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MORPHOLOGICAL CHARACTERIZATION AND CHEMICAL COMPOSITION FROM ADHESIVE LAYERS FOR DIRECT PULP COATING PROTECTION IN-VITRO STUDY

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ABSTRACT

OBJECTIVE: Analysis of two adhesive systems of different composition by scanning electron microscopy (SEM) for immediate dentin sealing to be included in the protocol of direct pulp capping with MTA.

METHOD: Ten extracted upper premolars separated into two groups, one corresponding to 5 samples of Clearfil SE Bond and Clear Esthetic Flow composite (Kuraray) and the other corresponding to 5 samples for Optibond FL and its Revolution Formula 2 composite (Kerr) which were handled according to the manufacturer's instructions, axially cut and taken to SEM.

RESULTS: Clearfil SE Bond (Kuraray) presented a greater penetration of the odontoblastic fibers, thus demonstrating its biocompatibility and its affinity in the ionic interaction with the inorganic composition of the dentin tissue. On the other hand, we observed that OptiBond FL (Kerr) generated the formation of a hybrid layer that diffuses through the dentinal tubules, this morphological layer is defined with a greater thickness in contrast to the Clearfil SE Bond group. However, it is important to mention the presence of spaces and the identification of lower penetration on the identification on the dentinal tubules.

CONCLUSIONS: 1.- Clearfil SE Bondhas greater adhesion to dentin thanks to MDP and seeks the same action of interacting with hydroxyapatite, just as MTA helps its formation. That is why we propose to include immediate dentin sealing with an adhesive that includes this type of MDP monomer, within the RPD protocol because it seeks the same result as MTA by different ways, it could be included in the protocol because they have affinity for ions or clinical elements for the formation of dentin tissue and together, they can reach the formation of hydroxyapatite.

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Keywords: Immediate Dentin Sealing, Pulp Coating, Clearfil SE Bond, Optibond FL, Dentin, SEM.

INTRODUCTION

Over the years, it has been demonstrated that the direct pulp capping technique (RPD) is a treatment that has a high success rate within the treatments offered for pulp therapy, even the protocol to carry out the RPD are already established and have included biomaterials that have been shown to have high rate of biocompatibility, cell stimulation and good sealing as a coating, taking into account that it is important to exclude bacterial contamination from this type of treatment, it is important to look for alternatives in terms of the restoration that provide a better seal, in order to have greater success in the future, bacterial products should be excluded since they have the ability to spread through the dentin and can irritate the pulp tissues (Abu-Nawareg et al., 2015).

Both tooth enamel and cementum are impermeable and free of nerve endings. However, once this sealing of surfaces is affected or mutilated and hard tissues are removed from the dentin surfaces, the exposed dentin becomes highly permeable and very sensitive to hydrodynamic stimuli due to the exposure of millions of microscopic dentin tubules (Michelich, Pashley and Whitford, 1978; Recommendations and Hypersensitivity, 2003), which represent pathways to the pulp; since that is where the dentin tubules terminate (Pashley, 1996).

Immediate Dentin Sealing (IDS) is a procedure that is performed at the level of the freshly cut dentin, it consists of waterproofing the dentin tubules, this is achieved by applying an adhesive with filler on a dental preparation, prior to taking the impression, preventing the dentin from being exposed for a long time and thus avoiding contamination of the dentin tubules (Magne and E, DMD, 2005)(Samartzi et al., 2021).

Microleakage is the main cause of tooth hypersensitivity and the development of secondary caries under restorative materials, which usually occurs due to the presence of a space between the tooth structure and the restorative materials. Some properties of the materials such as high solubility, high temperature and expansion coefficient, shrinkage to polymerization, the shape of the cavity and the method of application of the restorative material can affect the results in the future (Shafiei et al., 2013; Valizadeh et al., 2020). It is important to mention that microleakage can cause pulp inflammation in vital teeth due to bacterial toxins which decreases the longevity of the restoration due to bacterial colonization. Therefore it is important the application of immediate dentin sealing agents (bonding) just after dentin preparation or mutilation to decrease microleakage and bacterial contamination, decrease its sensitivity and improve adhesion of future restorations (Valizadeh et al., 2020)

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Pulp therapy in permanent teeth has been a subject of much study and importance in dentistry for many years. Because of this, the study of new ways to protect the pulp and provide it with the capacity to regenerate and recover from any type of aggression that could injure it is of utmost importance.

In recent years various materials have emerged that have been classified as regenerative in terms of their behavior when in contact with dental tissues for example, in direct pulp communications, where when applied on vascularized tissue, cell stimulation is sought for the repair of the communication through the formation of a dentin bridge; For this to happen and to have a good prognosis in the future, it is important to keep the dental pulp free of bacterial contamination to prevent the vascularized tissue from necrosis and the treatment from failing; therefore, it is necessary to achieve a correct occlusal seal and protection of the biomaterials to take advantage of their qualities and avoid their contamination due to bacterial microfiltration.

