ORIGINAL RESEARCH

Comparative Evaluation of Microleakage in Class V Cavities Restored with Newer Bioactive Restorative Materials: Activa Bioactive Restorative and Activa Pronto

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Abstract

Aim: To compare the microleakage in class V cavities restored with Activa Bioactive Restorative, Activa Pronto, and nanohybrid composite.

Materials and methods: Standardized class V cavity preparations (mesiodistal: 3 mm; occlusocervical: 2 mm; axial depth: 1 mm) were made on the buccal surface of 60 extracted intact maxillary premolar teeth. The preparations were divided into three experimental groups ($n = 20$) depending on the restorative material used. Group I: Nanohybrid composite resin, group II: Activa Bioactive Restorative, and group III: Activa Pronto. Samples were polished and thermocycled at 5–55 °C with a dwell time of 60 seconds for 1,000 cycles.

The apices were sealed with sticky wax and two coats of nail varnish applied 1 mm away from the restorative margins. Teeth samples were placed in 2% of methylene blue for 24 hours washed and processed for dye extraction method. Teeth samples were placed in a test tube containing 1 mL of concentrated nitric acid (65%wt) for 3 days. Test tubes were centrifuged at 14,000 rpm for 5 minutes, and 100 μL of the supernatant from each was transferred to a plate. The dye absorption was measured by an automated UV spectrophotometer at 550 nm using concentrated nitric acid as the blank.

Statistical analysis: One-way ANOVA test followed by Tukey's *post hoc* analysis was performed to compare the mean microleakage scores between the three groups.

Results: There was a statistically significant difference ($p < 0.001$) in mean microleakage scores between Activa Pronto (0.024 ± 0.002), Activa Bioactive Restoratives (0.045 ± 0.003), and nanohybrid composite resin materials (0.069 ± 0.003). The Activa Pronto group (0.024 ± 0.002) showed least microleakage values as compared to nanohybrid composite resin and Activa Bioactive Restorative group.

Conclusion: Activa Pronto and Activa Bioactive Restorative materials may be considered as replacement to the routinely used nanohybrid composites especially in class V cavities due to their bioactive properties and better esthetics.

Clinical significance: Based on the results of our study and that found in the literature, it is evident that newer bioactive restorative materials, Activa Pronto and Activa Bioactive Restoratives showed significantly less microleakage in class Vcavities when compared to conventionally used nanohybrid composite resins.

Keywords: Bioactive-restorative, Biomimetics, Composite resin restorations, Dye extraction test, Esthetic restorative materials, Marginal microleakage.

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Introduction

The overall occurrence of dental caries has significantly decreased due to advancements in preventive measures and enhanced dental care.[1] However, as the geriatric population continues to grow, there has been increase in the development root caries and noncarious cervical lesions.[2] Addressing these conditions presents both technical challenges and complexities in restoration.[3]

Selecting an appropriate restorative material for these lesions is challenging because of their multifactorial nature, difficulties in moisture control, and the complexities associated with bonding to root dentin.[4–7] Optimal materials should be less sensitive to technique variations, possess a lower modulus of elasticity to accommodate tooth flexion, and exhibit minimal plaque accumulation.[8–10]

Glass ionomer cements present numerous benefits, including ease of application, adhesion to enamel and dentin, biocompatibility, minimal shrinkage, a modulus of elasticity comparable to dentin, and fluoride ion release. However, they come with certain limitations, such as being vulnerable to drying out and moisture during the initial setting phase, being prone to early washout, and requiring a delay in finishing and polishing until the cement has fully hardened.[11]

Subsequent advancements in microhybrid and nanohybrid composites have enhanced esthetics, wear resistance, and immediate finishing capability, while also offering strong adhesion to the tooth. Despite their advantages, these composite resins are

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highly technique-sensitive, making proper isolation essential to achieve strong bonding and reduce the risk of microleakage.[12]

Restoring teeth with cervical lesions, it is advantageous to use a restorative material that possesses bioactive properties, a modulus of elasticity comparable to natural tooth structure, and strong adhesion to root dentin. Moreover, the material should demonstrate minimal susceptibility to contamination by saliva and blood.[13]

