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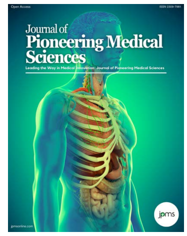

Comparative Evaluation of Microhardness of Hydrophilic Sealant and Flowable Composite on Permanent Molars- in vitro Study

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Abstract **Objectives:** Dental caries, or tooth decay, is one of the most prevalent chronic diseases globally. Despite advancements in oral hygiene practices and widespread fluoride use, these measures have proven less effective against occlusal caries compared to smooth-surface caries. Hydrophilic sealants and flowable composites are commonly employed as sealing materials to address this issue. This *in-vitro* study evaluates the comparative microhardness of hydrophilic sealants and flowable composites, with a focus on their potential clinical applications. **Methods:** Ten extracted molar samples were divided into two groups: Group I (Ultra-seal XT Hydro sealant) and Group II (Ivoclar Tetric n Flow composite). Each group was further subdivided into immediate and ageing subgroups. Mesiodistal sectioning of the teeth was performed and each tooth was sectioned into two halves using a low-speed diamond cutting blade. One-half was subjected to immediate microhardness testing, while the other underwent thermocycling to simulate ageing. A slot was created on the buccal surface, which was then etched, sealed and light-cured. Microhardness was measured using a Vickers hardness tester under a 200 g force for 20 seconds. Thermocycling involved immersion in a water bath at temperatures ranging from 5°C to 55°C for 15 seconds at each degree, followed by a 10-second dwell time, over 1500 cycles. Statistical analysis included the Mann-Whitney U test to compare groups and the Wilcoxon test to assess differences within groups. **Results:** The immediate mean microhardness for Group I (26±3.70) was higher than Group II (21.38±6.15), but the difference was statistically insignificant. Similarly, ageing microhardness values for Group I (27.62±5.61) were higher than Group II (24.12±6.92), with no statistically significant difference. Within-group analysis using the Wilcoxon test revealed no significant differences between immediate and ageing subgroups. **Conclusion:** While no statistically significant differences were observed, hydrophilic sealants demonstrated slightly higher microhardness values than flowable composites. These findings underscore the potential of hydrophilic sealants in clinical applications, though further *in-vivo* studies are needed to validate their long-term performance and practical relevance.

Key Words Flowable composite, hydrophilic sealant, microhardness testing, preventive dentistry, thermocycling, vickers hardness tester

INTRODUCTION

Dental caries, commonly known as tooth decay, remains one of the most widespread chronic diseases globally, affecting individuals of all ages [1]. This condition occurs due to the gradual destruction of the hard tissues of the teeth, such as enamel and dentin, caused by acids produced by bacteria like Streptococcus mutans and Lactobacillus species. These bacteria thrive in the biofilm (plaque) that accumulates on the tooth surface. When sugars and carbohydrates are consumed, the bacteria metabolize them into acids, leading to the weakening and demineralization of tooth structures [2]. Caries progression typically begins in the pits and fissures of molars, which are challenging to clean and prone to plaque accumulation [3]. Without timely intervention, caries can penetrate deeper layers of the tooth, causing pain, infection and potential tooth loss.

Recent decades have witnessed significant advancements in oral health awareness, with improved hygiene practices and widespread fluoride use contributing to the slowing of early-stage caries and reducing their prevalence in developing nations [4]. However, these measures have proven less effective in preventing caries on occlusal surfaces compared to smooth-surface caries. Given the high susceptibility of occlusal surfaces in permanent molars to decay, addressing their prevention has become a primary focus in restorative and preventive dentistry [5,6].

The deep pits and fissures of molars provide an ideal environment for bacterial growth and plaque retention, heightening their vulnerability to caries. Therefore, the development of effective sealing materials is critical for preventive dentistry [7]. Hydrophilic sealants and flowable composites are commonly used to meet this need. These materials act as protective barriers, preventing the accumulation of food particles and bacteria in areas that are difficult to clean. However, their differing material properties significantly influence their durability and performance in the oral environment.

