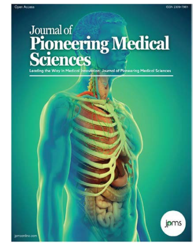
Journal of Pioneering Medical Sciences
Received: July 02, 2025 | Accepted: August 24, 2025 | Published: September 05, 2025
Volume 14, Issue S02, Pages 80-84

*DOI https://doi.org/10.47310/jpms202514S0213*



# Microhardness and Microleakage Assessment of a Newly Formulated Hydrophilic Nano-Sealant and a Flowable Nano-Composite: An *In Vitro* Study

**Jennifer Buela Peter[1], Jayashri Prabakar[2*], Ganesh J.[3], Rajesh Kumar Shanmugam[4] and Meignana Arumugham[5]**
[1,2,5]Department of Public Health Dentistry, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai -77, Tamil Nadu, India
[3,4]Department of Pedodontics & Preventive Dentistry, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai -77, Tamil Nadu, India

Author Designation: [1]Postgraduate, [2,3,4]Reader, [5]Professor

*Corresponding author: Jayashri Prabakar (e-mail: shrijaya2009@gmail.com).



**Abstract** **Objectives:** This study evaluated and compared the microhardness and microleakage performance of a newly formulated hydrophilic nano-sealant, a commercially available hydrophilic sealant (UltraSeal XT Hydro) and a formulated flowable nano-composite under thermocycling conditions. **Methods:** Sixty extracted human mandibular third molars were randomly allocated into three groups (n = 20 each). Group I: newly formulated hydrophilic nano-sealant; Group II: UltraSeal XT Hydro sealant; Group III: formulated flowable nano-composite. Occlusal surfaces were etched with 37% phosphoric acid for 20 s, rinsed, dried according to material specifications and the assigned material applied and light-cured for 20 s. All specimens underwent 1500 thermocycles between 5°C and 55°C. Microleakage was evaluated using 0.5% basic fuchsin dye penetration and confocal laser scanning microscopy, scored using Overbo and Raadal's criteria. Microhardness was measured on the cured surface using the Vickers hardness test with a 200 g load for 20 s. Data were analyzed using the Kruskal–Wallis and Chi-square tests; median (IQR) values are reported for non-parametric data. **Results**: Group I (new hydrophilic nano-sealant) showed the lowest median micro-leakage score (0.5 [0–1.0]), significantly lower than Group III (flowable composite) (p = 0.032). Micro-hardness was highest in Group II (median 15.1 [14.5–15.6] VHN) and lowest in Group III (10.1 [9.6–10.8] VHN); differences did not reach statistical significance (p = 0.061). **Conclusion**: The newly formulated hydrophilic nano-sealant demonstrated superior microleakage resistance compared to the formulated flowable nano-composite, while microhardness differences among materials were not statistically significant. Further *in vivo* studies with defined material compositions and larger samples are required before clinical recommendations can be made.

**Key Words** Dental restoratives, Nanotechnology, Surface Properties, Microleakage Prevention

## INTRODUCTION

Dental caries is one of the most prevalent chronic conditions worldwide, affecting all ages and influenced by lifestyle, socioeconomic and environmental factors [1,2]. While many developed countries report declining caries rates, developing nations face increasing prevalence due to high sugar consumption and inadequate fluoride exposure [3]. Occlusal pits and fissures although comprising only 12% of the tooth surface-are highly susceptible, accounting for up to 85% of carious lesions because of their complex morphology and plaque-retentive nature [4,5].

Pit-and-fissure sealants are a proven preventive measure, reducing caries risk by up to ninefold when effectively retained [6,7]. Their success depends on adequate penetration into fissures, adaptation to enamel walls and resistance to microleakage [8,9]. Moisture contamination during placement is a major cause of early sealant failure, making hydrophilic resin-based materials particularly valuable in settings where isolation is challenging [10].

