Evaluation of Sealing Materials Adhesion to Enamel

An *in vitro* study

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Sealing the pits and fissures of posterior teeth represents a local and specific method of caries prevention. The aim of this study was to evaluate the adhesion of two materials used in sealing pits and fissures: Pitt and Fisure and Fissurit FX (Voco), with the help of the scanning electronic microscope (SEM). The results of the study revealed a much higher quality of the Fissurit FX (Voco) product both in terms of adhesion to the enamel and material homogeneity. The Pitt and Fisure product showed a high degree of detachment from the enamel, marginal infiltration, large particles and a high concentration of inorganic particles.

Keywords: prevention, sealing material, SEM, adhesion

Oral hygiene has an incontestable importance throughout the life time. During childhood, general and local particularities in relation with age impose specific measures dental caries prevention. In addition to a correct hygiene, an adequate diet, a local and/or general fluorine usage reduces the risk of dental caries in children. Local prevention of dental caries, immediately after tooth eruption, is done either with the help of fluorinated gels, either with the help of sealants applied in the pits and fissures of posterior teeth. Immature permanent, but also temporary posterior teeth, can present anfractuous surfaces. This crown morphology enables food retention and the initiation of the caries process, if no prophylactic measures are taken [1-7]. Early enamel lesions have a potential to re-mineralize and prevent caries progress [8]. Fissure caries is most common in children due to deep pit and fissures. Pit and fissure areas on the occlusal surface of the teeth make them susceptible to dental caries, which need to be prevented or restored [9]. Caries continues to represent a major problem affecting all age groups, including children and adolescents, being the most prevalent disease worldwide. Pit and fissure sealants are a safe and effective way to prevent dental caries. This is the reason why a very high number of sealants, both composite materials and ionomer cements, is available on the market, at relatively comparable prices and frequently it is difficult to choose from among them [10].

We used in our research two sealants, Pit and Fisure sealant (DMP) and Fissurit FX (Voco) sealant (fig. 1).

Fig. 1. The two sealants used in the research

Pit & Fissure Sealant (DMP) is a radiopaque fluoride releasing light curing sealant for primary or permanent teeth. It is used in preventive dentistry where it has been clinically proven that sealants are effective in the prevention of caries. The fluoride that is released offers an additional protection against caries and its ideal viscosity allows it to penetrate into the deepest pits and fissures to ensure total sealing [11].

The sealant *Fissurit FX (Voco)* is a white light-curing fissure sealant with fluoride, and high filler content (>50%)., indicated for sealing of fissures and occlusal surfaces for caries prophylaxis, for sealing of extended fissures, sealing composite or cement fillings and for filling of small cavities and for sealing deciduous teeth, etc. At 55 % by weight, Fissurit FX is the most highly microfilled fissure sealant in its class after Grandio Seal [12].

Contains sodium fluoride, Bis-GMA, diurethane dimethacrylate and benzotriazolderivate (fig. 2).

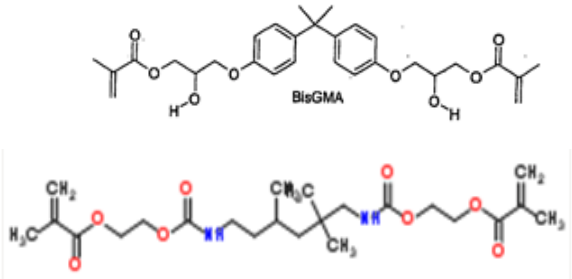

Fig. 2. Chemical structure of Bis-GMA (a) [12] and of diurethane dimethacrylate (b) [13]

The purpose of this study was to evaluate the adhesion of sealing materials applied on the enamel of the pits and fissures.

Experimental part

Material and method

The study was carried out on 20 premolars, which were extracted during orthodontic treatments in young patients.

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The selected teeth presented no caries lesions and no erosions on the enamel surface.

The teeth were divided into two groups, one for the sealant Pit and Fissure (DMP) and one for the sealant Fissurit FX (Voco).

The realization of this study respected all the stages of the posterior teeth sealing: professional cleaning, isolation, etching with 37% phosphoric acid, washing, drying and sealant application according to the manufacturer instructions.

The extracted and sealed teeth were held in artificial saliva for 14 day, at 37°C, for aging. After this period of time, the teeth were rinsed with water, and then immersed in 3% Methylene Blue substance for 24 h. After they were taken out of the solution of dye, the teeth were washed several times and then were left in the air to dry for a few minutes.

All the teeth were embedded in acrylic resin and then left untouched for one day. Afterwards the teeth were sliced in 1mm strips with the help of the sample slicing machine.

The equipment used for this study was the Scanning Electronic Microscope INSPECTS IN CO (SEM)-FEI Company, IsoMet1000- biomaterials sample slicing machine, and Stereomicroscope STEMI 2000C.

For the study with the Scanning Electronic Microscope (SEM), the tooth slices in figure 3 were chosen.