As part of a conservative approach, early efforts to prevent caries utilized the capillary forces of resinous materials to fill porous and rough areas of teeth [8]. Fissure sealants, introduced in the mid-1960s, were initially derived from the cyanoacrylate family. Due to their susceptibility to degradation by bacterial action, their use was initially confined to experimental contexts. However, the introduction of the acid-etch technique in 1969 and subsequent advancements in resin-based fissure sealants transformed their role in dentistry [9].

In 1971, the first resin-based fissure sealant, trademarked as NUVASEAL, was introduced [10]. Low-viscosity fissure sealants have since become integral to dental practice, proving effective in reaching carious lesions by penetrating enamel prism cores and filling interprismatic areas [8]. However, sealants applied to repair decayed areas on permanent teeth have demonstrated reduced effectiveness compared to traditional resin restorations due to contamination by moisture and saliva during application, thereby compromising long-term protection [11].

Ultradent Products introduced UltraSeal XT® Hydro, a hydrophilic, self-adhesive, light-cured resin-based pit and fissure sealant designed to prevent moisture contamination by effectively repelling moisture from pits and fissures [12,13]. This hydrophilic property makes it particularly useful in clinical settings where moisture isolation is challenging. By enhancing adhesion to the tooth surface, UltraSeal XT® Hydro offers reliable protection against dental caries. However, its reduced filler content may affect its mechanical properties, such as hardness and wear resistance [14].

Conversely, flowable composites have proven to be suitable sealing agents for minimally invasive procedures due to their low viscosity, fluoride release, ease of handling and reduced modulus of elasticity [15]. Introduced in 1972 for repairing cervical areas [16], these materials have evolved to address a range of dental applications, including providing stress relief in Class I, II and V restorations [15]. Innovations in their composition, such as increasing the concentration of filler particles, have enhanced their wear resistance and reduced polymerization shrinkage.

The effectiveness of fissure sealants and other caries-prevention materials is commonly evaluated based on their retention rates [17]. Since sealants are not expected to remain intact indefinitely, their periodic monitoring and reapplication are critical. Partial loss of sealant material can lead to plaque accumulation and marginal leakage, increasing the risk of secondary caries beneath the sealant [18]. Studies of fluoride-releasing fissure sealants report retention rates of 86.4% after three years and 43.3% after five years [19]. However, there is a scarcity of long-term clinical research comparing fissure sealants and flowable composites in terms of both retention rates and caries prevention.

This *in-vitro* study aims to evaluate the comparative microhardness of hydrophilic sealants and flowable composites when applied to permanent molars. By exploring the mechanical properties of these materials, the study seeks to enhance the clinical understanding of their durability and potential efficacy in long-term preventive care.

METHODS

Sample Collection and Ethical Permission

This *in-vitro* study involved 20 extracted molar samples obtained from healthy adults, free from decay or structural abnormalities. Ethical approval for the study was granted by the Saveetha Institutional Review Board (SRB/SDC/UG-2082/24/PHD/338). All procedures were conducted in compliance with ethical guidelines to ensure proper handling and utilization of biological specimens.

Sample Preparation and Specimen Preparation

The 20 molar samples were divided into two groups:

- **Group I:** Ultra-seal XT Hydro sealant
- **Group II:** Ivoclar Tetric n Flow composite

Each group was further subdivided into immediate and ageing subgroups. Mesiodistal sectioning of the teeth was performed using a low-speed diamond cutting blade, dividing each tooth into two halves. One-half was subjected to immediate microhardness testing, while the other underwent thermocycling to simulate ageing.

