Microleakage of Sealants Resin Composite Materials

An *in vitro* study

CATALINA IULIA SAVEANU*, ONUTA CONSTANTIN, CATALINA DANILA, VLAD DANILA, DANIELA ANISTOROAEI
University of Medicine and Pharmacy Grigore T.Popa, Faculty of Dental Medicine, 16 Universitatii Str., Iasi, 700115, Romania

The purpose of this in vitro study was to evaluate and compare the degree of microleakage of the enamel-sealants interface when used four different materials. Analysis of the penetration of sealing materials shows that they adhere different to the enamel and the characteristics of resin composite materials used in clinical practice as sealants, influencing dental material penetration to the surface once the viscosity of the inorganic filler.

Keywords: micro leakage, sealant, resin composite, prevention, permanent teeth

World Health Organization proposes for 2015 that the index DMFT at age 12 to be one. Those in the last decade the modern dentistry has become focused on primary measures prevention [1]. Dental sealants, and also pit and fissure sealants termed by Hiiri, Ahovuo-Saloranta, Nordblad and Mäkelä (2010) [2] or simply fissure sealants termed by Scheller-Sheridan 2013 [3] are a dental treatment intended to prevent tooth decay. Dental sealants are mainly used in children who are at higher risk of tooth decay, and typically they are placed as soon as the adult molar teeth come through [4]. White & Eakle (2000) stated that the fissure sealants are a preventive treatment that is part of the minimal intervention dentistry approach to dental care. [4, 5] The aim of fissure sealants is to prevent or arrest the development of dental caries [4,6]. Any sign of microleakage in sealants is considered as the weak point eventually leading to failure as the ireability to isolate pit and fissures would enhance the retention of bacteria, nutrients and their acidic metabolis products [7-10]. Pumice prophylaxis has used prior to the sealant application [7, 12, 13] with its effect on microleakage being mostly reported as beneficial [7, 14-16]. Many studies reported that there is no difference in microleakage level of the teeth between the methods of the dental preparation. [7, 9, 17-21].

In 1966, E.I. Cueto created the first sealant material, which was methyl cyanoacrylate [4, 22, 23]. Bunonocore made further advances in 1970 by developing bisphenol-a glycidyl dimethacrylate, which is a viscous resin commonly known as BIS-GMA [4, 23]. In 1974, glass ionomer cement fissure seals (GIC) were introduced by J.W. McLean and A.D. Wilson. [4, 23] Modern dental sealants generally are either resin based or glass ionomer (GI) based. Hybrid materials such as polyacid modified resin (*compomer*) which lies between these two categories [2, 4]. It is customary to refer to the development of resin based sealants in generations: [4, 23, 24] first generation: cured (set) with ultraviolet light [4, 24]; second generation: chemical-curing (auto polymerized) [4, 23, 24]; Third generation: visible light–cure [4, 23, 24]; fourth generation: contain fluoride [4, 23, 24]. In these conditions Curson et al. reported in their study that 89% of dentists sealed teeth at caries risk and 46% recommended pit and fissure sealing for teeth without carious risk [25]. Our studies concluded that the key to success for a good retention is the ability of sealing material to entry into dental surface with a maximal contact between substrate and material [6, 7]. Also the ability of a dental sealants to prevent the dental caries is based on the retention of the material, the content of fluoride and the ability to resists in the oral environment to the mechanical stresses as well as the various physical and chemical aggression [6, 7]. On the basis of limited evidence both GI and resin materials are equally acceptable in caries prevention, however retention rates between GI and resin have been shown to differ [26]. Resin has been shown to be the superior product for retention. A 2-year clinical trial comparing GI and Resin for fissure sealants demonstrated that the GI had a total loss rate of 31.78%, in contrast to the resin which had a total loss rate of 5.96% [27]. Also the photo activation source is very important. Although, Stritikus & Owens (2000) stated that the micro leakage of sealants and resin restorations utilizing two different curing lights is higher with Plasma Arc Curing with 1196 mW/cm2 power comparative with the conventional Ortholux curing light and they conducted that the conventional curing light appears to remain the best choice for polymerizing composite materials [28]. The aim of this study was to assess the microleakage for four different sealant resin composite materials after acid etching treatment.

Experimental part

The study was conducted in vitro, on the human molars and premolars extracted for orthodontic reasons. Four materials sealed were investigated as listed in table 1. For all materials we used adhesive system 3M™ Schotchbond Etch, MetaBond2 (Metabiomed) in accordance with the manufacturer.