Recent bioactive restorative materials are hybrids that combine the durability and esthetics of composite resins with the bioactive properties of glass ionomers. Activa Bioactive Restorative exemplifies this type of material, releasing calcium, phosphate, and fluoride ions. Its composition is akin to resin-modified glass ionomer cement (RMGIC), incorporating a blend of diurethane monomers. This bioactive material is formulated to release fluoride and respond to pH shifts in the oral environment by absorbing various types of ions, thereby maintaining the chemical stability of the tooth structure.[14]

Activa Pronto is an advanced version of Activa Bioactive Restorative material, offering enhanced properties. Its calcium and phosphate components, along with its shock-absorbing capability, closely mimic the natural properties of teeth. The moisture-friendly resin facilitates the release and recharge of these essential tooth-building ions, creating nucleation sites and an environment conducive to apatite formation and a strong marginal seal. Additionally, Activa Pronto is highly polishable and maintains its finish for an extended period.[15]

A review of the available literature revealed a lack of published data on the microleakage of Activa Pronto, a crucial factor for materials used in restoring cervical lesions. As a result, this study was done to compare the microleakage of two newer bioactive restorative materials, Activa Pronto and Activa Bioactive Restorative, with that of a nanohybrid composite resin in restoring cavities.

Materials and Methods

Sixty healthy, noncarious maxillary premolars, extracted for orthodontic and periodontal purposes, were gathered and cleaned of calculus and debris using a hand scaler (Hu-Friedy, Chicago, Illinois, United States). The samples were disinfected using 0.5% chloramine and stored for under a month prior to the restorative procedure. Cavities of class V were uniformly prepared (Fig. 1) using a round diamond bur and an air-rotor handpiece with water coolant, with the diamond bur switched out after completing every four cavity preparations. Cavities of defined dimensions were prepared on the buccal surface and positioned 1 mm coronal to the cementoenamel junction (CEJ). The cavities were prepared with a mesiodistal width, occlusocervical length, and an axial depth of 3, 2, and 1.5 mm, respectively. These measurements were standardized according to the study design proposed by Yavuz et al.[16] The cavity preparation dimensions were measured using a graduated periodontal probe (Hu-Friedy, Chicago, Illinois, United States). The samples were randomly allocated into three experimental groups, each containing 20 teeth, depending on the restorative material used.

- Group I: Nanohybrid composite resin (Filtek Z250).
- Group II: Activa Bioactive Restoratives.
- Group III: Activa Pronto.

Restorative Protocol

The preparations were etched with 37% phosphoric acid for 15 seconds, followed by a water rinse for 15 seconds. Excess water was blot-dried, leaving the surface moist. A microapplicator brush was used to apply the 3M Single Bond Universal bonding agent for 20 seconds. It was then thinned with gentle air pressure and cured with a light emitting diode (LED) curing light for 10 seconds. The preparations in the Filtek Z250 and Activa Pronto groups were restored in oblique increments, while those in the Bioactive Restorative group were bulk filled. Each group was light-cured for 20 seconds using an LED curing light (Woodpecker® Dental), which had an output irradiance of approximately 850–1000 mW/cm^2.

The samples were polished with Sof-Lex abrasive disks (3M ESPE) after the restorations were completed. They were then stored in artificial saliva at 37 ± 2°C and 100% humidity for 24 hours. Prior to dye extraction testing, the samples underwent 10,000 thermocycling cycles, alternating between 5 and 55°C water baths, with each temperature maintained for 60 seconds. Microleakage was then evaluated using the dye extraction method.

Methodology Fordye Extraction

Sticky wax was used to seal the apical foramina of the samples. After that, two coats of nail varnish were applied, margin of 1 mm was left around the restorative edges and then allowed to dry. The samples were immersed in a 2% methylene blue solution for 24 hours, then rinsed under tap water for 30 minutes (Fig. 2). After rinsing, the nail varnish was removed using polishing disks (Fig. 3).

The samples were placed in vials containing 65%wt nitric acid for 3 days to dissolve the methylene blue at the restoration-dentin