A standardized slot was prepared on the buccal surface of each tooth sample. For both groups, acid etching was conducted using 37% orthophosphoric acid. To achieve optimal bonding, the hydrophilic sealant samples were progressively dried to maintain slight moisture, creating a shiny appearance. In contrast, the enamel surface for flowable

Figure 1: Shows the samples with a slot prepared on the tooth's buccal surface

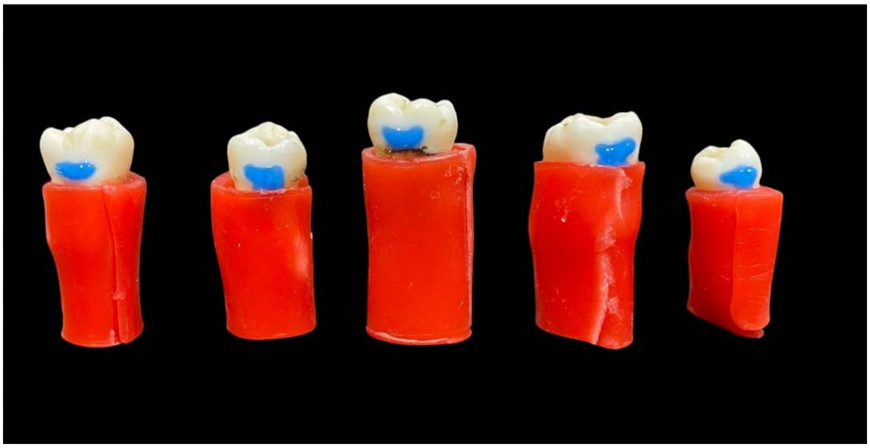

Figure 2: Shows the etched samples on a prepared slot on the buccal surface of the tooth

Figure 3: Shows the Ultra-seal XT Hydro sealant application on the prepared slots of teeth

composite application was conditioned to achieve a white, glacial appearance. The sealants and composites were applied according to the respective manufacturers' instructions and cured using a light-curing unit.

The immediate subgroup was tested for microhardness evaluation immediately after sealant or composite application, while the ageing subgroup underwent thermocycling before testing (Figures 1-4).

Figure 4: Shows the IvoclarTetric n flow composite application on the prepared slots of teeth

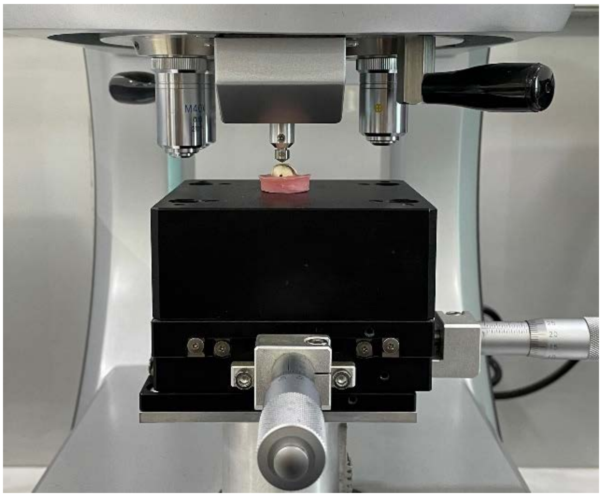

Figure 5: Shows the Vickers hardness test on the buccal surface of the tooth sample

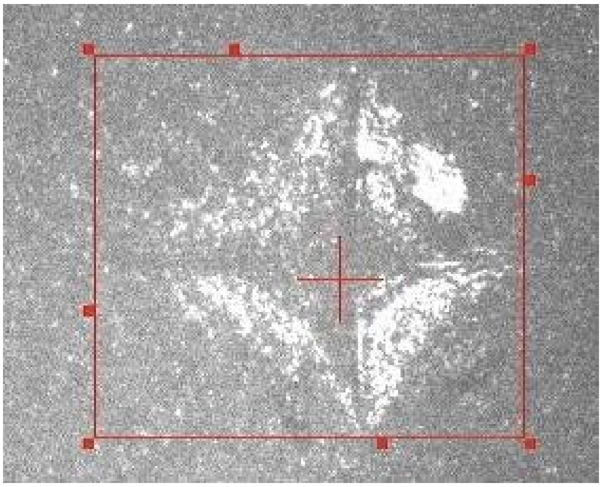

Figure 6: Indenter impression on the tooth surface after treatment with Ultra-seal XT Hydro sealant