The samples were studied by obtaining of the informed consent of the patient's. Samples were randomly divided into equal four groups (GR) and were sealed as follow: GR.1 = Fissurit® FX; GR.2 = DEFENSE CHROMA; GR.3 = WAVE (SDI, Australia); GR.4 = PermaFlo™.

The fissures were prepared mechanically by enlargement with a small round diamond bur at high speed. The teeth were sealed using adhesive system 3M™ Schotchbond Etch, MetaBond2 (Metabiomed) in accordance with the manufacturer. The samples were photoactivated with halogen lamp (QTH), with power by 570mW / cm^2 (3MESPE), sealed apically and coated with nail varnish 1 mm from the margin, stored in 1% methylene blue for 48 h at room temperature, cuted mesial-distal (with diamond disks), finished and then conditioned with H_3PO_4 37% for s. After exposure the images were immediately digitized and analysed.

Evaluation of the marginal leakage was done giving the following scores [7, 29]:

0 = no marginal leakage was present;

* *email:cisaveanu@prevod.umfiasi.ro; daniulia05@yahoo.com; Phone:(+40)745 701535*

Brand Name	Manufacturer	Filler content (v/v)	Composition/ Matrix
Fissurit® FX	VOCO GmbH Cuxhaven Germany	55%	TEGDMA 10-25%; UDMA 10-25%; Bis-GMA 5-10%; Bis-EMA 5-10%; NaF ≤2.5%
DEFENSE CHROMA	ANGELUS®, Brasil	50%	Bis-GMA; Modified urethane; TEGDMA; Barium aluminum borosilicate; Tetra-acrylic ester; Phosphoric acid; NaF;N-Methyl diethanolamine;Camphorquinone
WAVE	SDI, Bayswater, Australia	63%	Bis-GMA, UDMA
PermaFlow™	Ultradent, Products	68%	TEGDMA ≤225%; Bis-GMA 10%; MFP 0.3%

Table 1
LISTS OF MATERIALS INVESTIGATED

1 = microleakage to the external half of the enamel-sealant interface;

2 = microleakage extending more than of the inner half of the enamel-sealant interface;

3 = microleakage extending into underlying fissure.

Results and discussions

Analysis of the leakage for the sealing materials pointed out that they adhere different to the substrate of the enamel. The best adhesion of the material was obtained for the material Fissurit® FX (VOCO, Germany) (fig.1) compared to other groups samples (fig. 2).

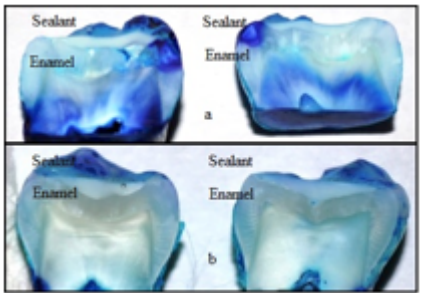

Fig. 1. Image of the interface between the enamel and - FX Fissurit® (VOCO, Germany)- microleakage score 0 (a) and (b)

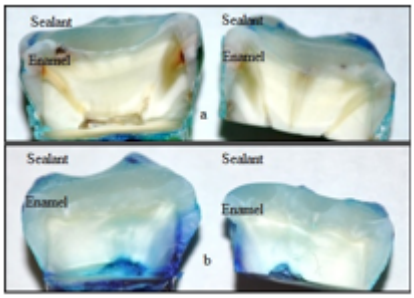

Fig. 2. Image of the interface between the enamel and - DEFENSE CHROMA (ANGELUS®, Brasil) - microleakage score 1 (a) and (b)

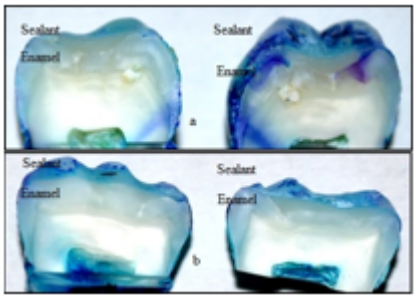

Fig. 3. Image of the interface between the enamel and - WAVE (SDI, Australia - microleakage score 1 (a) and (b)