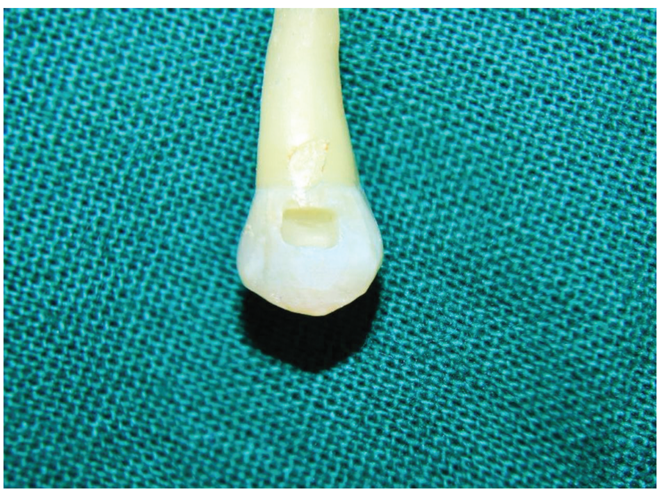

Fig. 1: Class V cavity preparation

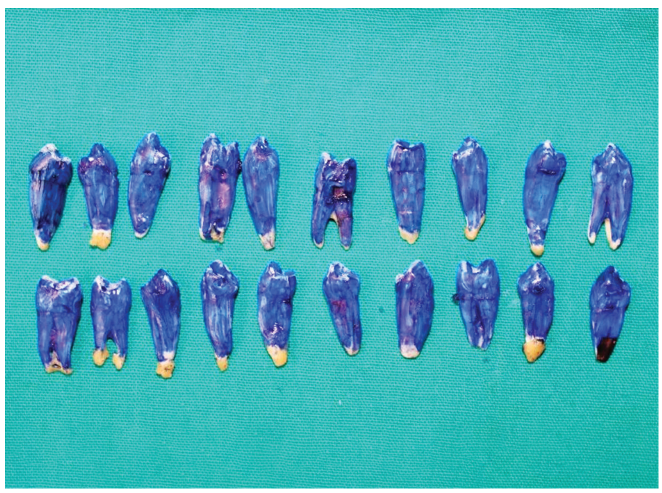

Fig. 2: Samples after 24 hours storage in methylene blue dye

interface for ultraviolet (UV) spectrophotometer analysis (Fig. 4). Each vial, containing 1000 µL of acid, was centrifuged at 14,000 rpm for 5 minutes. After centrifugation, 100 µL of the supernatant from each vial was transferred to a plate (Fig. 5). Dye absorption was measured at 550 nm using an automated spectrophotometer, with concentrated nitric acid as the blank. The spectrophotometer readings, indicating the light absorption of methylene blue at the resin-dentin interface, were used to measure microleakage in the restorations.

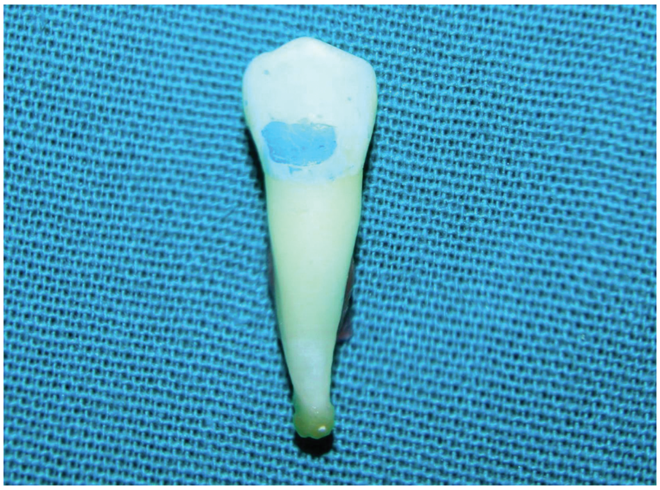

Fig. 3: Methylene blue stained sample after nail varnish removal

Fig. 4: Tooth samples dissolved in nitric acid for 3 days

Fig. 5: Tooth solution after centrifugation

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) for Windows, Version 22.0 (released 2013, Armonk, New York: IBM Corp.), was used for statistical analyses. A one-way ANOVA followed by Tukey's *post hoc* test was conducted to compare the mean microleakage scores across the three groups, with the significance level set at $p < 0.05$.

Results

The mean microleakage scores for nanohybrid composite group was 0.0699 ± 0.0456, for Activa Bioactive group was 0.0456 ± 0.0039, and Activa Pronto group was 0.0248 ± 0.0026. This difference in the mean microleakage scores between three groups was statistically significant at $p < 0.001$ (Fig. 6).

Multiple comparisons between three groups revealed that the Activa Pronto group showed significantly lesser mean microleakage scores as compared to Activa Bioactive Restorative group and Nano Hybrid Composite group at $p < 0.001$. This was then followed next by Activa Bioactive Restorative group showing significantly lesser mean microleakage scores as compared to Nano Hybrid composite group at $p < 0.001$. The mean microleakage scores were least in Activa Pronto group followed by Activa Bioactive Restorative group and highest in Nano Hybrid Composite group (Fig. 7).

