REVIEW ARTICLE

Moisture Tolerant Pit and Fissure Sealant: A Literature Review

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Abstract

Even in the 21st century, dental caries are considered a global burden, severely upsetting the health and quality of life of those affected. Apart from the fluoride use and regular oral hygiene, one of the most important prophylactic approaches against caries occurrence is the sealing of pits and fissures. Pit and fissure sealants are a core part of the preventive program in pediatric dentistry and should be considered as a key component of minimally invasive dentistry due to their broad patient benefit. The primary sealant efficacy measure is retention. If the sealant remains bonded to the tooth and offers a good seal, then it is right to expect the occurrence of caries to be diminished. Traditional pit and fissure sealants are hydrophobic. These materials are based on bisphenol A-glycidyl methacrylate (bis-GMA) and other monomers requiring a dry field which is hard to achieve in an oral environment, especially for children. This review highlights the literature on the effectiveness of moisture tolerant pit and fissure sealant, which are the hydrophilic pit and fissure sealant, and a general overview of the pit and fissure sealant materials used for sealing occlusal surfaces, its classification as well as indications and possible side effects.

Keywords: Hydrophilic sealant, Moisture tolerant sealant, Pit and fissure sealant.

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Introduction

Dental caries is a disease caused by a change in the composition and activity of bacterial biofilms exposed to fermentable carbohydrates over time, resulting in a breach in the demineralization–remineralization equilibrium.[1] According to the American Dental Association (ADA) published in the Caries Classification System in 2015, a noncavitated or initial lesion is defined as "initial caries lesion development before cavitation occurs. Noncavitated lesions are characterized by a change in color, glossiness, or surface structure as a result of demineralization before there is a macroscopic breakdown in surface tooth structure."

According to the National Health and Nutrition Assessment Survey (NHANES) data from 2011–2012, carious lesions on permanent teeth were seen in 21% of children aged 6–11 years and 58 percent of teenagers aged 12–19 years. The NHANES analysis also reported that children aged 9–11 years old had a higher prevalence of carious lesions (29%) than children aged 6–8 years old (14%).[2]

Preventive methods such as water fluoridation, fluoride toothpaste, fluoride varnishes, and sealants were largely responsible for the general decrease in dental cavities.

Pit-and-fissure sealants reduce the risk of carious lesions by efficiently penetrating and sealing anatomical grooves or fissures on molar occlusal surfaces that trap food debris and increase the presence of bacterial biofilm with a dental material.[3] Sealants have been used in clinical practice for many decades, so sealants have undergone many changes in their structure and usage in recent years for better and easier application.[4] Traditional pit and fissure sealants need a clean, dry etched enamel surface, and the clinician will wait for teeth to fully erupt for proper isolation as moisture contamination is a contraindication. Advanced moisture-tolerant resin-based sealant technology has been developed that performs well with and benefits from the persistent moisture in the mouth, allowing sealants to be placed on slightly moist teeth even during the early eruption.[4]

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This literature review provides a better understanding of pit and fissure sealants, as well as the efficacy of the hydrophilic Embrace WetBond sealant.

Materials and Methods

A literature search was undertaken to utilize medical subject headings in electronic databases (PubMed, Cochrane, and Google Scholar) from various publications (publication years- 2008–2020). There were no filters or language limitations in place throughout the search. The articles were reviewed by two reviewers and included eight reviews, 10 *in-vivo* studies, 12 *in-vitro* studies, three original articles, and three textbooks that assessed the use of moisture tolerant pit and fissure sealant in pediatric dentistry (both part of the authorship team).

