Research Article

Comparative Evaluation Of Conventional And Hydrophilic Pit & Fissure Sealants In Permanent First Molars Using Modified Ryge Criteria – A Randomized Clinical Trial

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Abstract

Background: Pit and fissure sealants are considered one of the most effective preventive strategies against occlusal dental caries in children. Moisture contamination during sealant placement is a major cause of sealant failure. Hydrophilic pit and fissure sealants have been introduced to improve retention and clinical success under moist conditions.

Aim: To comparatively evaluate the clinical performance of conventional and hydrophilic pit and fissure sealants in permanent first molars using Modified Ryge Criteria.

Methodology: A randomized clinical trial was conducted among children aged 6–12 years with fully erupted permanent first molars. Eligible participants were randomly allocated into two groups: Group I received conventional resin-based sealant and Group II received hydrophilic sealant. Clinical evaluation was performed at baseline, 3 months, 6 months, and 12 months using Modified Ryge Criteria assessing retention, marginal adaptation, surface texture, discoloration, and secondary caries.

Results: Hydrophilic sealants demonstrated better retention and marginal adaptation compared to conventional sealants over the follow-up period. The difference was statistically significant at 12 months ($p<0.05$). Secondary caries occurrence was minimal in both groups.

Conclusion: Hydrophilic pit and fissure sealants showed superior clinical performance and may serve as a more reliable alternative in situations where ideal moisture control is difficult.

Keywords: Pit and fissure sealants, Hydrophilic sealant, Conventional sealant, Dental caries, Modified Ryge Criteria, Randomized clinical trial.

Introduction

Dental caries is one of the most prevalent chronic diseases affecting children and adolescents worldwide and continues to be a major public health concern despite significant advances in preventive dentistry. The occlusal surfaces of permanent molars are particularly susceptible to dental caries because of their complex morphology characterized by deep pits and fissures that favour plaque accumulation and hinder effective cleaning by routine oral hygiene measures. Studies have shown that nearly 80–90% of caries in children occur in the pits and fissures of permanent molars, even though these surfaces constitute only a small proportion of the total tooth surface area. [1]

The permanent first molars erupt around the age of 6 years and are considered highly vulnerable to dental caries during the post-eruptive maturation period. Inadequate mineralization, immature enamel, and difficulty in maintaining oral hygiene during eruption increase the susceptibility of these teeth to caries development. [2] The morphology of pits and fissures often creates a favorable environment for the retention of microorganisms and fermentable carbohydrates, thereby accelerating the carious process. As a result, preventive strategies targeting occlusal surfaces are of paramount importance in pediatric and preventive dentistry. [3]

Pit and fissure sealants have been widely recognized as one of the most effective methods for preventing occlusal caries. Sealants act by forming a micromechanical and physical barrier over susceptible fissures, thereby preventing the colonization of cariogenic microorganisms and accumulation of food debris. The effectiveness of sealants in caries prevention has been extensively

documented, with studies reporting caries reduction rates of up to 80% in sealed permanent molars.[4] Due to their proven efficacy, pit and fissure sealants are strongly recommended by organizations such as the American Dental Association (ADA) and the Centers for Disease Control and Prevention (CDC) for children at high risk of dental caries. [5]

Conventional resin-based sealants are the most commonly used sealant materials because of their excellent retention and wear resistance. However, these materials are highly technique-sensitive and require a completely dry field during application. Salivary contamination during the bonding procedure significantly compromises the retention and longevity of conventional sealants by interfering with enamel etching and resin penetration. [6] Achieving adequate moisture control is often difficult in pediatric patients, partially erupted molars, community settings, and outreach programs. Consequently, sealant failure due to contamination remains a major clinical challenge.

To overcome the limitations associated with moisture sensitivity, hydrophilic or moisture-tolerant pit and fissure sealants were introduced. These newer-generation materials are specifically designed to perform effectively even in the presence of slight moisture contamination. Hydrophilic sealants possess enhanced resin chemistry that allows improved adaptation and penetration into etched enamel under moist conditions. [7] Such materials may offer significant advantages in pediatric dentistry and public health settings where ideal isolation is difficult to achieve.

