EVALUATION OF MARGINAL MICROLEAKAGE AND DEPTH OF PENETRATION OF GLASS IONOMER CEMENTS USED AS OCCLUSAL SEALANTS

AVALIAÇÃO DA MICROINFILTRAÇÃO MARGINAL E PROFUNDIDADE DE PENETRAÇÃO DOS CIMENTOS DE IONÔMERO DE VIDRO UTILIZADOS COMO SELANTES OCLUSAIS

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ABSTRACT

Objetive - the aim of this study was to conduct an *in vitro* comparison of marginal microleakage (MM) and the depth of penetration (DP) of glass ionomer cements (GIC) and a resin sealant (RS) into occlusal pit and fissures. Methods - for that purpose, 60 intact third molars were equally distributed to 5 groups: G1 – 37% phosphoric acid / Delton; G2 – 40% polyacrylic acid / Ketac-Molar / nail varnish; G3 – Fuji Plus conditioner / Fuji Plus/ nail varnish; G4 –37% phosphoric acid / Vitremer / Finishing gloss; G5 –37% phosphoric acid / Vitremer prepared with a 1:4 ratio of powder / Finishing gloss. The teeth were submitted to a thermal treatment corresponding to 300 cycles (15 sec, 5/55^{0}C), followed by complete coating with nail varnish, except for 1mm beyond the contour of the sealant. Afterwards, the teeth were immersed in 0.5% basic fuchsine for 24 hours. Thereafter, the teeth were sectioned in buccolingual direction and microscopically analyzed (150x magnification) by means of predetermined scores. The results were subject to the Kruskal-Wallis test. Results - there was no statistical difference between the materials tested in relation to the DP, being that all groups displayed nearly complete filling of the fissures. No sealant material was able to prevent dye penetration; however, the GICs provided better results of MM, with significant difference when compared to the RS. Conclusion – all materials investigated presented a satisfactory degree of penetration into the fissures; however, the glass ionomer cements displayed better performance in the marginal microleakage test compared to the resin sealant.
Uniterms: Pit and fissure sealant; Glass ionomer cements; Marginal microleakage, penetration.

RESUMO

Objetivo - o objetivo deste estudo foi comparar *in vitro* a microinfiltração marginal (MM) e o grau de profundidade de penetração (DP) de cimentos de ionômero de vidro (CIV) e um selante resinoso (SR) em fossas e fissuras oclusais. Materiais e Métodos - para tanto, 60 terceiros molares hígidos foram igualmente distribuídos em 5 grupos: G1- ácido fosfórico 37%/Delton; G2- ácido poliacrílico 40%/Ketac-Molar/esmalte cosmético; G3- Fuji Plus conditioner/Fuji Plus/ esmalte de cosmético; G4 - ácido fosfórico 37%/Vitremer/Finishing gloss; G5- ácido fosfórico 37%/Vitremer diluído na proporção de 1/4 de pó/Finishing gloss. Os dentes foram submetidos a um tratamento térmico correspondente a 300 ciclos (15 seg, 5/ 55^{0}C), seguindo da total cobertura com esmalte cosmético, exceto 1mm além do contorno do material selador, sendo então imersos em solução de fucsina básica 0,5%, por 24 horas. Posteriormente, os dentes foram seccionados vestíbulo-lingualmente, e avaliados microscopicamente (aumento 150X), por meio de escores pré-determinados. Os resultados foram submetidos ao Teste de Kruskal Wallis. Resultados - não houve diferença estatística entre os materiais testados em relação à DP, sendo que todos os grupos apresentaram um preenchimento quase total das fissuras. Nenhum material selador foi apto em impedir a penetração da solução corante, entretanto, os CIVs promoveram os melhores resultados de MM, distinguindo-se significantemente em relação ao SR. Conclusão - Todos os materiais testados apresentaram um grau de penetração satisfatório no interior das fissuras, no entanto, os cimentos de ionômero de vidro demonstraram melhor comportamento no teste de microinfiltração marginal, quando comparado ao selante resinoso.
Unitermos: Selante de fossas e fissuras; Cimentos de ionômero de vidro; Infiltração marginal, penetração.