History of Pit and Fissure Sealant

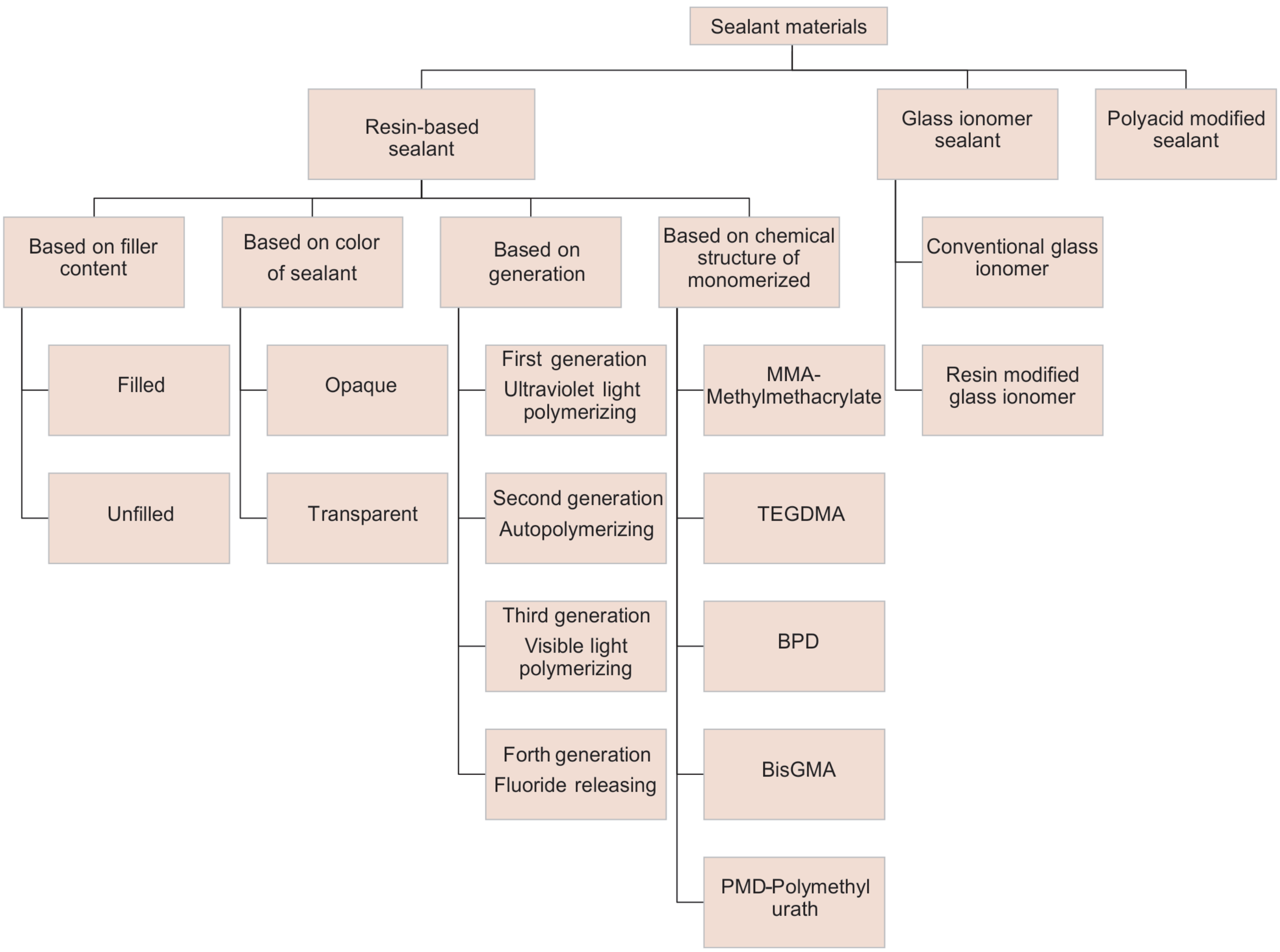
Deep pits and fissures promote food retention and are hard to clean. It provides a favorable environment for the oral microorganisms to sustain and convert the carbohydrates into acids, leading to enamel demineralization. For many years, it has been known that the teeth with pits and fissures are highly susceptible to caries (Table 1).[5]

In the mid-1960s, Cueto developed the first sealing substance, methyl cyanoacrylate, although it was never commercialized.

Table 1: Evolution of pit and fissure sealant

Year	*Author*	*Contribution*
1803	Hunter	Noted that "caries is often observed on the hollow parts of the molars"
1895	Wilson	Sealing of pits and fissures by placement of zinc phosphate cement
1923	Hyatt	A new aspect of prophylactic odontomy
1929	Bödecker	Deep fissures could be broadened with a large round bur to make the occlusal areas more self-cleansing: "fissure eradication"
1942	Kline and Knutson	Treatment with ammoniacal silver nitrate
1950	Ast et al.	Attempted either to seal or to make the fissures more resistant to caries with the use of topically applied zinc chloride and potassium ferrocyanide and the use of ammoniacal silver nitrate; they have also included the use of copper amalgam packed into the fissures
1955	Buonocore	Placement of bonded rein material in pits and fissure
1971		Pit and fissure sealant acknowledged by ADA
1978	Simonson	Use of preventive resin restoration
1986	Garcia-Godoy	Preventive glass ionomer restoration
2001		Degrange M. Penetration depth and marginal leakage of Embrace WetBond pit and fissure sealant
2002		Embrace WetBond pit-and-fissure sealant was launched by Pulpdent

Flowchart 1: Classification of pit and fissure sealant[3,6]



Bowen later invented a viscous resin called bisphenol A-glycidyl methacrylate, known as bis-GMA (Table 1).[6] However, pits and fissures can be classified as follows (Flowchart 1).