Several clinical studies have compared hydrophilic sealants with conventional resin-based sealants and reported varying outcomes regarding retention, marginal integrity, and caries prevention. While some studies suggest superior retention of hydrophilic sealants under moist conditions, others report comparable clinical performance between both materials. [8] Therefore, further randomized clinical trials are necessary to evaluate the long-term effectiveness and clinical success of these materials under routine clinical conditions.

The Modified Ryge Criteria is a standardized clinical evaluation system commonly used to assess the performance of restorative and preventive dental materials. It evaluates various parameters such as retention, marginal adaptation, marginal discoloration, surface texture, and presence of secondary caries. [9] The use of Modified Ryge Criteria enables a comprehensive and reliable assessment of sealant performance over time.

Considering the importance of sealant retention in preventing occlusal caries and the need for moisture-tolerant materials in paediatric dentistry, the present randomized clinical trial was conducted to comparatively evaluate conventional and hydrophilic pit and fissure sealants in permanent first molars using Modified Ryge Criteria

AIM AND OBJECTIVES

Aim: - To evaluate and compare the retention, cariostatic effect, discoloration, marginal adaptation, surface smoothness of conventional and hydrophilic pit & fissure sealants in children of age group 6-10 years.

Objectives:

1. To evaluate retention, cariostatic effect, discoloration, marginal adaptation, surface smoothness of Conventional and Hydrophilic Sealant in children of age group 6-10 years at 3 & 6 months.
2. To compare the retention of Conventional and Hydrophilic Sealant at 3 & 6 months.
3. To compare the cariostatic effect of Conventional and Hydrophilic Sealant at 3 & 6 months.
4. To compare discoloration of Conventional and Hydrophilic Sealant at 3 & 6 months.
5. To compare marginal adaptation of Conventional and Hydrophilic Sealant at 3 & 6 months.
6. To compare the surface smoothness of Conventional and Hydrophilic Sealant at 3 & 6 months.

METHODOLOGY

- The present study was a randomized split-mouth clinical trial conducted in the Department of Public Health Dentistry to compare the retention, cariostatic effect, discoloration, marginal adaptation, and surface smoothness of Conventional Clinpro™ 3M ESPE™ sealant and Hydrophilic Ultraseal XT® Hydro sealant using Modified Ryge Criteria.
- Ethical clearance was obtained from the Institutional Ethical Committee prior to the study. Purposive sampling technique was used.
- Sample size was calculated using OpenEpi Version 3 software with 80% power and 95% confidence interval.
- The formula used for calculating the sample size was: -n = 2 S2 (Z1 + Z2)2 / (M1-M2)2The estimated minimum sample size was 35 teeth per group. The sample size was finalized at 50 teeth per group(N=100).25 Subjects were selected according to split- mouth design.
- 25 systemically healthy children aged 6–10 years with four fully erupted permanent first molars having deep pits and fissures were selected according to inclusion and exclusion criteria.

Inclusion Criteria

- Children aged 6–10 years
- Fully erupted permanent first molars with deep pits and fissures
- No previous treatment in selected teeth
- deft score <2
- Absence of systemic disease
- Parental consent obtained

Exclusion Criteria

- Suspected carious lesions
- Enamel hypoplasia or fluorosis
- Self-cleansable fissures (V and U type)
- Parafunctional habits
- Uncooperative children
- Systemic diseases or medications affecting salivary flow
- Allocation of sealants to right/left quadrants was done using computer-generated randomization.
- The examiner was trained and calibrated before the study. A single calibrated operator performed all sealant applications and evaluations using Modified USPHS/Ryge Criteria.