INTRODUCTION

Several methods recognized by their efficacy in dental caries prevention have been employed so fat, contributing to change the oral health status of the population. For that purpose, besides the utilization of fluorides and patient education, special emphasis is given to the application of pit and fissure sealants, accepted as an important procedure for effective prevention of carious lesions in occlusal surfaces[7,23].

Pit and fissure sealing comprises the application of a resin material, forming a continuous and resistant pellicle that, when perfectly adapted and retained, is able to provide a mechanical barrier that prevents the accumulation of dental plaque [9,21,23,25,26]. According to Mass, et al.[13], the utilization of resin sealants lead to a significant reduction in the level of *Streptococcus mutans* on the occlusal surfaces of molars, being this reduction immediate and sustained by six months after application of the material.

On the basis of the outcomes observed in the literature, which demonstrate the efficacy of pit and fissure sealants, several investigations [1,2,3,4,5,6,7,8,12,15,16,19,22,24,25] have been conducted with different dental materials, aiming at prevention of occlusal caries. The glass ionomer cement has caught the interest of investigators because it is an extremely versatile material due to its properties, such as chemical bonding to enamel, minor polymerization shrinkage, coefficient of thermal expansion similar to that of the tooth structure, and fluoride release at long term to the dental enamel, thus presenting a cariostatic action[10,14,17,18,24]. Seppä and Forss[22] observed that fissures sealed with glass ionomer cement were more resistant to demineralization even after its macroscopic loss, possibly due to a combination between fluoride release to enamel and the presence of remaining material in the bottom of fissures. This was demonstrated by the clinical study conducted by Aranda and Garcia-Godoy[1], which revealed, by means of scanning electron microscopy, that there was considerable wear of the ionomer cement at twelve months postoperatively; however, its presence in the bottom of fissures of all teeth examined was evident.

The evolution in the formula of glass ionomer cements, namely the resin-modified glass ionomer cements, allowed a new option of sealant, providing a priceless contribution for health promotion. According to Sundfeld[25] occlusal sealing with resin-modified ionomers present excellent clinical performance as to retention at the surface, probably due to their ability to effectively penetrate the micropores in the dental enamel etched with phosphoric acid.

The aim of this study was to investigate the effectiveness of utilization of three glass ionomer cements, compared to a resin sealant, with evaluation of the degree of dye leakage in the interface between dental enamel and sealant; as well as the depth of penetration of the materials into occlusal pits and fissures of permanent molars.

MATERIALS AND METHODS

A total of 60 intact permanent third molars, recently extracted due to clinical or orthodontic indication, were included in this study. These teeth were stored in 0.1% thymol solution up to utilization in the study, being randomly distributed to six groups: Group 1 – 37% phosphoric acid for 30 seconds / Delton (Dentsply) / application with probe; 2 – 40% polyacrylic acid for 10 seconds / Ketac-Molar (ESPE) / nail varnish; 3 – Fuji Plus Conditioner for 20 seconds / Fuji Plus (GC-Corporation) / nail varnish; 4 – 37% phosphoric acid for 30 seconds / Vitremer / Finishing gloss (3M); 5 - 37% phosphoric acid for 30 seconds / Vitremer diluted at a ratio of ¼ of powder / Finishing gloss (3M). The occlusal surface was initially cleaned with water jet, air-dried, and the surface was checked as to the integrity of the anatomic structure. The tooth apices of the teeth were obturated with Velvalloy amalgam (SS White). Before sealing, all teeth were subject to prophylaxis with sodium bicarbonate by the appliance Prophy II (Dabi Atlante S. A.). Sealing in Groups 1, 2, and 3 was conducted according to the manufacturers' instructions. For Groups 4 and 5, acid etching was performed with 37% phosphoric acid for 30 seconds, and for Group 5 the powder/ liquid ratio was also altered (¼ of powder / 1 drop of liquid), for the achievement of a more fluid material. Insertion of the material into the fissures was performed with a probe, except for Group 2, which was applied under finger pressure[8].