Indication for Pit and Fissure Sealant[7,8]

- Both primary molars and permanent bicuspids that are newly erupted (less than 4 years ago) and/or rough grooves and fissures.
- A fissure, fossa, or pit, is present, especially when it catches an explorer's tip.
- No radiographic or clinical evidence of proximal caries.
- Patients at moderate or high risk of developing dental caries for a variety of reasons.
- Pits and fissures that are stained and have minimal decalcification or opacification, as well as no softness at the fissure's base.
- The fossa chosen for sealant placement should be well isolated from any other fossas that have been restored.
- There is an intact occlusal surface, where the contra-lateral tooth surface is carious or repaired.
- Patients with caries in the initial stages, poor plaque control, anatomically susceptible pits, and fissures, orthodontic appliance.
- Patients with susceptible pits and fissures in sufficiently erupted permanent teeth.
- Other preventative treatments, such as systemic or topical fluoride therapy, to avoid the occurrence of interproximal caries.

Contraindication for Pit and Fissure Sealant[8]

- Partially erupted teeth without adequate moisture control where isolation is not possible.
- Well-established cavitated caries lesion.
- Proximal caries, existing on the other surfaces of the tooth with definitive caries diagnosis.
- A large restoration is present on the occlusal surface.
- Teeth with self-cleaning small pits and fissures that are well coalesced.
- The primary tooth has a short life expectancy.
- Patient allergic to sealant material, having a balanced diet low in sugar, and maintaining excellent oral hygiene
- Pit and fissure that has been caries-free for at least 4 years.
- In children who are too young to comply during the procedure.
- Veneers, amalgam restorations, gold foil restorations, inlays, onlays, or crowns made of synthetic porcelain.

Adverse Effect

The release of major sealant components such as bisphenol A (BPA), which has been known to harm animal development, health, and reproduction, has raised safety concerns.

The American Association of Pediatric Dentistry Recommendations, on the contrary, state that the US Food and Drug Administration (FDA) and the American Dental Association (ADA) have established that low amounts of BPA exposure from dental sealants pose no known health hazards.[9]

New Advancements in Pit and Fissure Sealant

Resin-based sealants and glass ionomer sealants are most often used as sealing materials.[10] The most significant advantage of resin-based sealing materials is their long endurance, whereas the most significant advantage of glass ionomer sealants is their excellent fluoride-releasing capabilities. When applied as sealing materials, however, resin-based sealants and glass ionomer sealants both have drawbacks. Polymerization shrinkage, which may result in microleakage, allowing saliva and bacteria to penetrate the occlusal barrier and the occurrence of stronger accumulation, is such a disadvantage of resin-based sealing materials.[11] In cases where glass ionomer cement is used to seal, pit, and fissures, fracture of the material may occur because of its reduced ability to withstand occlusal forces.[10] Salivary contamination is the major cause of sealant loss, compromising retention more so in the first year, especially in children where isolation is difficult to achieve.[12] The conventional hydrophobic sealants have reported increased microleakage and reduced bond strength in fissures contaminated with saliva. Recently, resin-based sealant technology has advanced to introduce hydrophilic sealants that can tolerate moisture.

Basically, the hydrophilic sealant is similar to currently available sealants. Its hydrophilic resin chemistry differs significantly from that of traditional sealants' hydrophobic bis-GMA resins. Di, tri, and multifunctional acrylate monomers are incorporated with advanced moisture-activated acid-integrating chemistry to make it moisture tolerant.[13]

To eliminate the problem seen with traditional pit and fissure sealants, the commonly used and commercially available resin dental sealants with hydrophilic chemistry are as follows:

- Embrace WetBond (Pulpdent, Watertown, MA),
- Ultraseal XT hydro (Ultradent, South Jordan, UT),

Table 2: Studies on moisture tolerant sealant

Author	*Sample*	*Test material*	*Studied properties*	*Findings*
Bhatia MR et al.[14] (2012) *In vivo*	17 children (6–8 years)	• Embrace WetBond (Pulpdent Corporation, Watertown, USA) • Delton FS+ - (Dentsply International, York, PA)	• Retention	• At 12 months follow-up Embrace was relatively bet ter than Delton FS+ in having total retention, • The clinical assessment showed that both the materials had no statistical significant difference
Bagherian A et al.[15] (2013) *in vitro*	100 extracted maxillary premolar teeth	• Smartseal and Loc • Clinpro	• Microbial microleakage	• Hydrophilic sealants as acceptable alternative to conventional resin-based hydrophobic sealants.