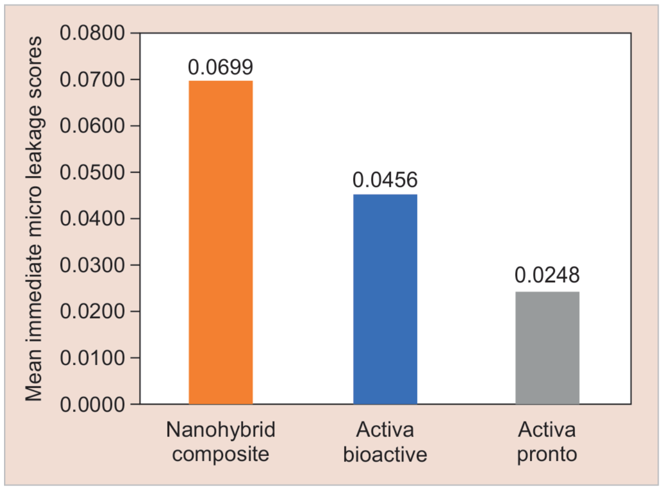

Fig. 6: Mean microleakage scores between three groups

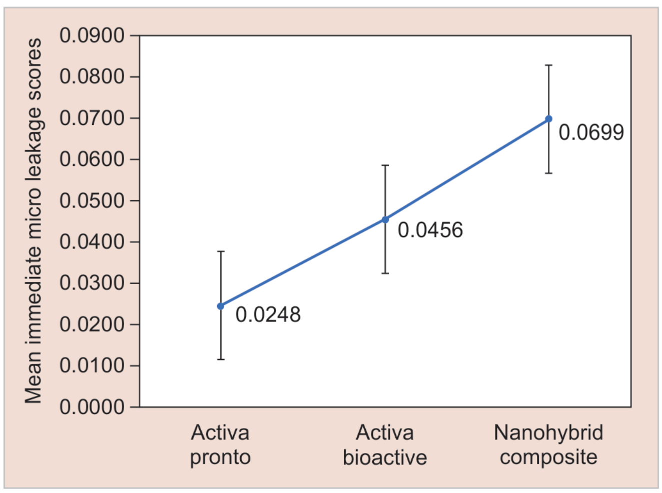

Fig. 7: Mean microleakage scores between three groups (arranged in ascending order)

Discussion

Restorative dentists face a significant challenge with cervical lesions resulting from caries, erosion, or abrasion, as the selected material must effectively bond to different types of tooth tissues. Class V restorations are among the least retentive in the oral cavity. Securing a perfect seal at the cervical margins of restorations is difficult due to challenges with isolation, insertion, contouring, finishing, and polishing, which can often result in secondary caries. Consequently, there is an ongoing effort to find a restorative material that provides superior adhesion and fluoride release for such lesions. This study aims to evaluate the effectiveness of newer bioactive restorative materials in sealing class V lesions.[17]

A range of materials have been utilized for restoring cavities, with resin composite and glass ionomer being the most commonly used. Each of these materials has its own set of benefits and drawbacks.

The results of our study showed that Activa Pronto showed significantly less microleakage (0.024 ± 0.002) followed by Activa Bioactive Restoratives (0.045 ± 0.0035) and lastly the nanohybrid composite showed the maximum microleakage values (0.069 ± 0.003). This difference in the mean immediate microleakage scores between three groups was statistically significant $p < 0.001$ (Tables 1 and 2).

Comparing group I (nanohybrid composite) to group III (Activa Pronto), Activa Pronto releases and replenishes essential ions like calcium, phosphate, and fluoride which aid in remineralizing and protecting dentinal tissues from demineralization. Additionally, bioactive restoratives utilize a rubberized polyurethane–methacrylate resin to improve fracture toughness and emulate the resilience of dentin. This material promotes the surface deposition of calcium phosphate and demonstrates excellent tissue biocompatibility.[18]

When comparing group II (Bioactive Restorative) with group III (Activa Pronto), it is observed that the interaction between bioactive materials and living tissue facilitates the formation of hydroxyapatite at the tooth-restoration interface, thereby helping to reduce microleakage.[19] Activa Pronto contains a newly patented bioactive molecule called Crysta MCP (methacrylate-functionalized calcium phosphate). This stabilized calcium phosphate is in a transitional state, allowing it to provide the necessary calcium, phosphate, and fluoride to damaged teeth, making these materials "smart dental materials."