After sealing, the teeth were kept in deionized water for 24 hours, at a temperature of 37°C. All specimens were thermocycled (300 cycles, immersion for 15 seconds at 5°C and 55°C). The teeth were coated with nail varnish (Maybeline Inc., New York- USA), except for the sealant and 1mm around it, and immersed in 0.5% basic fuchsine solution for 24 hours at 37°C.

The specimens were sectioned in buccolingual direction in a sectioning machine (Labcut 1010 – Extec Corp., Enfield, CT, USA), adding up to 6 to 7 sections per specimen, with an approximate thickness of 0.8 to 1mm. Both aspects of each section were analyzed three times at monthly intervals(by a single examiner, Kappa = 0,9), in a light microscope MITUTOYO TM – 505, with 150x magnification, for qualitative analysis of dye microleakage at the interface between sealant and dental enamel, by means of the scores established by Smales et al.[24]: 0 = no dye penetration; 1 = dye penetration up to ¼ of the fissure; 2 = dye penetration up to half of the fissure; 3 = dye penetration up to ¾ of the fissure, and 4 = complete dye penetration. The depth of penetration of the sealant into pits and fissures was based on the study of Vieira[27], as follows: 0 = shallow, medium and deep fissure with no penetration; 1 = shallow fissure with partial penetration; 2 = shallow fissure with total penetration and medium fissure with partial penetration; 3 = medium fissure with total penetration and deep fissure with partial penetration; and 4 = deep fissure with total penetration (Figure 1A). Data were statistically analyzed by the non-parametric Kruskal-Wallis test and Dunn's test, for comparison of the independent variables, at a significance level of 5% (α=0,05).

RESULTS

The microleakage test at the interface between sealant and tooth structure demonstrated significant statistically difference(p<0, 001) for the different study groups (Table 1). Individual comparisons between groups were performed by the Dunn's test.

The results demonstrated that Group 1 (Delton - Dentsply) presented the highest mean microleakage (3.307), regarded as a very high pattern of dye leakage. In Figure 2(A), it is observed that the dye penetrated into the fissure and reached the interface between the resin sealant and the dental enamel, which was observed in many specimens, some of which with extensive microleakage and dye penetration into the bulk of the sealing material and bottom of the fissure, being that no specimen presented absence of microleakage.

Analysis of the outcomes of depth of penetration of the sealant into pits and fissures according to the statistical data revealed that there was no statistically significant difference (p< 0.05) between the study groups. Observation of the results in Table 2 reveals that the mean penetration of the materials investigated into the pits and fissures was very satisfactory, even considering the maximum and minimum values found.

DISCUSSION

Fissure sealants are among the most effective preventive tools currently available. These materials afford a physical barrier with immediate action to protect the occlusal surface, a zone most susceptible to caries, especially among young children[1,2,7]. These positive features are determined, in party, by their physical properties, and in many ways are proportional to their retention rate in the oral cavity[1,2,7].

The fissure sealant material should be able to remain intact and firmly adherent to the tooth, preventing microleakage. The integrity of the tooth-sealant interface depends on a numbers of factors, such as mechanical and chemical properties of the material, anatomy of the fissure, conditions of the oral cavity, and mastication forces[16].

The results of the present in vitro study indicated that all materials demonstrated some slight degree of margin microleakage after thermocycling. The great microleakage was shown by Delton pit and fissure sealant (group 1), and the best result by the glass-ionomer cements.

However, some studies presented different outcomes[10,12,18,21], being that the resin sealants investigated exhibited small or no dye microleakage at the interface between sealant and dental enamel.