A well-penetrated fissure sealant, in addition to providing sealant retention, is desirable in order to decrease caries development in the deep crevice. Additionally, a thoroughly infiltrated sealant protects against shear stresses caused by masticatory movements [11]. Advances in nanotechnology have led to the development of nano-filled sealants and flowable composites with potential improvements in mechanical performance and sealing ability [12-15]. This *in vitro* study aimed to compare the microhardness and microleakage of a newly formulated hydrophilic nano-sealant, a commercial hydrophilic sealant and a formulated flowable nanocomposite to determine their suitability for preventing pit-and-fissure caries.

## METHODS

This *in vitro* study was conducted in the Department of Public Health Dentistry, Saveetha Dental College and Hospital, India.

### Sample Collection

Sixty extracted human mandibular third molars free from caries, cracks, restorations or developmental defects were included. Teeth with deep pits and fissures requiring sealant application were selected, cleaned with a prophylactic brush and stored in 2% thymol until use.

### Grouping and Materials

Teeth were randomly assigned to three groups (n = 20 each):

- Group I: Newly formulated hydrophilic nano-sealant (experimental formulation)
- Group II: UltraSeal XT Hydro sealant (Ultradent Products Inc., USA)
- Group III: Formulated flowable nano-composite (experimental formulation)

### Application of Sealant

Occlusal surfaces were etched with 37% phosphoric acid gel for 20 sec, rinsed with water and dried according to manufacturer or formulation protocol. Materials were applied to fissures and light-cured for 20 sec with an LED curing unit (1000 mW/cm² output) (Figure 1).


Figure 1: Tooth prepared for 3 different groups for microhardness, the etched samples on prepared surfaces and the 3 sealants of Group I- Newly formulated hydrophilic Nano-sealant, Group II- Ultra seal XT Hydro sealant and Group III- Formulated flowable nano-composite on the surfaces of the tooth.

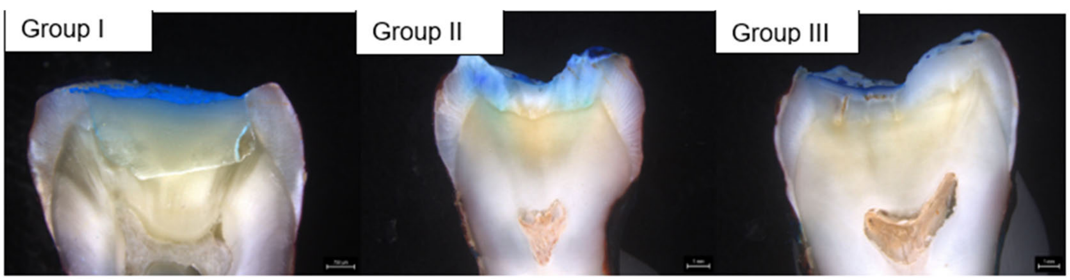



Figure 2: Microleakage images of Group I, II, III


Figure 3: Micro Vickers Hardness Tester

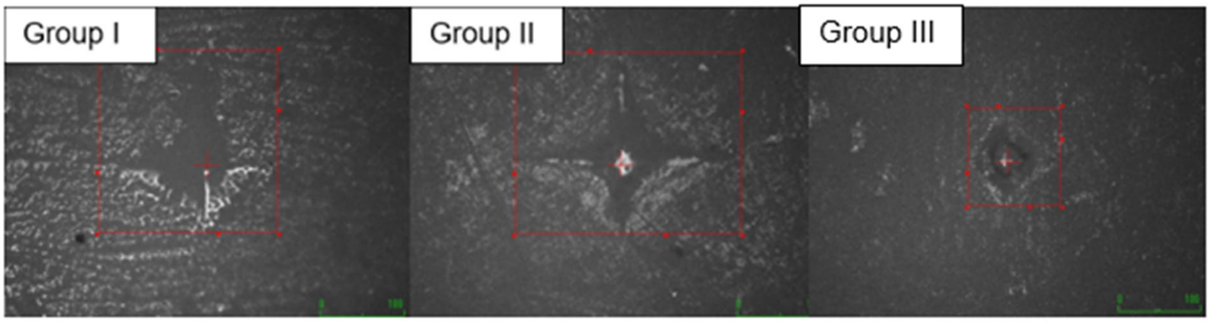



Figure 4: Microhardness images of Group I, II, III

### Thermocycling

All specimens underwent 1500 thermocycles between 5°C and 55°C, with a dwell time of 15 sec.