One possible reason why bioactive restorative materials like Activa Bioactive Restoratives (group II) and the reduced microleakage observed with Activa Pronto (group III), this can be attributed to its ionic resin component. These groups improve the interaction between the resin and the reactive glass filler particles, thereby improving adhesion to the tooth structure. Through a water-dependent ionization process, hydrogen ions are released from the phosphate groups and are replaced by calcium ions from the tooth structure. This ionic exchange creates a robust resin-hydroxyapatite complex, which helps form an effective seal against microleakage. In contrast, nanohybrid composite resin (group I) relies solely on micromechanical retention for adhesion to the tooth structure.[20] Our findings align with the studies of Ghazal et al., in which properties Activa Bioactive Restorative and Tetric N-Ceram were evaluated.[21]

Dentin bonding agents are crucial for sealing and retaining resin composite restorations. Universal bonding agents or self-etch adhesives, which contain methacryloyloxydecyl dihydrogen phosphate (MDP) monomers and have a pH of 2–2.5, are relatively mild acids that adequately etch dentin but have a limited effect on enamel. Bonding to enamel is essential for achieving a strong marginal seal and defending against microleakage. Therefore, in this study, we employed selective etching of enamel to enhance the effectiveness of the restoration.[22]

The technique used for placing restorations significantly affects polymerization shrinkage in composite resins. Research suggests that incremental placement of composite, rather than bulk filling, helps reduce shrinkage stresses. Moezyzadeh et al. demonstrated that the gingiva-occlusal oblique incremental layering technique resulted in less microleakage compared to the bulk fill technique for class V restorations. Consequently, our study utilized the oblique incremental layering technique for class V restorations.[23]

In this study, Activa Pronto demonstrated significantly less microleakage compared to other groups. Although there is no published data on this material, its performance might be attributed to its hydrophilic resin, which facilitates the diffusion of essential tooth-building ions. This allows Activa Pronto to penetrate and integrate with the tooth structure, providing a margin-free adaptation and improved seal.

Newer bioactive restorative materials, such as Activa Pronto and Activa Bioactive Restoratives, offer significant benefits, especially for class V cavities. They could potentially replace the commonly used nanohybrid composites in these cases, as they combine the

Table 1: Comparison of mean microleakage scores between three groups using one-way ANOVA test

Groups	*N*	*Mean*	*SD*	*Min*	*Max*	*p-value*
Nanohybrid Composite	20	0.0699	0.0035	0.064	0.075	<0.001*
Activa Bioactive	20	0.0456	0.0039	0.038	0.052	
Activa Pronto	20	0.0248	0.0026	0.020	0.030	

*Statistically significant

Table 2: Multiple comparison of mean difference in microleakage scores between three groups using Tukey's *post hoc* test

			95% CI for the difference		
Groups	*Groups*	*Mean difference*	*Lower*	*Upper*	*p-value*
Nanohybrid Composite	Activa Bioactive	0.0243	0.0217	0.0268	<0.001*
	Activa Pronto	0.0451	0.0425	0.0477	<0.001*
Activa Bioactive	Activa Pronto	0.0209	0.0183	0.0234	<0.001*

*Statistically significant

fluoride-releasing properties of glass ionomers with the esthetics of composite resins.[15]

Before these materials can be routinely used in clinical practice, additional studies are necessary to evaluate their antibacterial effectiveness, water sorption and solubility, fluoride release and recharge capabilities, and stability of the material.

Conclusion

Newer bioactive restorative materials enhance mechanical and biological properties, offer more stable bonding, and release essential ions such as calcium, phosphate, and fluoride. These benefits promote tooth remineralization and help in preventing the development of secondary caries.

Clinical Significance

Based on our study results and existing literature, it is evident that newer bioactive restorative materials, such as Activa Pronto and Activa Bioactive Restoratives, exhibited less microleakage in cavities compared to conventional nanohybrid composite resins. These bioactive materials offer improved mechanical and biological properties, more stable bonding, and release essential tooth-building ions like calcium, phosphate, and fluoride. These features support tooth remineralization and help prevent the formation of secondary caries. Given these benefits, these materials may be useful for restoring cavities in patients with a higher risk of caries. Nonetheless, additional studies are required to assess the bonding strength, color stability, bioactivity, solubility, and durability of these innovative bioactive restorative materials to ensure their long-term effectiveness in restorations.