Materials Used

- Pumice powder
- 37% phosphoric acid
- Clinpro™ 3M ESPE™ sealant
- Ultraseal XT® Hydro sealant
- LED photopolymerization unit

Clinical Procedure

- Oral prophylaxis was performed using ultrasonic scaler and rubber cup prophylaxis with pumice slurry.
- Teeth were isolated using rubber dam.

Group A – Conventional Sealant

- Teeth were etched with 37% phosphoric acid for 15 seconds, rinsed, dried, and sealant was applied.
- Sealant was light cured for 20 seconds.

Group B – Hydrophilic Sealant

- Teeth were etched for 20 seconds, lightly air dried without desiccation, and Ultraseal XT® Hydro was applied.
- Sealant was light cured for 20 seconds according to manufacturer instructions.
- Occlusion and sealant coverage were checked after polymerization.

Follow-Up

- Participants were recalled after 3 and 6 months.
- Clinical evaluation was done using dental mirror and explorer.
- Modified Ryge Criteria assessed retention, caries, marginal adaptation, colour match, and surface smoothness.

STATISTICAL ANALYSIS

The collected data was entered into Microsoft Excel and analyzed using SPSS version 26. Descriptive statistics including frequency and percentage were calculated. Chi-square test was used for intergroup comparison. Statistical significance was considered at $p<0.05$.

Table 1: Sealant Evaluation Criteria

Criteria	Score	Definition
Retention	0	Sealant was intact
	1	Sealant was partially lost
	2	Sealant was totally lost
Caries	0	Absence of caries

Criteria	Score	Definition
	1	Presence of caries
Marginal adaptation	0	The sealant had full adaptation to the adjacent tooth structure
	1	Evidence of gap detected by the tip of an explorer
Colour match	0	Acceptable colour match
	1	Slight discolouration
Smoothness of surface	0	As smooth as the adjacent tooth structure
	1	Not as smooth as the adjacent tooth structure but not porous
	2	Not as smooth as the adjacent tooth structure and porous

RESULTS

Table 2: Age and Gender Distribution in the Study Population

Category	Frequency n(%)
6 years	8(32%)
7 years	6(24%)
8 years	7(28%)
9 years	2(8%)
10 years	2(8%)
Male	14(56%)
Female	11(44%)

Table 3: Comparison of Retention rate of the two Sealants Group A(Conventional sealant) and Group B (Hydrophilic sealant)

Scoring criteria	3rd month		6th month	
	Group A	Group B	Group A	Group B
Intact	48(96%)	50(100%)	39(84.8%)	42(91.3%)
Partially lost	2(4%)	0(0%)	05(10.8%)	04(8.7%)
Totally lost.	0(0%)	0(0%)	2(4.4%)	0(0%)
Chi-square test value, p value	Chi square test value = 0.956, p =0.765		Chi square test value = 2.012, p =0.527	

p>0.05 – no statistically significant difference

Table 4: Comparison of Occurrence of Caries of Group A (Conventional sealant) and Group B (Hydrophilic sealant)

Scoring criteria	3rd month		6th month	
	Group A	Group B	Group A	Group B
Absence of caries	50 (100%)	50 (100%)	44 (95.6%)	46 (100%)

Presence of caries	00 (0%)	00 (0%)	02 (4.4%)	00 (0%)
Chi-square test value, p value	Chi square test value = 0.0, p =1.000		Chi square test value = 2.044, p =0.136	

p>0.05 – no statistically significant difference

Table 5: Comparison of Marginal adaptation of Group A (Conventional sealant) and Group B (Hydrophilic sealant)

Scoring criteria	3rd month		6th month	
	Group A	Group B	Group A	Group B
Sealant had Full adaptation to adjacent tooth structure.	48 (96%)	50 (100%)	39 (88.6%)	42 (91.3%)
Evidence of gap detected by tip of an explorer	02 (4%)	00 (0%)	05 (11.4%)	04 (8.7%)
Chi-square test value, p value	Chi square test value = 0.956, p =0.765		Chi square test value = 1.198, p =0.281	

p>0.05 – no statistically significant difference

Table 6: Comparison of Colour Match of Group A (Conventional sealant) and Group B (Hydrophilic sealant) with adjacent tooth structure