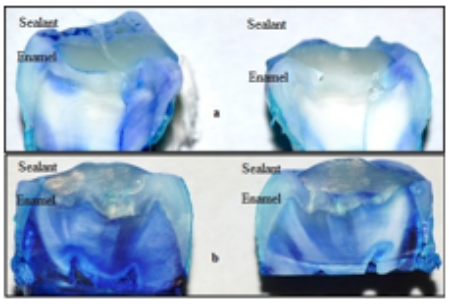

Fig. 4. Image of the interface between the enamel and - PermaFlo™ (Ultradent, USA) - microleakage score 3 (a) and (b)

The surfaces examined of the GR1 - FX Fissurit® (VOCO, Germany) had the best score - 0, which indicates that it does not present microleakage comparative with the samples for GR. 2 - DEFENSE CHROMA (ANGELUS®, Brasil) and for GR. 3 WAVE (SDI, Australia) with a score by 1, respectively microleakage to the external half of the sealant. For GR 4 - PermaFlo™ (Ultradent, USA) a single sample presented a maximum microleakage respectively score 3 which shows a microleakage extending to the fissure sealed. The low viscosity of the sealants allow good wetting of the dental surface. The four composite resin materials showed a different viscosity, depending on the percentages of inorganic fillers: Fissurit® FX – 55%, DEFENSE Chrome - 50% WAVE - 63% and PermaFlo™ - 68%. Fissurit FX are many advantage - filler content of 55% for outstanding abrasion proofness, quick and easy application from the direct-application syringe with bendable metal cannulae, optimal flow properties, high stability and good adhesion to enamel, perfect marginal adaptation, continuous fluoride release and is easy for detection by visual control conform with the manufacturer recomandation. Beresescu &Pacurar (2013) reported for the Fissurit FX material, an immediate retention of 100% at baseline, 91.52% at one year and 79.40% at two years [30]. The resin with a small percent of filler has a maximum fluidity and allowed a good penetration of the dental surface level, achieving a score 0 for microleakage. Also, the smaller diameter of the particles increases the area surfaces with organic matrix and increasing the viscosity of the material [3], and also the microleakage. Physical structure and the particle of the filler are very important for a good umectability of the dental substrat [6, 31]. Romanu et al. (2000) found that the modulus of elasticity (E) of the resin composite *flowable* is low. The adhesives with more particles of fillers are stiffer than most little or no charge [32]. Labella et al. (1999) concluded that the kinetic behaviour of resin composite at polymerization is dependent on the material used mainly characterized by almost linear shrinkage coefficient between 10-40% of the final value of contraction and time required to achieve 75% of the final contraction [29]. Mehl et al., (1997) found that the viscoelasticity it's very important and lead to better marginal integrity and those we opted for a photoactivation source with a lower rate of polymerization [34]. Also, in another study Saveanu & Dragos (2015) found it there were differences in surface roughness AFM (Park SYSTEMS XE -100) among the sealants but their values were significantly different in favor of resin composite with nanofiller 68%, and with Bis-GMA. For this material the analysis of the surface roughness [nm] for 5 µm obtained from AFM images was for Rzl 44.10 nm, comparative with resin composite with 55% filler Rzl=65.63 nm, and with resin composite with 50% filler

Rzl=164.76 nm, and for resin composite with nanofiller 63% and with UDMA Rzl =119,87 nm [35]. This is the explanation for a grand score of microleakage, respectively 3. Agrawal A. and A. Shigli [31] in their reviewed about in vitro of the microleakage achieve optimal results - 100% microleakage with score 0 for widening fissure system with spherical cutters in all samples and 85% microleakage with score 0 absent from all samples for abrasion with air and sodium bicarbonate powder.

Therefore, the ability of composite resin materials, used as sealants, preventing tooth decay is not limited to their physical, chemical, mechanical, rheological and biological but also technique dental cleaning and surface preparation [36-38].

Fissure geometry, residual particles, and the air remaining in the fissure can help limit penetration of the sealant. In this study the fissure of the teeth were prepared by using a spherical diamond cutters, and then was applied the adhesive system with 35% phosphoric acid, and than sealing material. Even so, 68% of filler content for PermaFlo™ proved to be too high for a good penetration into enamel substrate, achieving a score 3 for micro-leakage. Conditions of the study differs in vivo, such evidence is not subject to mechanical stress, temperature variations, be made under similar conditions of oral bio-chemical environment, they are kept at room temperature immersed in 1% methylene blue, 48 hours. However favorable results can guide the clinician in selecting a sealant performance.

Conclusions

Given the results of the current study, further investigations on the microleakage of sealants materials are warranted. Within the limitations of this study it was concluded that the characteristics of resin composite materials used in clinical practice as sealants influence the penetration of the material on the viscosity of inorganic fillers and the composite resins with less filler had the best scores of microleakage.

