 DOI: 10.21608/adjalexu.2021.73642.1191

EVALUATION OF BOND STRENGTH OF HYDROPHILIC PIT AND FISSURE SEALANTS

(IN VITRO STUDY)

Hagar Y.Zaghloul [1*] BDS, Amina M.Abdelrahman [2] PhD, Niveen S. Bakry [2] PhD,Seham A.Hanafy [3] PhD.

ABSTRACT

BACKGROUND: Pit and fissure sealants are considered a major tool of prevention. A new hydrophilic sealant which can be used in young permanent will be better for caries prevention.
OBJECTIVES: The aim of this study to assess the retention of the hydrophilic resin-based fissure sealant compared to the hydrophobic conventional fissure sealants.
MATERIAL AND METHOD: 22 premolars were collected and randomly allocated into two groups (n= 11), Group I (test); hydrophilic sealant Embrace wetbond; Group II (control) hydrophobic sealant Helioseal F. The buccal surface of all teeth was prepared, flattened, etched and rinsed. Group I was contaminated with artificial saliva then dried with cotton pellet and Group II was dried with air only. Sealants were applied and cured. Specimens were thermocycled and shear bond strength was evaluated using a universal testing machine. A stereomicroscope at magnification ×25 was used to evaluate mode of failure of each specimen.
RESULTS: According to statistical analysis (Mann whitney U), Hydrophilic sealant demonstrated significant lower median shear bond strength at P<0.001 compared to hydrophobic sealant. Hydrophilic sealant showed mostly adhesive mode of failure compared to higher mixed failure in hydrophobic sealant, however, it was non-significant at P= 0.19 (Fisher exact).
CONCLUSION: Hydrophilic sealant retention is not efficient as conventional hydrophobic sealant.
KEYWORDS: Prevention, pit and fissure sealant, dental caries, hydrophobic, hydrophilic.

---

1 Bachelor of Dental Surgery, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
2Professor of Pediatric Dentistry, Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Alexandria University, Egypt.
3Professor of Biomaterials Department, Faculty of Dentistry, Alexandria University, Egypt.

Corresponding author
E-mail: hagaryoussry828@gmail.com

INTRODUCTION

Dental caries is a common intraoral, multifactorial diseases. In its course, it affects both the individual and the public, medically, socially and economically(1) which constitute a burden on the most developed countries despite the advancement in the dental prevention(2).

Occlusal surfaces in adolescants are highly susceptible to caries as mentioned by Seiffert et al 2018 in a systematic assessment(3).Welbury et al in 2004 documented in EAPD guidelines that occlusal caries constitute about 50% of carious lesions although the occlusal surface presents 12.5% of tooth surface(4). Many attempts were approached to prevent dental caries(5), this is due to their morphological complexity trapping the plaque and food remnants and preventing proper leaning of the pits and fissures(6, 7) .

Upon the recommendation of Pediatric Restorative Dentistry Consensus Conference in 2002 (8, 9), there was a high evidence on the importance of sealing both primary and permanent molars. Polk et al 2018 reported that the early placement of a sealant in immature permanent teeth is an essential prophylactic procedure(10).

Resin-based pit and fissure are mainly used material for sealing as they are known for their best mechanical properties, the highest wear resistance and the greatest retention rates and sometimes the added fluoride element (11-13). However, the technique sensitivity and the need of strictly dry isolated field make the use of material questionable in some cases where moisture control cannot be achieved especially in cases of newly erupted permanent molars, uncooperative and special needs patients(14). Glass ionomer sealants were considered as a temporary solution where isolation is an issue as retention rate and wear resistance of glass ionomer sealants are deficient (15, 16).

A new bioactive hydrophilic sealant that combine the advantages of both resin-based sealant and glass ionomer sealant became mandatory to eradicate the need of dry field and add the advantage of remineralization of newly erupted immature enamel surface through fluoride release(17).