When comparing the performance of resin sealants and glass ionomer cements as to microleakage in sealing procedures, using a similar methodology as the present, Moore, et al.[16] (1995) observed significant difference in relation to dye penetration into fissures; however, the author

TABLE 1- Maximum and minimum values, means and standard deviations achieved by the Kruskal-Wallis test for analysis of marginal microleakage at the interface between dental enamel and sealant

Material	Maximum value	Minimum value	Mean	Standard deviation
Delton	3.980	1.630	3.307a	0.685
Ketac-Molar	0.770	0.120	0.332b	0.205
Fuji Plus	0.630	0.000	0.345b	0.208
Vitremer	0.910	0.000	0.308b	0.279
Vitremer diluted at ¼	3.710	0.040	1.196ab	1.098

H=35.131 with 5 degrees of freedom ($P \leq 0.001$)
Means followed by same letters do not present statistically significant difference

TABLE 2- Maximum and minimum values, means and standard deviations achieved by the Kruskal-Wallis test for analysis of depth of penetration of the sealant into pits and fissures

Material	Maximum value	Minimum value	Mean	Standard deviation
Delton	3.900	3.060	3.618a	0.297
Ketac-Molar	4.000	3.430	3.646a	0.149
Fuji Plus	4.000	3.050	3.618a	0.280
Vitremer	3.750	3.090	3.410a	0.202
Vitremer diluted at ¼	3.910	3.110	3.559a	0.243

H= 10.589 with 5 degrees of freedom (p=0.060)
Means followed by same letters do not present statistically significant difference

highlight that fluoride-releasing sealants provide better protection when compared to sealants that provide only a physical barrier.

The results of the present study point a good performance of glass ionomer cements in relation to dye leakage at the interface between dental enamel and sealant (Figures 2(B) and 3(A,B,C)), which may be associated to the physicochemical characteristics of the material, thus making it an excellent option as a material for pit and fissure sealing[6,25].

There was no significant difference in the degree of marginal microleakage between the conventional and resin-modified glass ionomer cements (Figures 3B and 2B), and also between luting cements and restorative (Figures 3A and 2B). Specimens with mild dye microleakage were observed in these groups, with higher frequency along the enamel margins, many of which with no microleakage, as also observed by Brackett, et al.[4].

The viscous consistency of the restorative glass ionomer is one of the difficulties for insertion of the sealant into the fissures. In Group 5, the powder/liquid ratio of the glass ionomer cement Vitremer was altered to ¼ of the measure of powder to 1 drop of liquid, making the mixture more fluid and flowable, enhancing penetration into the fissures (Figure 3C). However, the mean of dye penetration was higher than the other ratios tested (1.196). Thus, leading to a greather marginal microleakage, when compared to other glass ionomer cement tested according to the manufacturer's recommendations.

The sealants tested presented a similar pattern of penetration into the pits and fissures, with no statistically significant difference between the study groups, even though the fluidity of the resin sealant might provide better flow into the fissures (Figures 2(A, B) and 3 (A,B, C)).

With regard to the conventional glass ionomer cement, the viscosity of the material was compensated for by the accomplishment of finger pressure (Figure 3B), as suggested by Frencken, et al.[8]. On the other hand, this was not performed for Groups 4, which employed resin-modified glass ionomer cement in the ratio used for restoration, and the same pattern of filling of deep fissures was also achieved, despite the difficulties to adapt the material on the enamel surface (Figure 2B) .

Proper penetration of resin-modified glass ionomer cements into the fissure may be explained, according to some authors[3,5,6,9,25] by the acid etching of enamel, which would lead to an increase in the area available for adhesion of the material, enhancing its penetration and polymerization into the etched surface.

The alteration in the powder/liquid ratio of the resin-modified glass ionomer cement (Vitremer), did not interfere with the outcomes observed on the penetration test (Figure 3C).

Wide and shallow fissures allowed better penetration of the sealant into the fissures when compared to deep and narrow fissures, which displayed partial filling of the fissures, in agreement with the literature[11,17,20,26].

CONCLUSIONS

1. The material employed were not able to completely prevent dye penetration into the interface between dental enamel and sealant.

2. The glass ionomer cements Ketac-Molar, Fuji Plus and Vitremer provided the best outcomes of marginal sealing, with significant difference in relation to the resin sealant Delton, which presented the highest values of marginal microleakage.

3. The glass ionomer cement Vitremer, prepared at the ratio of ¼ of powder, presented an intermediate outcome, yet with no statistical difference compared to the other materials.