In the following study we propose Immediate Dentin Sealing (IDS) as an important step for the realization of direct pulp capping (RPD) due to the above mentioned qualities and taking into account that with less microfiltration we have more success in the future on the preservation of pulp vitality. We analyzed by scanning electron microscopy (SEM) the bonding of two different systems, a two-step Clearfil SE Bond (Kuraray) and a three-step Optibond FL (Kerr) to observe the interaction between each system together with the composite of the same company.

MATERIALS AND METHODS

This comparative in vitro experiment, the sealing of two state-of-the-art adhesive systems Clearfil SE Bond (Kuraray®) and Optibond FL (Kerr®) together with their composite systems Clearfil AP-X Esthetics Flow (Kuraray®) and Revolution formula 2 (Kerr®) on a biomaterial MTA Angelus (Dentsplay®) as direct pulp capping (RPD) on extracted teeth was evaluated.

Upper and lower premolars, which met the inclusion criteria free of caries, were included with pulp chambers that were radio graphically clear. The occlusal cavities were prepared following the conventional Black class I classification with a high speed #5 ball bur with a high-speed handpiece (Borgatta®) and using water irrigation, until the mechanical and induced pulp communication was achieved; subsequently an Angelus™ MTA material was dried and placed, once it had set, the adhesive materials were placed according to the manufacturer. Subsequently, the cavities were reconstructed with light-curing composites or resins from the same company to isolate the lining material from external contamination.

In Group I, the Clearfil SE Bond Adhesive system with Clearfil AP-X Esthetics Flow lightcuring resin (Kuraray®) was placed on the Angelus™ MTA.

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In Group II, the Optibond FL™ Adhesive system was placed with Revolution Formula 2 light-curing resin (Kerr®) on the Angelus™ MTA.

RESULTS

In the microscopy performed at 3500 and 5000 magnification we observed the penetration of Clearfil SE Bond (Fig. 1) and OptiBond FL (Fig. 2) adhesives into the dentin tubules. In our study we observed that our Clearfil SE Bond adhesive penetrated with greater diffusion (Fig. 1, A), thus demonstrating its biocompatibility, which presumably could be due to the 10-methacryloyloxyethyl dihydrogen phosphate monomer (MDP). Observing a greater penetration of the odontoblastic fibers thus demonstrating its biocompatibility and its affinity in the ionic interaction with the inorganic composition of the dentin tissue. (Fig.1, B) On the other hand, we observed that OptiBond FL (Fig. 2) generated the formation of a hybrid layer that diffuses through the dentinal tubules, this morphological layer is defined with a greater thickness in contrast to the ClearfilSE Bond group. However, it is important to mention the presence of spaces and a lower penetration identification on the dentinal tubules.

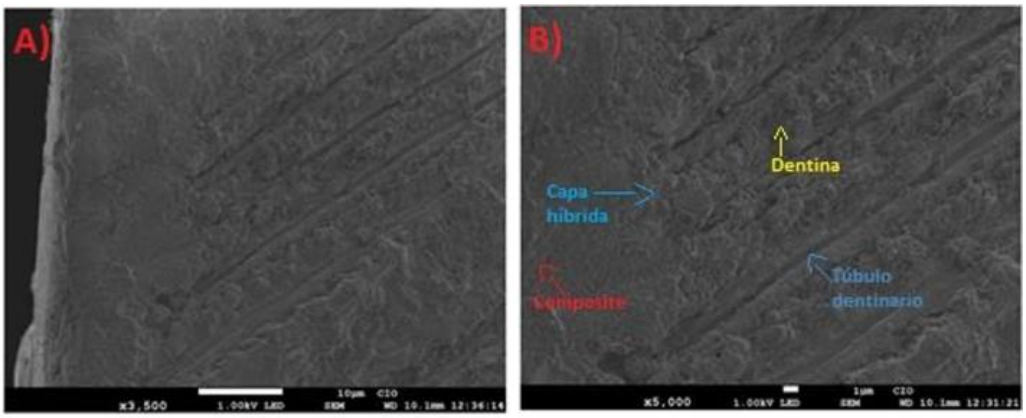

Fig. 1: A) The primary dentin layer including the dentinal tubules, the hybridadhesive layer and the composite can be seen, the intimate contact between the layers can be appreciated at 3500 magnifications in SEM. B) Closerapproach at 5000 magnifications in SEM.

Observing how the adhesive material of the hybrid layer penetrates the extensions of the dentinal tubules, highlighting the absence of spaces between one and the other.

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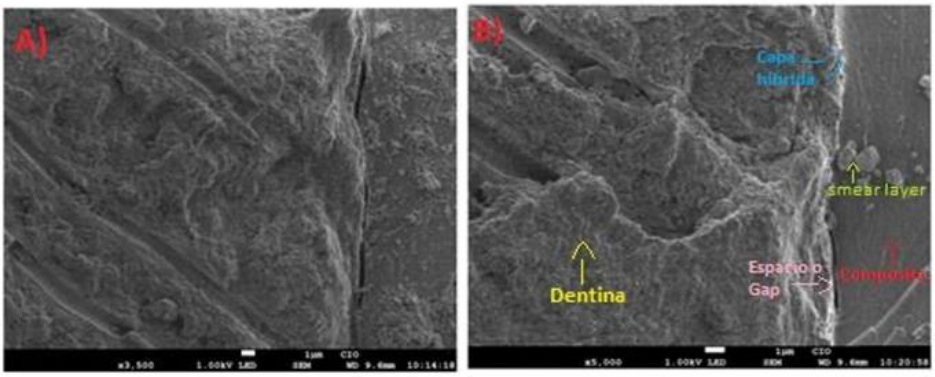