Embrace WetBond is a hydrophilic resin-based fissure sealant that does not contain Bis-GMA or bisphenol-A excluding the most hydrophobic component of resin-based sealant. The absence of Bisphenol-A is believed to be beneficial as it is known for its toxic effect on human organs(18). It is composed of hydrophilic multifunctional acidic acrylate monomers; Aliphatic urethane dimethacrylate, bis-methacryloyl phosphate, HEMA, tri-methylolpropane tri-methacrylate embedded in hydrophobic matrix which once cured it become insoluble in water creating a hydrophilic-hydrophobic equilibrium(19-25).

Embrace WetBond was evaluated by several studies. Baheti et al. 2020 compared the marginal integrity, discoloration and retention rates of hydrophilic sealant (Embrace WetBond) and hydrophobic sealant (Helioseal and Clinpro). 48 patients were enrolled in the clinical trial with 90 permanent molars. After a one year follow up , the highest retention rate, highest marginal integrity and least discoloration were reported by (Embrace WetBond) over (Helioseal and Clinpro) conventional hydrophobic sealants(13).
However, Bhatia et al in 2012 enrolled seventeen healthy children with sixty-eight first permanent molars in a split mouth design to evaluate the retention of (Embrace WetBond). It was concluded that there was no significant difference in retention of both hydrophilic and hydrophobic sealant(26).

Moreover, a clinical trial was reported by Schlueter et al.2013 it was done over a one-year period.55 patients were involved in the trial with corresponding molars sealed with either hydrophilic and hydrophobic sealant. After a one year follow up period , it was reported that The moisture-tolerant sealant Embrace was distinctly inferior to Helioseal because Embrace showed low retention rates and caries activity of 4% beneath it (21). Mesquita-Guimarães et al in 2016 evaluated the shear bond strength of hydrophilic resin-based fissure sealant on 90 extracted third molars teeth in a laboratory study using saliva contaminated and non- contaminated surfaces. Embrace WetBond exhibited the lowest shear bond results as reported in comparison to Fluoroshield hydrophobic sealant(27).

Therefore, due to these controversial results, it's mandatory to assess the retention of the hydrophilic resin-based fissure sealant compared to the hydrophobic conventional fissure sealants. Accordingly, the proposed null hypothesis of the present study is that there will be no difference between hydrophilic resin-based fissure sealant and the conventional hydrophobic resin-based fissure sealant material with regard to shear bond strength to the enamel of permanent teeth.

MATERIAL AND METHODS

The current study was an in-vivo experimental study. It was approved by the Scientific Research Ethical Committee, Faculty of Dentistry, Alexandria University, Egypt.

The sample size was calculated according to values reported by a previous study by Eliades et al 2013(28) . An alpha level was set at 5% with a significance level of 95% and a beta error accepted up to 20% with a power of study 80%. The minimum required sample size per subgroup was calculated to be 10. It was increased by 10% to make up for lab error to reach n=11 per subgroup. The total sample size = number of subgroups × number per subgroup = 4 × 11= 44(29).

Teeth involved in the study were extracted for orthodontic purposes, free from caries or cracks, restorations, or any developmental defects. The occlusal surfaces of teeth were with fluoride free prophylaxis paste using brushes and low speed handpiece. teeth were stored in saline solution until use. Teeth were randomly allocated into two groups. Group I (test group) (n= 11) for hydrophilic fissure sealant Embrace WetBond (Embrace WetBond Sealant, Pulpdent Corporation, Watertown, Mass., USA), group II (control group) (n=11) for conventional hydrophobic sealant Helioseal F (Ivoclar Vivadent, Schaan, Liechtenstein)(Table1).
The roots of the teeth were cut off 2mm below the cementum-enamel junction with water cooled, low speed diamond disc and crown was mounted individually on acrylic blocks with the buccal surface perpendicular to the long axis of the block.

The buccal surface was ground flat using 800 grit silicon carbide paper under water coolant to obtain 1-2 mm of flat enamel surface. Teeth were then divided into two groups according to type of the sealant used. Both sealants were applied using ready-made plastic mold 5mm in diameter 3 mm in height perpendicularly centralized over the treated enamel surface and stabilized using sticky wax.