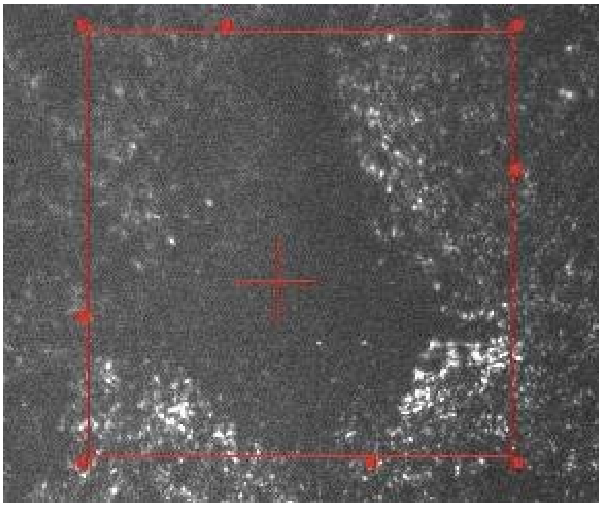

Figure 7: Indenter impression on the tooth surface after treatment with IvoclarTetric n flow composite

Thermocycling

The ageing subgroup samples underwent thermocycling to simulate oral environmental conditions. The samples were immersed alternately in water baths at temperatures ranging from 5°C to 55°C, with a 15-second transition between baths and a 10-second dwell time, for a total of 1500 cycles.

Microhardness Testing

The Vickers hardness test was employed to evaluate the microhardness of the sealant and composite surfaces. A pyramidal diamond indenter (Figure 5) in the Vickers hardness tester applied a 200 g force for 20 seconds on each sample. The Vickers Hardness Number (VHN) was calculated for each sample point to quantify microhardness (kg/mm²) (Figure 5-7).

Statistical Analysis

Data were analyzed using SPSS (version 23; SPSS Inc., Chicago, Illinois, USA). A p-value of <0.05 was considered statistically significant. Descriptive statistics, including mean and standard deviation, were calculated. The Mann-Whitney U test was used to compare mean microhardness values between Groups I and II, while the Wilcoxon signed-rank test assessed within-group differences in immediate and ageing subgroups.

RESULTS

Table 1 provides descriptive data for the immediate and ageing subgroups for Groups I and II. The immediate mean microhardness value for Group I (Ultra-seal XT Hydro sealant) was 26±3.70, which was higher than Group II (Ivoclar Tetric n Flow composite) with a mean of 21.38±6.15. However, the difference between the two groups was not statistically significant (p>0.05).

For the ageing subgroups, the mean microhardness value for Group I was 27.62±5.61, compared to 24.12±6.92 for Group II. Similarly, this difference was statistically insignificant (p>0.05) when analyzed using the Mann-Whitney U test (Table 2). Despite the lack of statistical significance, Group I consistently demonstrated higher microhardness values than Group II in both immediate and ageing conditions.

Within-group analysis using the Wilcoxon signed-rank test revealed no significant differences between immediate and ageing subgroups for either Group I or Group II (Table 3). This indicates that thermocycling and simulated ageing did not lead to a statistically significant change in the microhardness values of the tested materials.

The higher mean values observed for Ultra-seal XT Hydro sealant in both immediate and ageing conditions suggest a potential advantage in microhardness, though further studies with larger sample sizes and real-world conditions are necessary to validate these findings.