References

1.VIJAYARAGHAVAN,R., RAO,V.A., REDDYN.V., KRISHNA-KUMAR R., SUGUMARAN,D.K., MOHAN,G., Assessment and comparison of microleakage of a fluoride-releasing sealant after acid etching and Er:YAG laser treatment – An in vitro study Contemp Clin dent **3**(1), 2012, E-ISSN 0976-2361, p. 64-8.

2.HIIRI, A; AHOVUO-SALORANTA, A; NORDBLAD, A; MAKELA, M. Pit and fissure sealants versus fluoride varnishes for preventing dental decay in children and adolescents. The Cochrane database of systematic reviews Vol.3 March 2012.

3.SCHELLER-SHERIDAN, C. Basic Guide to Dental Materials. John Wiley & Sons. May 2013 ISBN 978-1-118-70831-6, p. 74–78. .

4.*** https://en.wikipedia.org/wiki/Dental_sealant.

5.WHITE J.M., & EAKLE W.S. Rationale and Treatment Approach in Minimally Invasive Dentistry. Journal of the American Dental Association 2000.

6.SAVEANU, C.,I., Plastic materials used in the dental caries prevention. Morpho-functional characteristics. Iasi, Romania, Gr.T.Popa Publishing 2011 ISBN 978-606-544-083-8

7.BAGHERIAN,A., AKBARI,M., REZAEIAN,M., AND ANSARI,G., Microleakage assessment of fissure sealant following fissurotomy bur or pumice prophylaxis use before etching Dent Res J (Isfahan); **10**(5): 2013, p.643–646.

8.GOING, R.E., LOESCHE, W.J., GRAINGER, D.A., SYED, S.A. The viability of microorganisms in carious lesions five years after covering with a fissure sealant. J Am Dent Assoc. **97**:1978, p.455–62.

9.HATIBOVIC-KOFMAN, S., BUTLER, S.A., SADEK, H., Microleakage of three sealants following conventional, bur, and air-abrasion preparation of pits and fissures. Int J Paediatr Dent. **11**:2001, p.409–16.

10. KIDD, E.A., Microleakage: A review. J Dent.**4**: 1976, p.199–206.

11.ASKARIZADEH,N., NOROUZI, N.,NEMATI, S.The effect of bonding agents on the microleakage of sealant following contamination with saliva J Indian Soc Pedod Prev Dent. **26**:2008, p.64–6.

12.BROCKMANN, S.L., SCOTT, R.L., EICK, J.D., A scanning electron microscopic study of the effect of air polishing on the enamel-sealant surface. Quintessence Int.**21**: 1990, p. 201–6.

13.CUETO, E.I., BUONOCORE, M.G., Sealing of pits and fissures with an adhesive resin: Its use in caries prevention.J Am Dent Assoc. **75**:1967 121–8.

14.BLACKWOOD,J.A.,DILLEY,D.C.,ROBERTS,M.W.,SWIFT,E.J.,JR Evaluation of pumice, fissure enameloplasty and air abrasion on sealant microleakage Pediatr Dent**24**:2002,p.199–203.

15.ANSARI, G., OLOOMI, K., ESLAMI, B., Microleakage assessment of pit and fissure sealant with and without the use of pumice prophylaxis. Int J Paediatr Dent. **14**:2004, p. 272–8.

16.SELECMAN, J.B., OWENS, B.M., JOHNSON, W.W., Effect of preparation technique, fissure morphology, and material characteristics on the in vitro margin permeability and penetrability of pit and fissure sealants. Pediatr Dent. **29**:2007, p.308–14.

17.HATIBOVIC-KOFMAN, S., WRIGHT, G.Z., BRAVERMAN, I., Microleakage of sealants after conventional, bur, and air-abrasion preparation of pits and fissures. Pediatr Dent.**20**:1998,p.173–6

18.COURSON, F., RENDA, A.M., ATTAL, J.P., BOUTER, D., RUSE, D., DEGRANGE, M., In vitro evaluation of different techniques of enamel preparation for pit and fissure sealing. J Adhes Dent. **5**: 2003, p. 313–21

19.GRANDE, R.H., BALLESTER, R., SINGER, J.M., SANTOS, J.F., Microleakage of a universal adhesive used as a fissure sealant. Am J Dent. **11**: 1998, p.109–13.