The specimens of group I were etched with 37% phosphoric acid gel (Total Etch, Ivoclar Vivadent, Schaan, Liechtenstein) for 15 seconds, rinsed for 10 seconds and was air dried for 5 seconds. The specimens were immersed in artificial saliva first for 5 seconds then the excess moisture was removed with a cotton pellet for 5 seconds keeping the tooth surface slightly moist giving the enamel a glossy appearance, then the hydrophilic pit and fissure sealant Embrace wet bond was applied and light cured for 20 seconds using LED light curing system (Ivoclar Vivadent, Schaan, Liechtenstein.inc.) as instructed by the manufacturer (25).

As for Group II each specimens enamel surface was etched with 37% phosphoric acid gel (Total Etch, Ivoclar Vivadent, Schaan, Liechtenstein) for 15 seconds, rinsed for 10 seconds and then dried with stream of oil free air for 5 seconds to obtain the dull chalky white appearance of the enamel surface. The conventional hydrophobic pit and fissure sealant was applied and light cured for 20 seconds using LED curing system (Ivoclar Vivadent, Schaan, Liechtenstein.inc.) as instructed by the manufacturer.

All teeth were then subjected to 500 thermal cycles, with changing temperature between 5°±C and 55±5°C in a water bath with a dwell time of 30 seconds (25, 30).

Shear bond strength(19, 31) was tested using a universal testing machine. Each tooth was mounted in a special attachment so that each sealant specimen was oriented parallel to the shearing rod. Shear load of cross head speed equals 1 mm/minute at the interface between sealant specimen and enamel surface until debonding occurs.

The bond strength was calculated according to following equation: Shear bond strength (MPa) = the maximum failure load recorded in (N)/surface area in mm2

Finally Fracture mode assessment (27) was completed by examining each specimen using the light stereomicroscope (OLYMPUS SZ II. Olympus optical Co. Tokyo, Japan) under x25 magnification to determine the location and type of failure whether it was cohesive or adhesive or mixed (fig 3-6).

Statistical analysis:

Data were collected and entered to the computer using statistical package for social science (SPSS) program (version 20) for statistical analysis(32).Data were entered as numerical or categorical, as appropriate. Quantitative data were tested for normality using kolmogrov-smirnov test. The studied variables were not normally distributed so the non-parametric statistics were adopted. Shear bond strength values were analyzed using Mann Whitney U test and mode of failure was analyzed using Fisher exact test.

Table (1): Composition of materials evaluated in the study

Material used	composition	% in weight
Embrace WetBond pit and fissure sealant	Acrylate ester monomers, glass-filled paste, uncured acrylate ester monomers Silica amorphous Sodium fluoride	(55-60%) (5%) (<1%)
Helioseal F pit and fissure sealant	Bis-GMA matrix monomer, urethane dimethacrylate, and triethylene glycoldimethacrylate Silicon dioxide and fluorosilicate glass Titanium oxide, stabilizers and catalyst	(58.6%) (40.5%) (<1wt%).

Table (2): Comparison of shear bond strength (SBS) between group I hydrophilic sealant (test group) and group II hydrophobic sealant (control group).

SBS (MPa)	Hydrophilic sealant group I (n= 11)	Hydrophobic sealant group II (n= 11)
Median (Min – Max)	1.5 (0.5 - 3.2)	9.1 (5.2 – 16.2)
Test of significance P value$^{\xi}$	< 0.001*	

Table (3): Comparison of mode of failure between group I hydrophilic sealant (test group) and group II hydrophobic sealant (control group).

Mode of failure	Hydrophilic sealant group I (n= 11)	Hydrophobic sealant group II (n= 11)
	N (%)	
Cohesive failure	0 (0)	0 (0)
Adhesive failure	7 (63.6)	3 (27.3)
Mixed failure	4 (36.4)	8 (72.7)
P value$^{\$}$	0.19	

RESULTS

Shear bond strength test result showed median 1.5 MPa in the hydrophilic sealant group however the hydrophobic sealant group demonstrated a median 9.1 MPa. The hydrophilic sealant showed lower significant median scores compared to hydrophobic sealant at P value (p<0.0021). table (2) fig (1)

The most in common median failure mode was adhesive for hydrophilic sealant (63.6 %) (fig 3,5), on the other hand, the hydrophobic sealant group showed a higher median result of Mixed failure (72.7 %) (fig 4,6). However, the difference between both groups was non-significant with P value (P=0.19) in the failure mode table (3) fig (2)

Figure (1): Bar graph representing median score for shear bond strength in group I hydrophilic sealant (test group) and group II hydrophobic sealant (control group).