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References

1. Wu B, Hybels C, Liang J, et al. Social stratification and tooth loss among middle-aged and older Americans from 1988 to 2004. Community Dent Oral Epidemiol 2014;42(6):495–502.
2. Kumara-Raja B, Radha G. Prevalence of root caries among elders living in residential homes of Bengaluru city, India. J Clin Exp Dent 2016;8(3):e260.
3. El-Marakby AM, Al-Sabri FA, Alharbi SA, et al. Noncarious cervical lesions as abfraction: etiology, diagnosis, and treatment modalities of lesions: a review article. Dentistry 2017;7(438):1–6.
4. Lussi A, Hellwig E, Ganss C, et al. Dental erosion. Oper Dent 2009;34(3):251–262.
5. Peumans M, De Munck J, Van Landuyt KL, et al. Restoring cervical lesions with flexible composites. Dent Mater 2007;23(6):749–754.
6. Grippo JO, Simring M, Schreiner S. Attrition, abrasion, corrosion and abfraction revisited: a new perspective on tooth surface lesions. J Am Dent Assoc 2004;135(8):1109–1118.
7. Osborne-Smith KL, Burke FJT, Wilson NHF. The aetiology of the non-carious cervical lesion. Int Dent J 1999;49(3):139–143.
8. Ichim I, Li Q, Loughran J, et al. Restoration of non-carious cervical lesions: part I. Modelling of restorative fracture. Dent Mater 2007;23(12):1553–1561.
9. Ichim I, Schmidlin PR, Kieser JA, et al. Mechanical evaluation of cervical glass-ionomer restorations: 3D finite element study. J Dent 2007;35(1):28–35.
10. Osborne-Smith KL, Burke FJT, Mc Farlane T, et al. Effect of restored and unrestored non-carious cervical lesions on the fracture resistance of previously restored maxillary premolar teeth. J Dent 1998;26(5–6):427–433.
11. El-Bahrawy E, Attia R. Fluoride releasing potential and recharging capacity of different bioactive restorative materials (a comparative *in-vitro* study). Egypt Dent J 2020;66(2):1295–1309.
12. Kidd EAM. Microleakage: a review. J Dent 1976;4(5):199–206.
13. Fabianelli A, Pollington S, Davidson CL, et al. The relevance of microleakage studies. Int Dent SA 2007;9(3):64–74.
14. Ghazal D, Koheil S, Mehesen M. Microleakage of a recent type of bioactive restorative materials (Activa) (*in vitro* study). Alexandria Dent J 2020;46:92–98.
15. Advantages C. in a Dental Composite Nature's Magic. pp. 3–4.
16. Yavuz I, Aydin AH, Ulku R, et al. New technique: Measurement of microleakage volume in the marginal gaps of the dental restorations. Biotechnology & Biotechnological Equipment 2005;19(3):184–191.
17. Benazzi S, Nguyen HN, Schulz D, et al. The evolutionary paradox of tooth wear: simply destruction or inevitable adaptation? PLoS One 2013;8(4):e62263.
18. Skaria S, Berk KJ. Experimental dental composites containing a novel methacrylate-functionalized calcium phosphate component: evaluation of bioactivity and physical properties. Polymers (Basel) 2021;13(13):2095.
19. Jain K, Katge F, Poojari M, et al. Comparative evaluation of microleakage of bioactive, ormocer, and conventional GIC restorative materials in primary molars: an *in vitro* study microleakage of three restorative materials. Int J Dent 2022;2022:7932930.
20. Kaushik M, Yadav M. Marginal microleakage properties of Activa bioactive restorative and nanohybrid composite resin using two different adhesives in non carious cervical lesions - an *in vitro* study. J West Afr Coll Surg 2017;7(2):1–14.
21. Ghazal DM, Koheil S, Mehesen M. Microleakage of a recent type of bioactive. Alex Dent J 2020;46(2):92–98.
22. Perdigão J, Araujo E, Ramos RQ, et al. Adhesive dentistry: current concepts and clinical considerations. J Esthet Restor Dent 2021;33(1):51–68.
23. Moezizadeh M, Kazemipour M. Effect of different placement techniques on microleakage of class V composite restorations. J Dent 2009;2(1):205–211.