluoride(28). Designed primarily as a core build-up and luting material, ParaCore can be used with ParaBond adhesive to achieve a strong bond with dentin. This combination enables the creation of a **monoblock structure**, where the post, cement, and dentin act as a single unit, optimizing force distribution and minimizing microleakage. Its **dual-cure mechanism** ensures complete polymerization even in the absence of light, making it ideal for deep orifices.

Advantages:
- **High Mechanical Strength**: ParaCore demonstrated significantly superior compressive strength, flexural strength, and fracture resistance.(28)
- **Dual-Cure Polymerization**: Enables predictable setting even in deep canal areas where light access is limited.(29)
- **Monoblock Bonding**: When combined with ParaBond, it produces a unified restoration that reinforces the tooth against fracture and leakage.
- **Fluoride Release**: May offer antibacterial benefits and assist in preventing secondary caries

Disadvantages:
- **Technique Sensitivity**: Requires appropriate adhesive protocol and moisture control to ensure optimal bonding.(29)

- **Polymerization Shrinkage**: Although reduced by dual-cure technology, it is still a concern if placement is not well controlled.(28)
- **Difficult Removal in Retreatment**: Its strong adhesion and radiopacity can make retrieval challenging during nonsurgical endodontic retreatment.
- **Limited Clinical Data as Intraorifice Barrier**: Most evidence is derived from extrapolated data on core build-up applications or in vitro study.(30)

Commercially available as:

- **ParaCore®** (Coltène/Whaledent, Altstätten, Switzerland)

CONCLUSION

The long-term success of endodontically treated teeth is heavily influenced by the prevention of coronal microleakage and reinforcement of the remaining root structure. Intraorifice barriers (IOBs) have emerged as an effective strategy to achieve both objectives. By sealing the canal orifice and minimizing microleakage, IOBs protect against bacterial recontamination—a critical factor in endodontic failure. Moreover, certain IOB materials contribute significantly to the mechanical reinforcement of the cervical root, reducing susceptibility to vertical root fractures.

Among the materials reviewed, **Biodentine** and **bulk-fill flowable composites** demonstrated superior fracture resistance, while **MTA** and **TheraCal LC**, especially when combined with bonding agents, showed favorable sealing ability and moderate strengthening effects. **Resin-modified glass ionomers (RMGIC)** offer ease of use and fluoride release but exhibit variable mechanical performance. The success of any IOB depends not only on its sealing ability and mechanical properties but also on proper **clinical protocol**, **orifice preparation**, and **material handling**.

While current evidence supports the use of IOBs, further **long-term clinical studies** are needed to establish standardized guidelines for material selection and application to optimize outcomes in restorative endodontics.

REFERENCES

1. Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I. Endodontic failure caused by inadequate restorative procedures: Review and treatment recommendations. The Journal of Prosthetic Dentistry. 2002 June;87(6):674–8.
2. Sim TP, Knowles JC, Ng YL, Shelton J, Gulabivala K. Effect of sodium hypochlorite on mechanical properties of dentine and tooth surface strain. Int Endod J. 2001 Mar;34(2):120–32.
3. Hajaj T, Perdiou A, Sinescu C, Rominu M, Negrutiu ML, Talpos R, et al. Evaluation of Different Coronal Sealing Materials in the Endodontically Treated Teeth: An In Vitro Study. Ţălu Ş, editor. Advances in Materials Science and Engineering. 2021 Jan;2021(1):9977951.
4. Swartz DB, Skidmore AE, Griffin JA. Twenty years of endodontic success and failure. J Endod. 1983 May;9(5):198–202.
5. Roghanizad N, Jones JJ. Evaluation of coronal microleakage after endodontic treatment. J Endod. 1996 Sept;22(9):471–3.
6. Swanson K, Madison S. An evaluation of coronal microleakage in endodontically treated teeth. Part I. Time periods. Journal of Endodontics. 1987 Feb;13(2):56–9.
7. Sakalli B, Basmaci F, Dalmizrak O. Evaluation of the penetration of intracoronal bleaching agents into the cervical region using different intraorifice barriers. BMC Oral Health [Internet]. 2022 Dec [cited 2025 July 17];22(1). Available from: https://bmcoralhealth.biomedcentral.com/articles/10.1186/s12903-022-02300-4
8. Patel S, Kanagasingam S, Pitt Ford T. External Cervical Resorption: A Review. Journal of Endodontics. 2009 May;35(5):616–25.
9. Chng HK, Yap AUJ, Wattanapayungkul P, Sim CPC. Effect of traditional and alternative intracoronal bleaching agents on microhardness of human dentine. J of Oral Rehabilitation. 2004 Aug;31(8):811–6.
10. Lee GP, Lee MY, Lum SOY, Poh RSC, Lim K -C. Extraradicular diffusion of hydrogen peroxide and pH changes associated with intracoronal bleaching of discoloured teeth using different bleaching agents. Int Endodontic J. 2004 July;37(7):500–6.
11. Abouassi T, Wolkewitz M, Hahn P. Effect of carbamide peroxide and hydrogen peroxide on enamel surface: an in vitro study. Clin Oral Invest. 2011 Oct;15(5):673–80.
12. Rotstein I, Zyskind D, Lewinstein I, Bamberger N. Effect of different protective base materials on hydrogen peroxide leakage during intracoronal bleaching in vitro. Journal of Endodontics. 1992 Mar;18(3):114–7.
13. Yasa E, Arslan H, Yasa B, Akcay M, Alsancak M, Hatirli H. The force required to fracture endodontically roots restored with various materials as intra-orifice barriers. Niger J Clin Pract. 2017;20(10):1237.
14. Chauhan P, Garg A, Mittal R, Kumar H. A comparative evaluation of fracture resistance of endodontically treated teeth using four different intraorifice barriers: An in vitro study. J Conserv Dent. 2019;22(5):420.
15. mahalaxmi v, Priyank H, Kumar C. Evaluation of the Effect of Flowable Composite, Vitremer and Biodentine as intraorifice Barriers on the Fracture Resistance and Coronal Microleakage of Roots Obturated with Gutta Percha – an in Vitro Study. International Journal of Contemporary Medical Research. 2017 Sept;4(9).
16. Bansal P, Gupta A, Arora V, Jha P, Nikhil V. Anin vitrocomparative evaluation of different intraorifice barriers on the fracture resistance of endodontically treated roots obturated with gutta-percha. J Conserv Dent. 2016;19(2):111.
17. Deshpande S, Gaddalay S, Damade Y, Khanvilkar U, Chaudhari A, Anala V. Reinforcing the cervical dentin with bonded materials to improve fracture resistance of endodontically treated roots. J Conserv Dent. 2022;25(2):179.