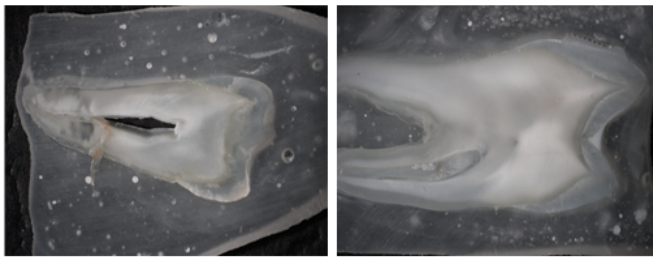

Fig 3. Optical microscopy immage of a tooth slice sealed with the *Pitt and Fissure - DMP* (left) *Fissurit FX - Voco* (right) sealant on which the SEM images have been recorded

Results and discussions

In figure 4-a, we can visualize the SEM image of a tooth slice sealed with the Pitt and Fissure sealant at a x100 magnification factor, and we can observe a slight detachment of the sealant at the interface with the enamel. The detachment might be explained either by a weak adhesion of the sealant to the enamel, either by an improper sealing technique or the detachement of the sealant during the tooth slicing.

Subsequently, at a larger magnification factor (x500), in the case of the SEM image in figure 4-b, we can see in a much closer plane, numerous fissures at the interface of the sealant with the enamel. We can also observe numerous inorganic particles of 50-60 μm in the sealing material structure.

If we move the image on the other side of enamel/ sealant interface (fig.5-a) we can observe a much larger detachment of the sealing material, and also large inorganic particles in the sealing material. Restricting the studied aria (at an x1000 magnification factor) we can see more details of the structure and of the composition of the sealing material (fig. 5-b).

We can assume that the detachment of the sealant off the enamel surface could be owed to the sealants' composition, which determines a weak adhesion.

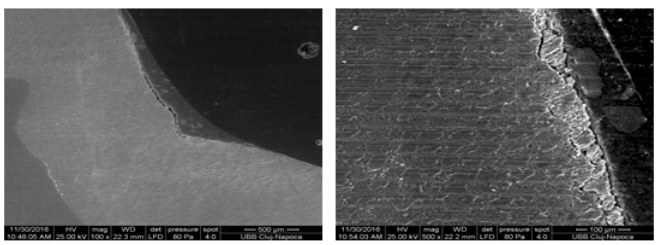

Fig 4. SEM image of a tooth sclice sealed with the *Pit and Fissure sealant –DMP* at x100 magnification (a) and at x500 magnification (b)

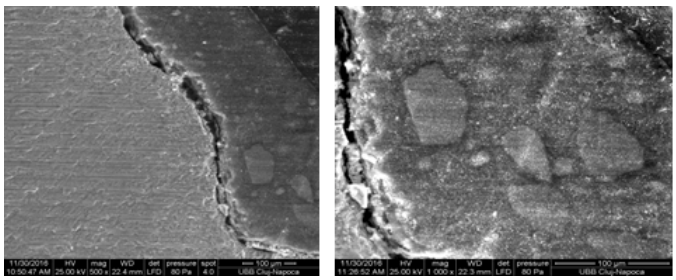

Fig 5. SEM immage of a tooth sclice sealed with the *Pit and Fisure sealant - DMP* at x500 magnification (a) and at x1000 magnification (b)

In figure 6 we can visualize the SEM image of a tooth slice sealed with the Fissurit FX (Voco) sealant at a x100 magnification factor, and we can observe a uniform sealing with very fine cracks, probabely due to the slicing of the tooth.

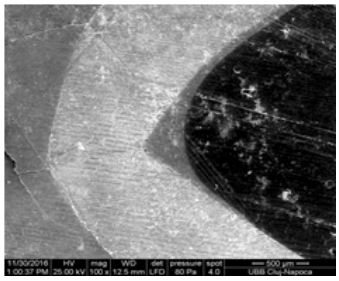

Fig. 6. SEM image of a tooth sclice sealed with the *Fissurit FX - Voco* sealant (x100 magnification)

In figure 7-a and figure 7-b, at higher magnification factor (x500, respectively x1000) we can observe a fine sealant/ enamel interface. The sealing material adheres almost perfectly to the enamel surface and it shows a surface on which we can see very small inorganic particles (of maximum 2-3 μm in dimensions) and also agglomerates of inorganic particles of very small dimensions.

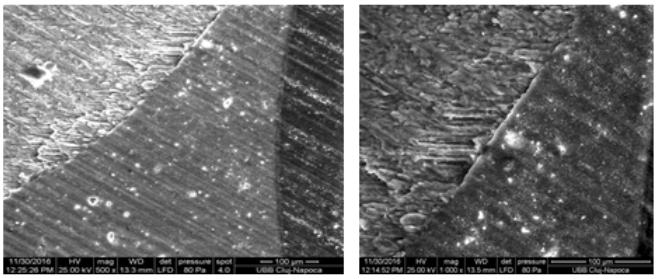

Fig 7. SEM image of a tooth sclice sealed with the *Fisurit FX sealant - Voco* at a x500 magnification (a) and at x1000 magnification (b)

In figure 8 we can very clearly see at a x2500 magnification, the sealant/enamel interface, respectively the permeation of the sealat in the microretentivities of the enamel.