Table 1: Mean microhardness values of Immediate and ageing for Group I and II

Outcome	N	Mean Std.	Deviation
Immediate: Hydrophilic sealant	10	26.00	3.70
Immediate: Flowable composite	10	21.38	6.15
Ageing: Hydrophilic sealant	10	27.62	5.61
Ageing: Flowable composite	10	24.12	6.92

Table 2: Comparison of mean microhardness values of Immediate and ageing between Group I and II

	Comparison between groups	
Between groups	Immediate values	Aging values
Mann whitney U test value	7.00	12.00
p-value	0.24	0.91

Table 3: Comparison of mean microhardness values of Immediate and ageing within groups

	Immediate and Aging	
Within groups	Group I	Group II
Wilcoxon test value	-0.135	-0.944
p-value	0.893	0.345

DISCUSSION

In this study, the microhardness values of Group I (Ultra-seal XT Hydro sealant) were higher in both immediate and ageing conditions (mean: 26 and 27.62, respectively) compared to Group II (Ivoclar Tetric n Flow composite), which had means of 21.38 and 24.12, respectively. Although Group I consistently demonstrated higher microhardness, statistical analysis using the Mann-Whitney U test revealed no significant differences between the groups for either the immediate (p = 0.24) or ageing (p = 0.91) conditions. Within-group comparisons using the Wilcoxon signed-rank test also showed no significant differences between immediate and ageing conditions, though the ageing group exhibited slightly higher microhardness values.

Microhardness is an indirect measure of the degree of conversion (DC) of resin materials, which reflects the extent of polymerization following irradiation [20]. A higher degree of conversion is associated with improved mechanical properties, including increased marginal integrity and reduced solubility. Low degrees of conversion in occlusal sealants can lead to marginal failure and provide opportunities for bacterial proliferation, ultimately compromising the material's effectiveness [21].

The findings of this study align with previous research. Sulimany et al. reported the highest ageing microhardness values for Embrace WetBond sealant (31.70±3.59), which is comparable to our study's results for hydrophilic sealants [22]. Diener *et al.* [23] also found that ageing impacted microhardness over time, though no significant differences were observed between different sealant types. Similarly, Ayman et al. noted a trend of increasing microhardness over time due to the ageing process, consistent with our findings, although they reported significant results for Embrace WetBond sealant specifically [22]. The variation in findings across studies may be attributed to differences in testing methodologies, sample conditions and the specific sealant properties assessed.

Esfahani *et al.* [24] reported a lower mean microhardness (15.96±4.27) for fluoride-releasing fissure sealants compared to the results of the current study. This discrepancy may be due to differences in the assessment tools and procedural protocols, highlighting the importance of standardized methodologies in comparative studies.

Clinical studies comparing Embrace WetBond to other sealants have demonstrated superior mechanical properties, including higher marginal integrity, retention and wear resistance, while maintaining comparable clinical success rates [25,26]. However, other studies comparing Embrace WetBond to Helioseal F found no significant differences in caries prevention or marginal adaptation, emphasizing the need for context-specific material selection.

Limitations

This study has several limitations. The application of sealants on the buccal surface does not fully replicate clinical conditions, where pit and fissure sealants are placed in varied morphological types with differing depths. The *in-vitro* design does not account for oral cavity complexities, such as salivary flow, masticatory forces, pH changes and bacterial presence.The sample size (20 molars) limits the generalizability of the findings. The study did not simulate ageing under conditions fully representative of clinical settings.

Future *in-vivo* studies are essential to evaluate these materials under real-world conditions, including varying forces, salivary interactions and pH fluctuations. Broader material analysis with diverse product ranges and additional parameters such as wear resistance, bond strength, fracture toughness and esthetic stability will also be valuable. Furthermore, the development of new hybrid materials combining the desirable properties of hydrophilic sealants and flowable composites could lead to improved clinical performance.

CONCLUSION

The study concludes that while no statistically significant differences were observed between the hydrophilic sealant and flowable composite in terms of microhardness, the hydrophilic sealant demonstrated consistently higher values. These findings underscore the potential of hydrophilic sealants for enhanced durability in preventive dentistry. However, further research is required to validate these results in clinical settings and explore hybrid materials for superior performance.

Acknowledgments

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Conflicts of Interest

The authors declare no conflicts of interest. Institutional affiliations are mentioned to ensure transparency.

Ethical Statement

The study was conducted following ethical guidelines, with approval from the Saveetha Institutional Review Board (SRB/SDC/UG-2082/24/PHD/338). All teeth used were extracted for non-research purposes, with proper consent obtained.

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