### Microleakage Evaluation

Specimens were coated with nail varnish except for a 1 mm window around the restoration margin, immersed in 0.5% basic fuchsin for 24 h, rinsed, sectioned buccolingually and examined under a confocal laser scanning microscope. Dye penetration was scored using Overbo and Raadal's criteria (Figure 2).

### Microhardness Evaluation

A low-speed diamond cutting blade was used to split the tooth into two pieces following mesiodistal sectioning. The cured occlusal surface was polished flat and tested with a Vickers hardness tester (Figure 3) Using a 200 g load for 20s. Three indentations per specimen were averaged. (Figure 4).

### Statistical Analysis

Data were analyzed using SPSS v23. Non-parametric data were summarized as median (IQR). Group comparisons used the Kruskal–Walli's test (microhardness) and Chi-square test (microleakage). Significance was set at $p<0.05$.

## RESULTS

### Microleakage Assessment

Each group's average microleakage scores are displayed in Table 1, Group I (median 0.5 (0–1.0)) had significantly lower microleakage than Group III (median 1.5 [1.0–2.0]) ($p = 0.032$). Group II showed intermediate scores (1.0 [0.5–1.5]) with no significant difference from either Group I or III.

### Microhardness assessment

The Kruskal Wallis Test revealed that Group II had a greater instantaneous mean microhardness value 15.1 (14.5–15.6) than Group I: 13.9 (13.3–14.4), Group III: 10.1 (9.6–10.8). Differences did not reach statistical significance ($p = 0.061$) (Table 2).

## DISCUSSION

### Caracterisation

Primary preventative care is crucial in developing nations such as India, where children and adolescents account for over 40% of the population. Primary prevention removes the possibility of disease occurrence, making it the preferred method. It alleviates pain, suffering and incapacity, while also being widely accepted. For decades, pit and fissure sealants have been the most popular preventive tools. Preventive methods such as sealants may cost more than restoration materials like dental amalgam [16-18].

Table 1: Chi-square test, *significant microleakage of Group I- Newly formulated hydrophilic Nano-sealant, Group II- Ultra seal XT Hydro sealant, Group III- Formulated flowable nano-composite, Overbo and Raadal score criteria

| Sample (n = 10) | Microleakage Score (Frequency) | | |
|---|---|---|---|
| Groups | Score 0 (n) | Score 1 (n) | Score 2 (n) |
| Group I- Newly formulated hydrophilic Nano-sealant | 4 | 4 | 2 |
| Group II- Ultra seal XT Hydro sealant | 3 | 4 | 3 |
| Group III- Formulated flowable nano-composite | 2 | 3 | 5 |
| CHI-SQUARE TEST (p-value) | 0.05** | | |

Table 2: Kruskal Wallis test, *not significant microhardness of Group I- Newly formulated hydrophilic Nano-sealant, Group II- Ultra seal XT Hydro sealant, Group III- Formulated flowable nano-composite, SD - Standard deviation

| Sample (n = 10) | Micro hardness Mean±SD | Kruskal wallis test | Significance |
|---|---|---|---|
| Group I- newly formulated hydrophilic nano-sealant | 14.5±0.92 | 24.01 | 0.061 |
| Group II- ultra seal XT hydro sealant | 15.1±0.95 | | |
| Group III- formulated flowable nano-composite | 10.1±1.12 | | |

### Microhardness and Microleakage

The newly formulated hydrophilic nano-sealant demonstrated significantly lower microleakage than the formulated flowable nano-composite, aligning with reports that hydrophilic resin sealants may perform better in fissure adaptation under moist conditions.