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Author	*Sample*	*Test material*	*Studied properties*	*Findings*
Bhat PK et al.[16] (2013) *in vivo*	80 children (6–9 years)	• Delton® FS+ • Clinpro™ Sealant (3M ESPE • EmbraceTM WetbondTM Sealant (Pulp dent Corporation • GC Fuji VII Glass Ionomer Cement (GC Corporation)	• Retention and development of Caries	• Resin-based sealant with moisture tolerance was as effective as traditional Bis-GMA-based sealants in terms of retention and caries prevention
El Motayam KE et al.[17] (2013) *In vitro*	15 extracted maxillary first premolar	• Fisseal • Vertise Flow • Embrace WetBond	• Nanoleakage • Length of resin tags	• Vertise Flow composite showed the longest resin tags penetration and the best sealing ability to etched enamel surface. • Vertise Flow showed lesser nanoleakage
Eliades A et al.[18] (2013) *in vitro*	20 specimen of each product 60 extracted premolar	• Embrace Wetbond • Fusio • Helioseal-F • Vertise-Flow	• Curing efficiency • Extent of oxygen inhibition • Flow • Hardness • Adaptation, microleakage and fissure penetration	• Self adhesive restorative materials showed increased hardne ss and better curing efficiency, oxygen inhition properties • They exhibited poor flow characterics and inferior fissure sealing quality
Iyer RR et al.[19] (2013) *In vitro*	50 extracted premolars and third molars	• Seal-Rite (Pulpdent corporation) • Embrace Wetbond (Pulpdent corporation)	• Effect of fissure morphology in Penetration and adaptation of material	• Embrace Wetbond exhibited greater penetration and better adaptation
Khogli AE et al.[20] (2013) *in vitro*	22 extracted third molars	• Embrace wetbond • Delton	• Compare Microleakage and penetration	• Sealing ability of Embrace wetbond was influenced by surface condition and showed comparable results
Schlueter N et al.[21] (2013) *In vivo*	55 children (12–15 years)	• Embrace™ WetBond • Helioseal®	• Retention • Quality of the sealings • Occurrence of caries	• The moisture-tolerant fissure sealing material Embrace was inferior to the sealant Helioseal
Panigrahi A et al.[22] (2015) *in vitro*	40 extracted third molars	• Embrace™ WetBond™ (Pulpdent, Watertown, MA)	• Influence of different moisture contamination on microtensile bond strength	• Saliva contamination adversely affected the m icrotensile bond strength of the embrace wetbond sealant. • Reconditioning could improve the microtensile bond strength of sealants as compared to air thinning and air drying
Subramaniam P et al.[23] (2015) *in vitro*	20 specimen of glass carbomer sealant 20 specimen of Fuji type VII 20 extracted premolars	• Glass carbomer sealant material (GCP Dental, The Netherlands) • Fuji type VII (GC Corporation, Tokyo, Japan)	• Solubility • Microleakage	• The solubility of glass carbomer sealant was lesser than the conventional glass ionomer sealant • No significant difference in microleakage between glass carbomer sealant and the conventional resin sealant.
Subramaniam P et al.[24] (2015) *in vivo*	108 children (6-9 years)	• Glass carbomer sealant material (GCP Dental, The Netherlands • Embrace™ WetBond™	• Compare retention • Caries incidence	• No significant difference betwe en retentions and in caries incidence between both sealants