Fig. (1): Bar graph representing median score for shear bond strength in group I hydrophilic sealant (test group) and group II hydrophobic sealant in MPa (control group).

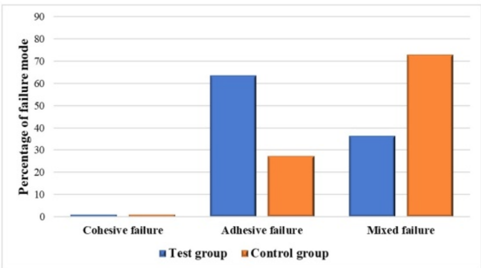

Fig. (2): Mode of failure in group I hydrophilic sealant (test group) and group II hydrophobic sealant (control group).

Fig. (2): Mode of failure in group I hydrophilic sealant (test group) and group II hydrophobic sealant (control group).

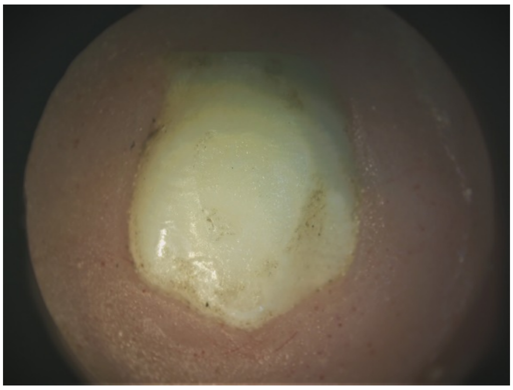

Fig. (3): Adhesive mode of failure in group I hydrophilic sealant.

Fig. (4): Mixed mode of failure in group I hydrophilic sealant.

Fig. (5): Adhesive mode of failure in group II hydrophobic sealant.

Fig. (6): Mixed mode of failure in group II hydrophobic sealant.

DISCUSSION

The development of efficient dental preventive strategies is only built on the fundamental understanding of dental caries initiation and progression in individual teeth (23) Pit and fissure sealants have been considered an outstanding adjunct to oral health care preventive strategies in the decrease of occlusal caries onset and progression (7) as the occlusal pits and fissures are the most vulnerable parts due to their irregularities(24). Ideal clinical settings guarantee excellent sealants results, however, ideal application is not easy to achieve in children and partially erupted teeth, moisture contamination represent a challenge to resin-based pit and fissure sealants as they are mainly dependent on micromechanical bonding to etched enamel surface (25). The fissure sealant effect can be widely anticipated on erupting teeth as first permanent molars known for their caries susceptibility(18, 20). A bioactive hydrophilic resin-based pit and fissure sealant is able to tolerate the moisture where isolation is difficult, it can bind through micromechanical and chemical bond to slight moist enamel and is activated in the presence of moisture. Consequently,It can add new potentials leading to better results(19, 33).

The ultimate goals of sealant material depend primarily on its ability to bond adequately to the tooth surface, maintain a leak free interface, and be completely retentive under occlusal loads to offer the optimal clinical performance. To have a complete picture of the hydrophilic resin-based sealant performance under occlusal loads shear bond strength in conjunction with the mode of failure must be assessed to evaluate the efficiency of the material (19, 27, 34-36).

The main objective of our study is to compare between hydrophilic sealant (Embrace WetBond) and hydrophobic sealant (Helioseal F) using laboratory tests involving shear bond strength and failure mode in permanent teeth.