4. With regard to the depth of penetration of sealants into pits and fissures, there was no statistically significant difference between groups.

REFERENCES

1- Aranda M, Garcia-Godoy F. Clinical evaluation of the retention and wear of a light-cured pit and fissure glass ionomer sealant. J Clin Pediat Dent. 1995;19(4): 273-7.

2- Birkenfeld LH, Schulman A. Enhanced retention of glass-ionomer sealant by enamel etching: a microleakage and scanning electron microscopic study. Dent Mat. 1999;30(10):712-8.

3- Bottenberg P, Gräber H, Lampert F. Penetration of etching agents and its influence on sealer penetration into fissures *In Vitro*. Dent Mat. 1996;12(2):96-102.

4- Brackett WW, Gunnin TD, Johnson WW, Conkin JE. Microleakage of light-cured glass-ionomer restorative materials. Quintessence Int. 1995;26(8):583-5.

5- Brocklehurst PR, Joshi RI, Northeast SE. The effect of air-polishing oclusal surfaces on the penetration of fissures by a sealant. Int J Paediat Dent. 1992;2(3):157-62.

6- Fan PL, Seluk LW, O'Brien J Penetrativity of sealants: I. J Dent Res. 1975;54(2):262-5.

7- Forss H, Halme E. Retention of a glass ionomer cement and resin-based fissure sealant and effect on carious outcome after 7 years. Community Dent Oral Epidemiol. 1998;26(1):21-5.

8- Frencken JE, Makoni F, Sithole WD. Atraumatic restorative treatment and glass-ionomer sealants in a school oral health programme in Zimbabwe: evaluation after 1 year. Caries Res. 1996;30(6):428-33.

9- Gwinnettt AJ, Ripa LW. Penetration of pit and fissure sealants into conditioned human enamel *In vivo*. Arch Oral Epidemiol. 1973;18:435-41.

10- Hatibovivic-Kofman S, Wrigth GZ, Braverman I. Microleakage of sealants after conventional, bur, and air-abrasion preparation of pits and fissures. Pediat Dent. 1998;20(3):173-6.

11- Hoppner MG, Sundfeld RH. Evaluation the penetration of dental sealants in the dental fissure [abstract]. J Dent Res. 1996;75:179.

12- Johnson IM, Duke S, Camm J, Hermessch CB, Buikema DJ. Examination of a resin-modified glass-ionomer material as a pit and fissure sealant. Quintessence Int. 1995;26(12):879-83.

13- Mass E, Eli I, Lev-Dor-Samovici, Weiss EI. Continuous effect of pit and fisssure sealing on *S. Mutans* presence in situ. Pediat Dent. 1999;21(3):164-8.

14- McLean JW, Wilson AD. The clinical development of the glass ionomer cement II. Some clinical aplications. Aust Dent J. 1977;22(2):120-7.

15- Mejare I, Mjör IA. Glass ionomer and resin-based fissure sealants: a clinical study. Scand J Dent Res. 1990;98(4):345-50.

16- Moore BK, Winkler MM, Ewoldsen N. Laboratory testing of light-cured glass ionomers as pit and fissure sealants. Gen Dent. 1995;43(2):176-80.

17- Monico M, Tostes M. “In Vitro”evaluation of the penetration and microleakage of Fuji IX in pits and fissures of third molars. J Dent Res. 1999;78(5):963.

18- Övrebö RC, Raadal M. Microleakage in fissures sealed with resin or glass ionomer cement. Scand. J Dent Res. 1990;98:66-9.

19- Percinoto C, Cunha RF, Delbem ACB, Aragones A. Penetration of a light-cured glass ionomer and a resin sealant into occlusal fissures and etched enamel. Amer J Dent. 1995;8(1):20-2.

20- Powell KR, Graig GG. An *in vitro* investigation of the penetrating efficacy of BIS-GMA resin pit and fissure coatings. J Dent Res. 1978;57(5-6):691-5.

21- Rudolph JJ, Phillips RW, Swartz ML. In vitro assessment of microleakage of pit and fissure sealants. J Prosthet Dent. 1974;32(1):62-5.