20.FUKS,A.B., GRAJOWER,R., SHAPIRA,J. In vitro assessment of marginal leakage of sealants placed in permanent molars with different etching times ASDC J DentChild**51**:1984,p.425–7.

21.RUDOLPH, J.J., PHILLIPS, R.W., SWARTZ, M.L., In vitro assessment of microleakage of pit and fissure sealants. J Prosthet Dent. 1974;**32**:62–5.

22.AVINASH,J.; MARYA,C.M.; DHINGRA,S.; GUPTA,P.; KATARIA,S.; MEENU,BHATIA, H. P. Pit and Fissure Sealants: An Unused Caries Prevention ToolJ Oral Health Comm Dent **4**(1) 2010: p.1–6

23.AHOVUO-SALORANTA, A; FORSS, H; WALSH, T; HIIRI, A; NORDBLAD, A; MAKELA, M; WORTHINGTON, HV (28 March 2013). Sealants for preventing dental decay in the permanent teeth. The Cochrane database of systematic reviews **3**: March 2013

24.HIREMATH, S.S.,. Textbook of Preventive and Community Dentistry. Elsevier India. 2011, April, p. 428–432. ISBN 978-81-312-2530-1.

25.COURSON, F., VELLY, A.M., DROZ, D., LUPI-PEGURIER, L., MULLERBOLLA, M., Clinical decision on pit and fissure sealing according to the occlusal morphology. A descriptive study. Eur J Paediatr Dent. Mar;12(1):2011 p.43-9.

26.SETH, S., Glass ionomer cement and resin-based fissure sealants are equally effective in caries prevention (PDF). JADA **142** (5):2011 p.551-2.

27.BEUN, S.; BAILLY, C.; DEVAUX, J.; LELOUP, G. Physical, mechanical and rheological characterisation of resin-based pit and fissure sealants compared to flowable resin composites. Dental Materials **28** (4): 2012 p.349-59.

28.STRITIKUS, J., OWENS B., An in vitro study of microleakage of occlusal composite restorations polymerized by a conventional curing light and a PAC curing light. J Clin Pediatr Dent. Spring; **24**(3) 2000 p. 221-227.

29.SĂVEANU, I., TODIRASCU, A., MAFTEI, I, & DĂNILĂ I., The influence of The Etching Time On The Enamel Hybridization In Preventive Sealing. In vitro study Romanian Journal of Oral Reabilitation December; **3**(4):2011, ISSN 2066-7000 p.84-9

30.BERESESCU L., PACURAR M., Clinical assessment of the efficiency of two pit and fissure sealants. AMT; **2**(1):2013, p. 301-3.

31.SAVEANU C.I., DRAGOS O., CHIRIAC H. Correlation between morphology, structure and composition at the glass ionomer bioadhesive materials, JOAM, **14**(7-8): 2012, p.826-34.
32.ROMINU, M., BRATU, D., LAKATOS, S., ZENO, F., Polymerization in dentistry, Brumar Publishing, Timi^{o}oara 2000.
33.LABELLA, R., LAMBRECHTS, P., VAN MEERBEEK, B., VANHERLE, G., Polymerization shrinkage and elasticity of flowable composites and filled adhesives, Dental Materials, Publishing **15**, 1999, p.128-37.
34.MEHL, A., HICKLE, R., KUNZELMANN, K.H., Physical properties and gap formation of light cured composites with and without "soft start polymerization, J Dent **25**, 1997, p. 321-30.
35.SAVEANU C.I., DRAGOS O., Atomic Force Microscopy study for assessing the characteristics of news materials sealants IJAR, Vol. **5** No.3, 2015 pg.562-564.
36.MONEA, M., STOICA, EAl., BECHIR, E.S., BURCEA , Al., PANGICA, A.M., In Vitro Study on the Sealing Ability of Mineral Trioxide Aggregate, Mat.Plast., **53**, no.1, 2016, p.6
37. SAVA ROSIANU, R., SINESCU, C., NEGRUTIU, M.L., HOSSZU, T., TUDOR, A., PODARIU A. C., Microscopic Assessment of the Enamel Etching Pattern According to Different Etching Times Using Orthophosphoric Acid Gels Mat.Plast., **53** no.1, 2016, p.153
38 MUNTEAN,A., MESAROS,A., FESTILA, D., MOLDOVAN, M., MESAROS,M., In Vitro Microleakage Evaluation Around Three Types of Dental Sealants Mat.Plast., **53,** no.1, 2016, p.166

Manuscript received: 4.05.2016