The study involved twenty-two premolars that were extracted for orthodontic purposes, teeth were cleaned and carefully examined to ensure the absence of caries or cracks or any developmental defects that may affect the result of the study. The choice of premolar in the present study is explained as their fissure morphology is not complicated ensuring the good flow and avoiding the problems of air bubbles involvement in well confined fissure(25) . In the same instance fissures were insured to have deep morphology susceptible to plaque accumulation. Teeth were collected and stored in saline solution for preservation.

Aging of the material under laboratory in-vitro condition was fulfilled through thermocycling to simulate the stresses to which teeth and the sealants are subjected to in the oral environment. Thermocycling generates repeated cycles of expansion and contractions at the interface between the enamel and the resin material and this is because of the high expansion contraction coefficient of the resin material (25, 30, 37).

All specimen were directed perpendicularly centralized over enamel surface so as the buccal surface of each tooth was parallel to the mold, as it allows the direction of shearing force to be perpendicular to the bonded specimen, sealants were applied and cured according to the manufacturer’s instructions material all specimens were subjected to shear force in universal testing machine so as the shearing rod will be perpendicular to the specimens(27) . The cross head speed of the shearing rod used in our current study was slow set at 1 mm\min as it provide more uniform rhythm between stress and time (38, 39).

In the light of the result of our current study, the median shear bond strength score of hydrophilic sealants (Embrace WetBond) is significantly lower than the hydrophobic sealant (Helioseal F). This might be attributed to multiple reasons. An etched enamel surface has a highly reactive surface energy that can be easily occluded by any debris from the saliva in a matter of seconds. As the surface of enamel must be glossy enough to allow the hydrophilic sealant to complete the setting reaction the surface must be contaminated with saliva. This may lead to incomplete penetration of the resin and in consequence an inappropriate bonding(27).

Moreover, Eliades et al.in 2013(28) suggested that the high surface tension of the residual moisture at the bottom of the fissure and low surface tension of the hydrophilic sealant create a thick crescent shape layer. This layer prevent a regular penetration of the sealant thus preventing the setting and the polymerization of the sealant(30).

Furthermore, as the absence of Bisphenol-A is believed to be an advantage because of the reduction of the polymerization shrinkage and the prevention of its harmful effect on the human organs. However, its absence deprives the hydrophilic sealant of a great adhesive ability offered by the Bisphenol-A (40).

Hydrophilic sealant (Embrace WetBond) demonstrated high median adhesive failure, in contrast, the hydrophobic sealant (Helioseal F) represented high median mixed failure. These results confirm the shear bond strength results.

While in our study methodology attempted to simulate clinical condition by preventing the specimen dehydration and thermocycling to simulate the aging, one of the limitations would be subjecting the material to clinical effects as beverages, food, mouthwash, saliva and the mechanical loads of the oral cavity. In addition to the inability to provide a complete wet environment as the oral cavity in laboratory setting.

Within the limitation of our current study, hydrophilic sealant Embrace wetbond demonstrated low mean shear bond strength values and less bonding compared to the conventional hydrophobic pit and fissure sealant. So, this necessitates the rejection the null hypothesis of the present study is that there will be no difference between hydrophilic resin-based fissure sealant and the conventional hydrophobic resin-based fissure sealant material with regard to shear bond strength to the enamel of permanent teeth.

CONCLUSION

Based upon the mentioned results, it was concluded that the hydrophilic resin-based pit and fissure sealant showed lower retention rates and failure in adhesion compared to the conventional hydrophobic resin-based sealant.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

The authors received no specific funding for this work.