22- Seppä L, Forss H. Resistance of occlusal fissures to demineraization after loss of glass ionomer sealants in vitro. Pediat Dent. 1991;13(1):39-42.

23- Simonsen RJ. Glass ionomer as fissure sealant - a critical review. J Publ Hlth Dent. 1996;56(3):146.

24- Smales RJ, Gao W, Ho TF. *In vitro* evaluation of sealing pits and fissures with newer glass-ionomer cements developed for the ART technique. J Clin Pediat Dent.1997;21(4):321-3.

25- Sundfeld RH. Análise microscópica da penetração “in vivo”de selantes de fóssulas e fissuras. Efeito de tratamentos superficiais e materiais. Araraquara; 1990. [Tese de Doutorado. Faculdade de Odontologia da UNESP].

26- Taylor CL, Gwiinnett AJ. A study of the penetration of sealants into pits and fissures. J Amer Dent Ass. 1973;87:1181-8.

27- Vieira SR. Avaliação da profundidade de penetração de selantes para fissuras e da incidência de cárie em fissuras clinicamente hígidas. Bauru; 1993. [Tese de Doutorado – Faculdade de Odontologia de USP].

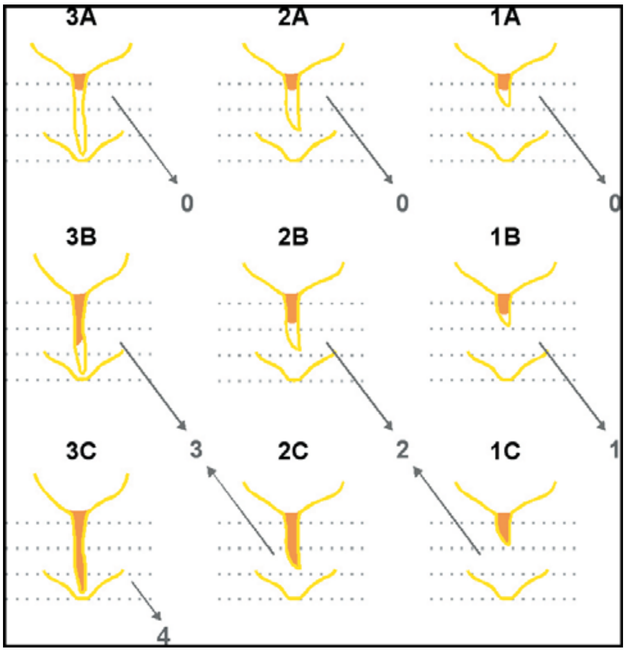

FIGURE 1- (A) - Diagram of the scores according to the relationship between depth of fissure/sealant penetration

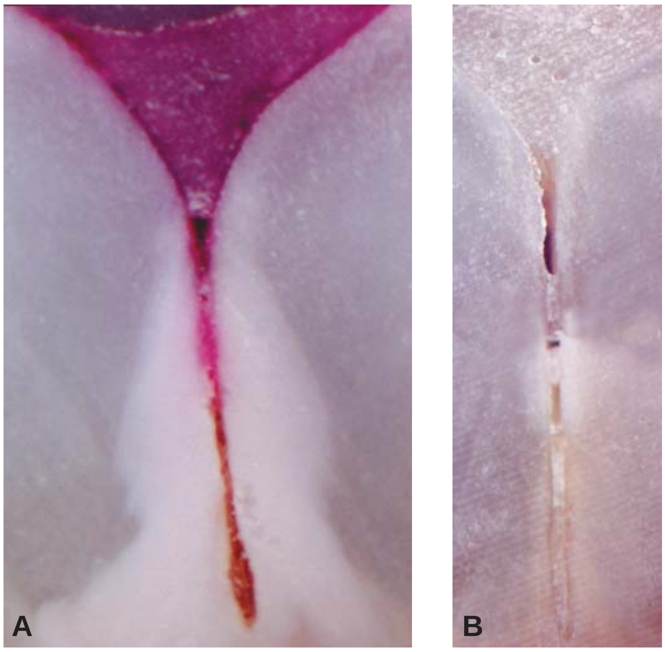

FIGURE 2- Tooth sections displaying fissures sealed with:- (A) resin sealant – score 4 for (MM) and score 3 for (DP); (B) Vitremer – score 0 for (MM) and score 3 for (DP)