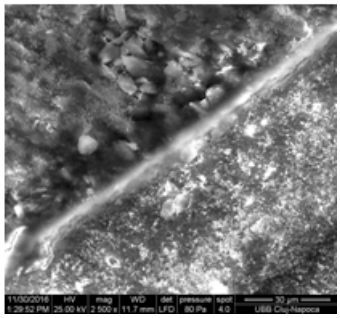

Fig 8. SEM image of a tooth sclice sealed with the *Fisurite FX sealant - Voco* (x2500 magnification)

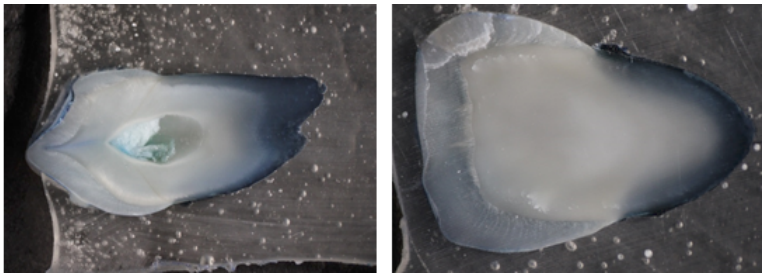

Fig 9. a) Optical microscopy image of a tooth slice sealed with the Pitt and Fisure sealant after immersion in the 3% Methylene Blue substance; b) Optical microscopy image of a tooth slice sealed with the Fissurit FX (Voco) sealant after immersion in the 3% Methylene Blue substance

Also, an important part of the adhesion of the sealant to the enamel is the etching of the tooth surface, with the purpose of creating microretentivities (microfissures) in which the sealant can permeate. If the sealing material has a uniform composition and a very fine inorganic filling, it will be able to easily permeate the microfissures created in the enamel by the etching, and therefor ensure an adequate adhesion.

Figure 9 also shows an obvious marginal infiltration in the case of the tooth slice sealed with the Pitt and Fissure sealant-DMP (a) caused by the interface fissures, and the lack of marginal infiltration in the case of the tooth slice sealed with Fissurit FX-Voco (b).

Pitt and Fissure sealant (DMP) contain large particles and a high concentration of inorganic substances.

This study revealed a higher degree of detachment on a restricted area at x1000 magnification (50%) for the Pitt and Fisure sealant (DMP). The Fissurit FX (Voco) sealant shows an extremely reduced detachment (2%) at the same magnification factor of the SEM.

The better adhesion of the Fissurit FX (Voco) material is due to the homogeneity of the material and the very small dimensions of the inorganic substances (2-3μm).

A study carried out by the University of Zagreb compared the retention times in the fissure of Fissurit FX and Helioseal Clear Chroma in a 1-year clinical study of retention rates. Fissurit FX had the highest retention rate of the fissure sealants tested and caries was not observed in any of the teeth treated with Fissurit FX [14,15].

Due to their heterogeneous structure and complex nature it is difficult to classify the dental resins [16].

Fissure geometry, residual particles, and the air remaining in the fissure can help or limit penetration of the sealant [17].

Infiltrants used in sealing present very low viscosity, low contact angles to the enamel and high surface tension are light curable resins that are optimized for rapid penetration into the capillary structures of the lesion [18].

After the researches of Muntean et al [19], the results viewed as the theoretical level of leakage which may or may not occur in vivo, but may be accepted as an aid for selection of a good sealant material before placement of a fissure sealant.

After Reddy et al [20], in vitro methodologies such as the one used in this study have the advantage of quantifying the loss of sealant material, rather than an in vivo approach which would calibrate loss of material as present, partially present or absent.

In vitro methodologies used in the studies have the advantage of quantifying the loss of sealant material, rather than an in vivo approach which would calibrate loss of material as present, partially present or absent [21].

The dental resin based materials used in the study of Bechir et al [22] were deposited with same protocol like in our study, but on the surface of the damaged teeth of patients. Other study of Bechir et al [23], underline that that used dental resins have proven their beneficial qualities.

The researches of Beresescu et al [24], showed that some dental materials are influenced by the acidic environment (artificial saliva with different *p*H) and if the material is protected by the tooth structure, resistance to abrasion will be satisfactory.

In conformity with the study of Saveanu et al [25] in vivo assessment of two resins, most of the differences statistically significant were obtained by analyzing color criterion, generally the diacrylic hybrid composite resin with ceramic particles showing the best scores.

Conclusions

The study revealed an accentuated detachment of the Pitt and Fisure sealant (DMP) and the lack of homogeneity of the material.

Fissurit FX sealant (Voco) presented a higher homogeneity of the material and extremely reduced detachment, owed by the material composition.

Maintaining the good oral hygiene, the periodic inspections, the use of an adequate sealing material and an adequate technique for deposition, lead to an efficient prevention of caries.

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