REFERENCES

1. Petersen PE. World Health Organization global policy for improvement of oral health-World Health Assembly 2007. Int Dent J 2008; 58:115-21.
2. Reynolds EC. Calcium phosphate-based remineralization systems: scientific evidence? AustDent J 2008; 53:268-73.
3. Seiffert A, Zaror C, Atala-Acevedo C, Ormeño A, Martínez-Zapata MJ, Alonso-Coello P. Dental caries prevention in children and adolescents: a systematic quality assessment of clinical practice guidelines. Clin Oral Invest 2018; 22: 3129-41.
4. Welbury R, Raadal M, Lygidakis N. EAPD guidelines for the use of pit and fissure sealants. EJPD 2004; 5:179-84.
5. Godhane A, Ukey A, Tote JV, Das G, Naphde M, Patil P. Use of pit and fissure sealant in prevention of dental caries in pediatric dentistry and recent advancement: A review. Int J Dent Med Res 2015;1:220-3.
6. Ratnaditya A, Kumar MGM, Avula SS, Jogendra MZ, Kandregula CR, Chowdhary Kopuri RK. Clinical evaluation of retention in hydrophobic and hydrophillic pit and fissure sealants-a two year follow-up study. J Young Pharm 2015;7:171-9.
7. Gawali PN, Chaugule VB, Panse AM. Comparison of microleakage and penetration depth between hydrophilic and hydrophobic sealants in primary second molar. Int J Clin Pediatr Dent 2016; 9:291-5.
8. Cvikl B, Moritz A, Bekes K. Pit and Fissure Sealants—A Comprehensive Review. Dent J 2018; 6:18.
9. Feigal RJ, Donly KJ. The use of pit and fissure sealants. Pediatr Dent 2006; 28:143-50.
10. Dionysopoulos D, Sfeikos T, Tolidis K. Fluoride release and recharging ability of new dental sealants. EJPD 2016; 17:45-51.
11. Bhat PK, Konde S, Raj SN, Kumar NC. Moisture-tolerant resin-based sealant: a boon. Contemp Clin Dent 2013; 4:343-8.
12. GÜÇLÜ ZA, Dönmez N, Hurt AP, Coleman NJ. Characterisation and microleakage of a new hydrophilic fissure sealant-UltraSeal XT® hydro™. J Appl Oral Sci 2016; 24:344-51.
13. Baheti AS, Bhayya DP, Gupta S, Kumar P, Shyagali TR. Assessment of Clinical Success of Three Sealants: Embrace-Wetbond, Clinpro, and Helioseal-F in Permanent Molars: An In Vivo Study Pediatr Dent 2020;3:7-13.
14. Wright JT, Crall JJ, Fontana M, Gillette EJ, Nový BB, Dhar V, et al. Evidence-based clinical practice guideline for the use of pit-and-fissure sealants: a report of the American Dental Association and the American Academy of Pediatric Dentistry. J Am Dent Assoc 2016; 147:672-82.
15. Beauchamp J, Caufield PW, Crall JJ, Donly K, Feigal R, Gooch B, et al. Evidence-based clinical recommendations for the use of pit-and-fissure sealants: a report of the American Dental Association Council on Scientific Affairs. J Am Dent Assoc 2008;139:257-68.
16. Pardi V, Pereira AC, Mialhe FL, de Castro Meneghim M, Ambrosano GMB. A 5-year evaluation of two glass-ionomer cements used as fissure sealants. Community Dent Oral Epidemiol 2003;31:386-91.
17. Askarizadeh N, Heshmat H, Zangeneh N. One-year clinical success of embrace hydrophilic and helioseal-f hydrophobic sealants in permanent first molars: a clinical trial. J Dent 2017;14:92-99.
18. Quaglio JM, Sousa MB, Ardenghi TM, Mendes FM, Imparato JCP, Pinheiro SL. Association between clinical parameters

and the presence of active caries lesions in first permanent molars. Braz Oral Res 2006; 20:358-63.