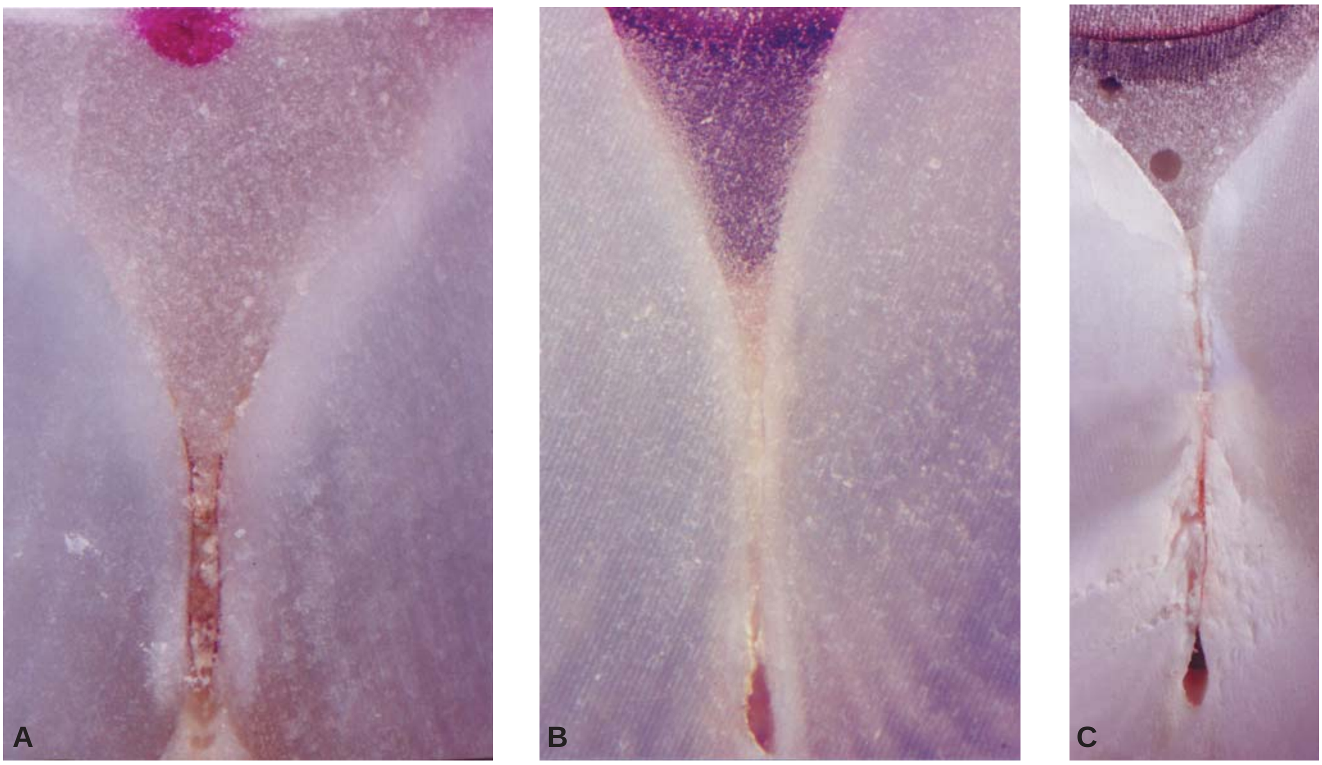

FIGURE 3- Tooth seccions displaying fissures sealed with:- (A) Fuji Plus – score 0 for (MM) and score 3 for (DP), (B) Ketac-Molar – score 0 for (MM) and score 3 for (DP); (C) Vitremer dilueted at ¼ - score 0 for (MM) and score 3 for (DP)