Microhardness differences among materials were not statistically significant, despite the commercial hydrophilic sealant showing the highest median value. Hardness is an indirect indicator of the degree of polymerization; lower values, as seen in the flowable composite, may suggest reduced wear resistance.

Sulimany *et al.* claims that they conducted a comparison between sealants that release fluoride and those that do not. After age, the VHN of the Embrace TM group increased significantly from 24.33±5.60 to 31.70±3.59 ($p = 0.001$), suggesting that the effect of aging differs depending on the kind of material, as per the interaction model between time factor and material type [19]. As per the findings of Gunasekaran *et al.* [20], a substantial difference ($p<0.001$) between the mean microhardness values of Group Aegis (4.40±0.46) and Group Ultraseal XT/Hydro (9.88±1.46).

Microleakage scores for Group I (Formulated Phosphorylated BisGMA sealant) were determined to be 30% for scores 0 and 1 and 20% for scores 2. Compared to groups II (Ultra seal XT Hydro sealant) and III (Formulated flowable nano-composite), which had mean scores of 0.86±0.25 and 0.63±0.45, respectively, group I (Formulated Phosphorylated BisGMA sealant) had a mean microleakage score of 1.3±1.16 higher. The thixotropic feature, sophisticated adhesive technology and hydrophilic nature of the sealant may be the cause. Some writers, like Babaji *et al.* [21] found no significant difference in microleakage between the flowable composite and fluoride-releasing pit and fissure sealants such as Tetric flow, Helioseal F and Enamel loc. In order to determine the effect of sealant viscosity and enamel or dentin bonding agent (DBA) on sealant microleakage, Mehrabkhani *et al.* [22] conducted the study and found there were no bonding subgroups and no discernible differences in the microleakage scores between the enamel and dentin bonding agents in either group. The low viscosity sealant showed less microleakage than the high viscosity sealant in both the DBA ($P = 0.002$) and NB ($P = 0.041$) categories. The results demonstrated that pit and fissure sealant microleakage was reduced by using a low viscosity sealant.

## CONCLUSIONS

The experimental hydrophilic nano-sealant exhibited significantly lower microleakage than the experimental flowable nano-composite. Micro-hardness differences among tested materials were not statistically significant. Further research with larger samples, defined material composition and *in vivo* trials is necessary before clinical recommendations.

## Limitations

Limitations inclues Material compositions for experimental formulations were undisclosed, limiting reproducibility. The study was underpowered for microhardness detection ($p = 0.061$ suggests possible type II error). *In vitro* conditions cannot fully replicate intraoral temperature, pH and mechanical stresses. Use of extracted third molars may not generalize to other tooth types.

## Ethical Statement

Prior to its start, the study received ethical approval from the Saveetha Institute of Medical and Technical Sciences Scientific Review Board.

## REFERENCES


[1] Sulimany, A.M. *et al.* "Effect of aging on the microhardness of different resin-based fluoride-releasing fissure sealants: an *in vitro* study." *The Journal of Contemporary Dental Practice*, vol. 22, no. 10, February 2022, pp. 1144–1149.

[2] Kumaraguru, M. *et al.* "Oral health status of school-going children aged 12-15 years in Tiruvallur district, Tamil Nadu-a cross-sectional study." *South Eastern European Journal of Public Health*, October 2024, pp. 677–683. doi:10.70135/seejph.vi.1810.

[3] Rakshitha, V.S. *et al.* "Comparative evaluation of microhardness of hydrophilic sealant and flowable composite on permanent molars: an *in vitro* study." *Journal of Pioneering Medical Sciences*, vol. 13, no. 7, December 2024.

[4] Mehta, S. *et al.* "Evaluation of neo-implant abutment junction sealing gel among Indian patients." *Bioinformation*, vol. 19, no. 4, April 2023, p. 502.

[5] Krishnan, A. *et al.* "Comparison of pull-out bond strength and microleakage of lithium disilicate onlay with and without immediate dentin sealing." *Journal of Applied Biomaterials & Functional Materials*, vol. 23, April 2025.