19. Khatri SG, Samuel SR, Acharya S, Patil S, Madan K. Retention of moisture-tolerant and conventional resin-based sealant in six-to nine-year-old children. Pediatr Dent 2015;37:366-70.
20. Topal B, Kirzioglu Z. Evaluation of the fissure sealants applied to erupting permanent molars in accordance to eruption stages: A prospective study. Niger. J Clin Pract 2019; 22:1495.
21. Schlueter N, Klimek J, Ganss C. Efficacy of a moisture-tolerant material for fissure sealing: a prospective randomised clinical trial. Clin Oral Invest 2013; 17:711-6.
22. Marghalani HY. Sorption and solubility characteristics of self-adhesive resin cements. Dent Mater 2012;28: e187-e98.
23. Nazir MA, Bakhurji E, Gaffar BO, Al-Ansari A, Al-Khalifa KS. First Permanent Molar Caries and its Association with Carious Lesions in Other Permanent Teeth. J Clin Diagn Res 2019;13:36-9.
24. Prabhakar A, Dahake PT, Raju O, Basappa N. Fluoride: is it worth to be added in pit and fissure sealants? Int J Clin Pediatr Dent 2012; 5:1-5.
25. Marimuthooa T, Asfarb NAM, Rahmanb MA, MP SN. In-vitro comparative study of marginal leakage and penetration ability of moisture-tolerant and conventional resin-based pit and fissure sealants with different surface preparations. Arch Orofac Sci 2017; 12:12-22.
26. Bhatia M, Patel A, Shirol D. Evaluation of two resin based fissure sealants: a comparative clinical study. J Indian Soc Pedod Prev Dent 2012; 30:227-30.
27. Mesquita-Guimarães KSFd, Sabbatini IF, Almeida CGd, Galo R, Nelson-Filho P, Borsatto MC. Bond strength of a bisphenol-a-free fissure sealant with and without adhesive layer under conditions of saliva contamination. Braz Dent J 2016; 27:309-12.
28. Eliades A, Birpou E, Eliades T, Eliades G. Self-adhesive restoratives as pit and fissure sealants: a comparative laboratory study. Dent Mater 2013; 29:752-62.
29. Rosner B. Fundamentals of biostatistics. (international student edition). Belmont, CA: Thompson 2006.
30. Ku J, Lee J, Ra J. In vitro evaluation of microleakage and penetration of hydrophilic sealants applied on dry and moist enamel. J Korean Acad Pediatr Dent 2017;44(3):272-9.
31. 36.Babaji P, Vaid S, Deep S, Mishra S, Srivastava M, Manjooran T. In vitro evaluation of shear bond strength and microleakage of different pit and fissure sealants. J Int Soc Prev Community Dent 2016;6: S111-5.
32. Kirkpatrick L, Feeney B. A simple guide to IBM SPSS: for version 20.0: Nelson education; 2012.
    Alsabek L, Al-Nerabieah Z, Bshara N, Comisi JC. Retention and remineralization effect of moisture tolerant resin-based sealant and glass ionomer sealant on non-cavitated pit and fissure caries: Randomized controlled clinical trial. J Dent 2019; 86:69-74.
33. Ataol E, Ertan A, Cehreli ZC, Technology. Sealing effectiveness of fissure sealants bonded with universal adhesive systems: influence of different etching modes. J Adhes Sci Tech 2017; 31:1626-34.
34. Eid SA, Khattab NMA, Elheeny AAH. Untreated dental caries prevalence and impact on the quality of life among 11 to14-year-old Egyptian schoolchildren: a cross-sectional study. BMC Oral Health 2020;20:1-11.
35. Panse AM, Nair MC, Patil AS, Bahutule SR. Comparison of microleakage, bond strength, and fracture strength of no etch no bond novel flowable composite as a pit and fissure sealant in comparison to the conventional sealants: an in vitro study. Int J Pedod Rehabil 2018; 3:28-32.
36. Prabhakar A, Murthy SA, Sugandhan S. Comparative evaluation of the length of resin tags, viscosity and microleakage of pit and fissure sealants–An in vitro scanning electron microscope study. Contemp Clin Dent 2011; 2:324-30.
37. de Abreu CW, Duarte Filho G, Kojima AN, Jóias RM, Mesquita AMM. Evaluation of crosshead speed influence on shear bond strength test. Braz Dent Sci 2014; 17:50-3.
38. Lindemuth JS, Hagge MS. Effect of universal testing machine crosshead speed on the shear bond strength and bonding failure mode of composite resin to enamel and dentin. Mil Med 2000; 165:742-6.
39. Fleisch AF, Sheffield PE, Chinn C, Edelstein BL, Landrigan PJ. Bisphenol A and related compounds in dental materials. J Pediatr 2010; 126:760-8.