Scoring criteria	3rd month		6th month	
	Group A	Group B	Group A	Group B
Acceptable Colour Match	50 (100%)	50 (100%)	41 (93.2%)	42 (91.3%)
Slight Discoloration	0 (0%)	0 (0%)	03 (6.8%)	04 (8.7%)
Chi-square test value, p value	Chi square test value = 0.00, p =1.000		Chi square test value = 1.265, p =0.248	

p>0.05 – no statistically significant difference

Table 7: Comparison of Surface Smoothness of Group A (Conventional sealant) and Group B (Hydrophilic sealant)

Scoring criteria	3rd month		6th month	
	Group A	Group B	Group A	Group B
As smooth as adjacent tooth structure.	48 (96%)	50 (100%)	38 (86.4%)	44 (95.7%)

Not as smooth adjacent tooth structure but not porous.	02 (4%)	0 (0%)	06 (13.6%)	02 (4.3%)
Not as smooth adjacent tooth structure & porous.	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Chi-square test value, p value	Chi square test value = 0.956, p =0.765		Chi square test value = 1.278, p =0.349	

p>0.05 – no statistically significant difference

Table 8: Intragroup comparison of Retention rate of the sealants at 3 and 6 months

Scoring criteria	Group A		Group B	
	3rd month	6th month	3rd month	6th month
Intact	48 (96%)	39 (84.8%)	50 (100%)	42 (91.3%)
Partially lost	2 (4%)	05 (10.8%)	0 (0%)	04 (8.7%)
Totally lost.	0 (0%)	2 (4.4%)	0 (0%)	0 (0%)
Chi-square value, p value	Chi square test value = 3.516, p =0.139		Chi square test value = 2.267, p =0.368	

p>0.05 – no statistically significant difference

Table 9: Intragroup comparison of Occurrence of caries in both groups at 3 and 6 months

Scoring criteria	Group A		Group B	
	3rd month	6th month	3rd month	6th month
Absence of caries	50 (100%)	44 (95.6%)	50 (100%)	46 (100%)
Presence of caries	00 (0%)	02 (4.4%)	00 (0%)	00 (0%)
Chi-square test value, p value	Chi square test value = 0.864, p =0.852		Chi square test value = 0.0, p =1.000	

p>0.05 – no statistically significant difference

Table 10: Intragroup comparison of Marginal adaptation of the sealants at 3 and 6 months

Scoring criteria	Group A		Group B	
	3rd month	6th month	3rd month	6th month
Sealant had	48 (96%)	39 (88.6%)	50 (100%)	42 (91.3%)

Full adaptation to adjacent tooth structure.				
Evidence of gap detected by tip of explorer	02 (4%)	05 (11.4%)	00 (0%)	04 (8.7%)
Chi-square value, p value	Chi square test value = 3.016, p =0.224		Chi square test value = 2.267, p =0.368	

p>0.05 – no statistically significant difference

Table 11: Intragroup comparison of Colour Match of the sealants to adjacent tooth structure at 3 and 6 months