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Author	*Sample*	*Test material*	*Studied properties*	*Findings*
Ratnaditya A et al.[25] (2015) *in vivo*	216 children (6–9 years)	• Delton FS • Embrace Wetbond	• Retention	• At the end of two years Embrace Wetbond showed completely retained sealants compared to Delton FS
Khatri SG et al.[26] (2015) *In vivo*	34 children (6–9 years)	• Embrace WetBond • Helioseal	• Retention rate • Development of Caries	• Embrace exhibited higher retention and lower caries scores compared to Helioseal
Gawali PN et al.[12] (2016) *in vitro*	28 extracted primary madibular 2nd molar (9–11 years)	• UltraSeal XT • Fissurite F	• Microleakage • Depth of penetration	• The microleakage seen with hydrophilic sealant under moist surface condition was less • In dry and moist surface environments, the penetration depth of the hydrophobic sealant was found to be greater than that of the hydrophilic sealant
GÜÇLÜ ZA et al.[27] (2016) *in vitro*	20 extracted molars	• UltraSeal XT	• Characterize • Resistance to micr oleakage	• Laser preconditioning was found to decrease microleakage
Güçlü ZA et al.[21] (2016) *In vitro*	30 extracted molar	• UltraSealXT®hydro™sealant	• To evaluate the suitability of different enamel conditioning regimes with respect to the Microleage	• Teeth treated with a combination of laser irradiation and acid etching demonstrated significantly lower microleakage scores
Askarizadeh N et al.[28] (2017) *in vivo*	23 children (6–9 years)	• Embrace • Helioseal-F	• Clinical effectiveness of Embrace hydrophilic and Helioseal-F hydrophobic sealants in permanent first molars	• One-year clinical success of Embra ce hydrophilic sealant was similar to that of Helioseal-F hydrophobic sealant
Prabakar J et al.[29] (2018) *in vivo*	30 schoolchildren (12–15 years)	• Clinpro™3M™ ESPE™ • UltraSealXT®	• Retention • Cariostatic effect • Discoloration	• UltraSeal XT® Hydro had better retention than the conventional Clinpro™ 3M™ ESPE™. • No difference in cariostatic effect and discoloration was found.
Güçlü ZA et al.[30] (2018) *In vitro*	60 extracted molars	• UltraSeal XT® hydro™	• Impact of laser pre-conditioning and moisture contamination on the resistance to microleakage	• Laser pre-conditioning prior to conventional acid etching significantly increased resistance to microleakage even if the surface of the enamel was moist or cold
Alsabek L et al.[31] (2019) *in vivo*	40 children (6–9 years)	• Embrace™ WetBond™ Sealant (Pulpdent Corporation, Watertown, Mass., USA • Fuji TRIAGE® (GC, Tokyo, Japan)	• Clinical retention • Remineralization ability	• Embrace™ Wet Bond™ showed superiority over the glass ionomer sealant tested in retention after six months follow up • The differences were found not to be statistically significant in the remineralization effect
Haricharan PB et al.[32] (2019) *in vivo*	90 children (7–11 years)	• GC Fuji Type IX • Embrace WetBond sealant	• Retention • Caries-preventive effects	• No significant difference was observed between the sealants either in the retent ion or in caries prevention

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Author	*Sample*	*Test material*	*Studied properties*	*Findings*
Khatri SG et al.[33] (2019) *in vivo*	34 children (6–9 years)	• Aegis™ (Bosworth Company) • Embrace Wetbond™ Sealant	• Retention • Development of Caries	• Embrace Wetbond was less effective as compared to Aegis in terms of retention • Caries –preventive effect of Aegis was higher as compared to that of the Embrace Wetbond sealant. • Caries – • Caries –preventive effect of Aegis was higher as compared to that of the Embrace Wetbond sealant.
Ezzeldin NI et al.[34] (2019) *in vitro*	15 disks of GI Fuji Triage 15 disks of Embrace WetBond	• GI Fuji Triage • Embrace WetBond	• Sorption • Solubility • Color change • Fluoride release	• EWB did not show any superiority over GI at different pH solutions or periods. • The greater fluoride release was seen from GI

- Smartseal and Loc (Detax Gmbh & Co, Ettlingen, Germany),
- GCP GLASS SEAL Glass carbomer sealant—Glass ionomer-based sealant.

The development and commercialization of a moisture-tolerant resin-based sealant have addressed some of the issues that have previously been faced in the traditional resin-based sealants and their usage in areas where moisture management is difficult to achieve.

Few studies have been carried out and further studies are encouraged to prove and establish various properties of sealants tolerant to moisture (Table 2).

Conclusion

Conclusions drawn are:

- In comparison, the resin-based sealants had better retention than the glass ionomer sealer.
- In terms of caries prevention and retention, traditional bis-GMA-based sealants were shown to be as effective as moisture-tolerant resin-based sealants.
- Empirical research and systematic studies on the effectiveness of sealants specifically in primary molars are missing when it comes to primary teeth, as sealants in primary teeth are extensively recommended as part of preventive programs for young children.[35]

Past issues have been eliminated due to the invention of a moisture-tolerant, resin-based sealant, and adhering to the right sealant technique outlined above can result in success in preventing pit and fissure caries. Making it feasible to maintain a caries-free dentition for the majority of children, adolescents, and adults.[36] However, more research is needed to ensure clinical longevity and to establish pit and fissure sealants as effective, especially in children at high risk of caries, children who salivate excessively, children who are mentally and physically challenged, very young children, uncooperative infants, and children with partially erupted molars.

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