[6] Nair, V. *et al.* "Assessment of dye penetration and penetration depth of hydrophilic sealant and flowable composite." *Journal of Pioneering Medical Sciences*, vol. 13, no. 7, December 2024.

[7] Gajewski, V.E. *et al.* "Monomers used in resin composites: degree of conversion, mechanical properties and water sorption/solubility." *Brazilian Dental Journal*, vol. 23, 2012, pp. 508–514.

[8] Popli, H.P. *Comparing microleakage of Fisurit F and flowable composite used as pit and fissure sealant: an in vitro study.* Master's thesis, Rajiv Gandhi University of Health Sciences, India.

[9] Güçlü, Z.A. *et al.* "Characterisation and microleakage of a new hydrophilic fissure sealant: UltraSeal XT hydro." *Journal of Applied Oral Science*, vol. 24, no. 4, 2016, pp. 344–351.

[10] Pathmashri, V.P. *et al.* "Microhardness of pit and fissure sealant treated tooth after exposure to two different kinds of beverages: a pilot study." *Drug Invention Today*, vol. 11, no. 8, August 2019.

[11] Hu, Y.T. *et al.* "The antibacterial effect and physical performance of pit and fissure sealants based on an antibacterial core–shell nanocomposite." *Journal of the Mechanical Behavior of Biomedical Materials*, vol. 117, May 2021.

[12] Lai, C.C. *et al.* "Development of antibacterial composite resin containing chitosan/fluoride microparticles as pit and fissure sealant to prevent caries." *Journal of Oral Microbiology*, vol. 14, no. 1, December 2022.

[13] Fernandes, K.S. *et al.* "A comparison between three different pit and fissure sealants with regard to marginal integrity." *Journal of Conservative Dentistry and Endodontics*, vol. 15, no. 2, April 2012, pp. 146–150.

[14] Ibrahim, H.A. *et al.* "Clinical study of different composite resin systems in Class I cavities: an 18-month randomized clinical trial." *Brazilian Dental Science*, vol. 26, no. 3, August 2023.

[15] Sengar, E.V *et al.* "Comparative evaluation of microleakage of flowable composite resin using etch and rinse, self-etch adhesive systems and self-adhesive flowable composite resin in Class V cavities: confocal laser microscopic study." *Materials*, vol. 15, 2022, p. 4963.

[16] Zanza, A. *et al.* "The influence of thermomechanical compaction on the marginal adaptation of four different hydraulic sealers: a comparative ex vivo study." *Journal of Composites Science*, vol. 7, no. 1, January 2023, p. 10.
[17] AlJefri, G.H. *et al.* "Penetration and adaptation of the highly viscous zinc-reinforced glass ionomer cement on contaminated fissures: an *in vitro* study with SEM analysis." *International Journal of Environmental Research and Public Health*, vol. 19, no. 10, May 2022, p. 6291.
[18] Mallineni, S.K. *et al.* "Silver nanoparticles in dental applications: a descriptive review." *Bioengineering*, vol. 10, no. 3, March 2023, p. 327.
[19] Sulimany, A.M. *et al.* "Effect of aging on the microhardness of different resin-based fluoride-releasing fissure sealants: an *in vitro* study." *The Journal of Contemporary Dental Practice*, vol. 22, no. 10, February 2022, pp. 1144–1149.
[20] Gunasekaran, R. *et al.* "Comparative evaluation of wear strength and compressive strength of two pit and fissure sealants with a nanofilled resin coating: an *in vitro* study." *International Journal of Clinical Pediatric Dentistry*, vol. 17, no. 1, January 2024, pp. 31.
[21] Babaji, P. *et al.* "*in vitro* evaluation of shear bond strength and microleakage of different pit and fissure sealants." *Journal of International Society of Preventive and Community Dentistry*, vol. 6, Supplement 2, September 2016, pp. S111–S115.
[22] Mehrabkhani, M. *et al.* "Effects of sealant, viscosity and bonding agents on microleakage of fissure sealants: an *in vitro* study." *European Journal of Dentistry*, vol. 9, no. 4, October 2015, pp. 558–563.