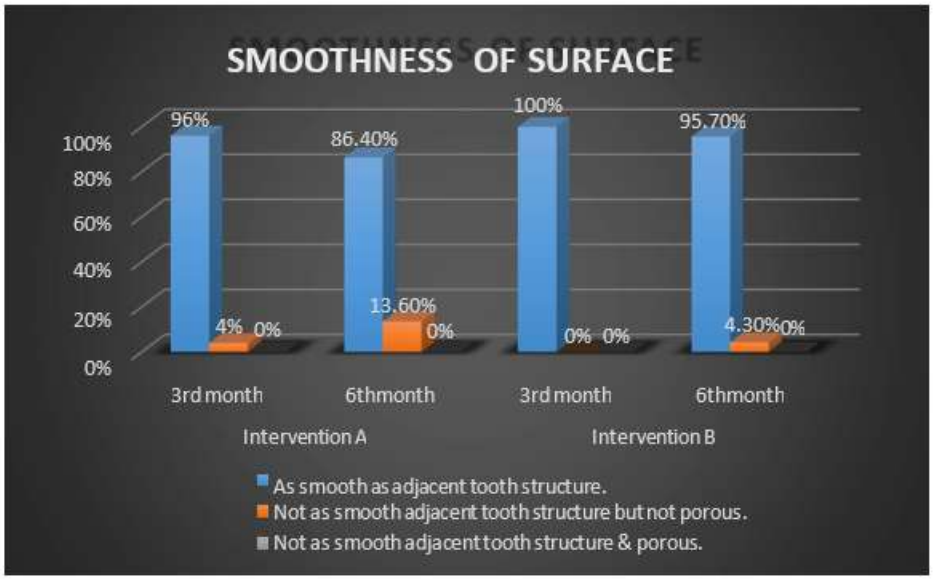
Scoring criteria	Group A		Group B	
	3rd month	6th month	3rd month	6th month
Acceptable Colour Match	50 (100%)	41 (93.2%)	50 (100%)	42 (91.3%)
Slight Discoloration.	0 (0%)	03 (6.8%)	0 (0%)	04 (8.7%)
	Chi square test value = 2.023, p =0.412		Chi square test value = 2.267, p =0.368	

p>0.05 – no statistically significant difference

Table 12: Intragroup comparison of Surface Smoothness of the sealants at 3 and 6 months

Scoring criteria	Group A		Group B	
	3rd month	6th month	3rd month	6th month
As smooth as adjacent tooth structure.	48 (96%)	38 (86.4%)	50 (100%)	44 (95.7%)
Not as smooth adjacent tooth structure but not porous.	02 (4%)	06 (13.6%)	0 (0%)	02 (4.3%)
Not as smooth adjacent tooth structure & porous.	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Chi square test value = 3.264, p =0.195		Chi square test value = 1.278, p =0.349	

p>0.05 – no statistically significant difference



Graph 1: Intragroup comparison of surface smoothness of the sealants at 3 and 6 months

A total of 25 children participated in the study, including 14 males and 11 females. Among the participants, 8 children were aged 6 years, 6 were aged 7 years, 7 were aged 8 years, and 2 children each belonged to 9 and 10 years age group. Evaluation of sealant retention at 3 months revealed that in Group A (Clinpro™), 48 sealants were intact and 2 were partially lost, whereas all 50 sealants in Group B (Ultraseal XT® Hydro) remained intact. At 6 months, Group A demonstrated 39 intact, 5 partially lost, and 2 totally lost sealants, while Group B showed 42 intact and 4 partially lost sealants with no total loss. No statistically significant difference was observed between the groups regarding retention rates ($p>0.05$). No carious lesions were observed in either group at 3 months; however, at 6 months, two teeth in Group A showed evidence of secondary caries, whereas no caries was detected in Group B. The difference in caries occurrence between the groups was statistically insignificant ($p>0.05$). Marginal adaptation assessment at 3 months demonstrated full adaptation in 48 sealants and marginal gaps in 2 sealants in Group A, while all sealants in Group B showed complete adaptation. At 6 months, Group A showed full adaptation in 39 sealants and gaps in 5 sealants, whereas Group B demonstrated complete adaptation in 42 sealants and gaps in 4 sealants. No statistically significant difference was observed between the groups ($p>0.05$). Evaluation of colour match showed acceptable colour match without discoloration in both groups at 3 months. At 6 months, acceptable colour match was observed in 41 out of 44 sealants in Group A and 42 out of 46 sealants in Group B, with no statistically significant difference between the groups ($p>0.05$). Surface smoothness assessment revealed no changes in either group at 3 months. At 6 months, 38 sealants in Group A and 42 sealants in Group B retained smooth surfaces, while slight roughness was observed in 6 sealants of Group A and 4 sealants of Group B. None of the sealants demonstrated porous surfaces, and no statistically significant difference was found between the groups ($p>0.05$).