18. Nagas E, Uyanik O, Altundasar E, Durmaz V, Cehreli ZC, Vallittu PK, et al. Effect of different intraorifice barriers on the fracture resistance of roots obturated with Resilon or gutta-percha. J Endod. 2010 June;36(6):1061–3.
19. Oskoee SS, Bahari M, Daneshpooy M, Ajami AA, Rahbar M. Effect of Different Intraorifice Barriers and Bleaching Agents on the Fracture Resistance of Endodontically Treated Anterior Teeth. Journal of Endodontics. 2018 Nov;44(11):1731–5.
20. Mehta S, Ramugade M, Abrar S, Sapkale K, Giuliani V, Burbano Balseca M. Evaluation of coronal microleakage of intra-orifice barrier materials in endodontically treated teeth: A systematic review. J Conserv Dent. 2022;25(6):588.
21. Moorthy A, Hogg CH, Dowling AH, Grufferty BF, Benetti AR, Fleming GJP. Cuspal deflection and microleakage in premolar teeth restored with bulk-fill flowable resin-based composite base materials. Journal of Dentistry. 2012 June;40(6):500–5.
22. Gupta A, Arora V, Jha P, Nikhil V, Bansal P. An in vitro comparative evaluation of different intraorifice barriers on the fracture resistance of endodontically treated roots obturated with gutta-percha. J Conserv Dent. 2016;19(2):111–5.
23. Renuka N, Aparna P, Sai SK. Effect of intra - orifice barriers on the fracture resistance of endodontically treated teeth – An Ex-Vivo study. pravara med rev. 2018;10(1).
24. Bahuguna N. Cervical root resorption and non vital bleaching. Endodontology. 2013;25(2):106.
25. Fadag A. Fracture resistance of endodontically treated anterior teeth restored with different post systems: An in vitro study. Eur Endod J [Internet]. 2018 [cited 2025 July 22];
26. Hu YH, Pang LC, Hsu CC, Lau YH. Fracture resistance of endodontically treated anterior teeth restored with four post-and-core systems. Quintessence Int. 2003 May;34(5):349–53.
27. Roberto AR, Sousa-Neto MDD, Viapiana R, Giovani AR, Souza Filho CBD, Paulino SM, et al. Effect of different restorative procedures on the fracture resistance of teeth submitted to internal bleaching. Braz oral res. 2012 Feb;26(1):77–82.
28. Sharma A, Shetty P, Ali A, Bhardwaj M, Dubey D, Chhabra S. Comparative evaluation of the compressive, tensile, and flexural strengths of paracore®, flourocore®2+, and multicore® resin-based core build-up materials – An in vitro study. J Conserv Dent. 2021;24(6):576.
29. García-Varela S, Ramos JC, Ginzo-Villamayor MJ, Castelo-Baz P, Méndez-Díaz R, Anache-D'Abate MA, et al. Effect of Dentin Irrigants on Push-Out Bond Strength in Resin Cementation Protocols for Fiber Posts in Endodontically Treated Teeth: An In Vitro Study. Materials. 2024 Mar 21;17(6):1432.
30. Dey R, Sil R, Desai P, Ghorai L. Comparison of Fracture Resistance of Endodontically Treated Human Mandibular Molars Restored with Paracore Dual-cure Composite and EverX Posterior Composite: An In-vitro Study. JCDR. 2024 [cited 2025 July 30]