DISCUSSION

Pit and fissure sealants are considered one of the most effective preventive measures against occlusal dental caries, particularly in children with newly erupted permanent molars. The present randomized split-mouth clinical trial evaluated and compared the clinical performance of conventional hydrophobic sealant (3M ESPE Clinpro™) and hydrophilic sealant (Ultraseal XT® Hydro™) using Modified USPHS/Ryge Criteria.

Children aged 6–10 years were selected because the risk of occlusal caries is highest during the early post-eruptive phase when enamel maturation is incomplete and pits and fissures are highly susceptible to plaque accumulation. The split-mouth design used in the present study minimized confounding factors such as oral hygiene practices, dietary habits, and salivary variations, thereby increasing the reliability of comparison between both sealants. Similar methodology has been recommended in previous sealant studies.[10,11]

In the present study, both sealants demonstrated satisfactory clinical performance at 3 and 6 months follow-up. Ultraseal XT® Hydro™ exhibited slightly better retention compared to Clinpro™ sealant, although the difference was statistically insignificant ($p>0.05$). These findings were consistent with the studies conducted by Prabakar et al. and Askarizadeh et al., who reported

improved or comparable retention rates of hydrophilic sealants under moist conditions.[12,13] The improved retention of hydrophilic sealants may be attributed to their moisture-tolerant resin chemistry, thixotropic nature, and superior penetration into etched enamel surfaces.[14]

No significant difference in caries occurrence was observed between the two groups. Only two teeth in Group A exhibited secondary caries at 6 months, which may be associated with partial sealant loss. The minimal caries development observed in both groups may be attributed to the fluoride-releasing property of the sealants and the protective effect of residual sealant tags within fissures. Similar findings were reported in previous clinical studies.[15]

Marginal adaptation and surface smoothness are important determinants of sealant longevity and resistance to microleakage. In the present study, both sealants demonstrated satisfactory marginal adaptation and surface smoothness with no statistically significant differences. These findings were in agreed with the study conducted by Jaewon Ku et al., which reported comparable sealing ability and marginal integrity between hydrophilic and hydrophobic sealants.[16]

Slight discoloration was observed in both groups at 6 months; however, the difference was statistically insignificant. Surface discoloration may be influenced by dietary habits, oral hygiene maintenance, and plaque accumulation.[17]

Within the limitations of the present study, both sealants exhibited comparable clinical success. However, Ultraseal XT® Hydro™ demonstrated slightly better retention and marginal adaptation under moist conditions. The short follow-up duration and limited sample size were limitations of the present study. Therefore, long-term clinical trials with larger sample sizes are recommended to further evaluate the durability and effectiveness of hydrophilic sealants

CONCLUSION

The present study had certain limitations that should be considered while interpreting the results. The follow-up duration of six months was relatively short for evaluating the long-term clinical success and durability of pit and fissure sealants. Since sealant retention and caries prevention are better assessed over extended periods, longer follow-up intervals are necessary. The study was conducted at a single institution with a limited sample size, which may restrict the generalizability of the findings to larger populations. In addition, minor variations in moisture control during sealant placement could have influenced the retention and marginal adaptation of the materials, especially in pediatric patients where isolation is often challenging.

Within these limitations, the present study concluded that both conventional and hydrophilic sealants were clinically effective in preventing occlusal caries; however, hydrophilic sealants demonstrated comparatively better retention and marginal adaptation. Their moisture-tolerant properties make them a suitable preventive option in pediatric dentistry and community settings where ideal isolation is difficult to achieve.

Future studies with larger sample sizes, multicentric designs, and longer follow-up periods are recommended to further validate these findings. Comparative evaluation of newer bioactive and fluoride-releasing sealants may also provide additional evidence regarding the most effective materials for long-term caries prevention.

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