Fig. 2: A) A defined layer of greater thickness is observed between the hybrid layer, the dentin and the composite, the presence of spaces and a lesser identification of penetration on dentinal tubules. This could refer to the layer mentioned by the author Pascal Magne regarding the elastic modulus that absorbed the tension diffused by the masticatory forces. B) A slight contamination of the hybrid layer can be observed, which is probably smear layer extracted from the dentinal tubules during the acid etching, since its purpose is to permeate these tubules so that the adhesive or primer can penetrate more deeply into the dentinal tubules.

DISCUSSION

Taking into account that one of the main benefits of Mineral Trioxide Aggregate is to induce the formation of hydroxyapatite when in contact with physiological solutions and that it has an excellent ability to prevent microleakage compared to other endodontic sealing cements, and being a cement derived from Portland cement, and having a high compatibility with pulp tissues, MTA has proven to have a high success rate as the material of choice for direct pulp capping (RPD)) (Roberts et al., 2008).

Sarkar et al. (Sarkar et al., 2005) reported for the first time small white formations and precipitations after 1 to 2 hours on the surface of gray MTA, doing SEM analysis on phosphate precipitates, revealed globular morphology of oxygen, calcium and aluminum chemical composition, while X-ray diffraction suggested the presence of hydroxyapatite. Bozeman et al. (Bozeman, Lemon and Eleazer, 2006) confirmed this information by performing a study that also included X-ray diffraction (XRD) and scanning electron microscopy (SEM) analysis of both white and gray MTA precipitates under the same conditions.

Faeze Jamali et al. (Jamali Zavare et al., 2020) in 2020 observed under SEM studies that adding salts increases the pH and the release of calcium ions in MTA cements helping hydroxyapatite crystals to form on the cement surfaces within 7 to 14 days, showing high peaks of

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hydroxyapatite formations constantly increasing over this period of time and thus creating the formation of a dentin bridge on the RPD.

According to Yoshida et al. (Yoshida et al., 2012) some specific monomers contained in dental adhesives, could ionically interact with hydroxyapatite (HAp) which causes a better integration to dentin, achieving restorations with longer longevity and lower postoperative sensitivity after placement of adhesive restorations.

Clearfil SE bond contains within its formula a monomer called 10-methacryloyloxyalkyl dihydrogen phosphate (10-Methacryloyloxydecyl dihydrogen phosphate) (MDP), which has been continuously studied to have the ability to integrate more deeply into the deeper layers of dentin (hybrid layer and adhesive layer) and to have a higher affinity with hydroxyapatite, due to the affinity they share within their ionic components (elements), and also, it interacts adequately with the odontoblastic prolongations within the dentin tubules.

On the other hand, OptiBond FL OptiBond FL (SDS Kerr DentalTM Orange, California). It is a three-step adhesive: enamel etch-primer-adhesive. Some authors note that it results in good bonding results, however, the application technique is more meticulous and requires more time from the clinician. On the other hand, it is convenient to point out that the etching acid contained in this adhesive system is intended to sweep away any contamination or dentin sludge that may have penetrated the surface of the cavity preparation. However dehydrating the surface. It is important to emphasize, according to the criteria established by Pascal Magne (Magne, 2005) on adhesive systems and final restorations, that in the OptiBond FL system we have a significantly improved adaptation. However, it is important to clarify, from a practical clinical point of view, that this final adaptation must be taken into account before the patient in clinical practice, since OptiBond FL is a highly recommendable material in the placement of posterior bonded restorations, because it allows hybridization of dentin as a low elastic modulus (stress-absorbing) liner with a significantly improved adaptation to dentin, in the case of RPD the rinsing and drying of the cavity could affect the adaptation of the biomaterial, affecting the adaptation of the veneering biomaterial (in this case MTA) since the setting of these materials requires a longer time (up to 24 hours), since freshly placed is more soluble to air and water which could affect our main objective, which was to protect that biomaterial. Clearfil SE Bond, being a two-step adhesive, its clinical application protocol is better adapted and more reliable in clinical practice, demonstrating a strong synergism in the clinical protocol of a direct pulp capping.

CONCLUSIONS

Under the conditions previously described in the study, the following conclusions were obtained:

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1.- Clearfil SE Bond has greater adhesion to dentin thanks to MDP and seeks the same action of interacting with hydroxyapatite, just as MTA helps its formation.

2.- That is why we propose to include immediate dentin sealing with an adhesive that includes this type of MDP monomer, within the RPD protocol because it seeks the same result as MTA by different ways.

3.- Clearfil SE Bond Having MDP could be included in the protocol because they have affinity for ions or clinical elements for the formation of dentin tissue and together they can reach the formation of hydroxyapatite.

4.- The acrylate group that composes the monomeric chain of MDP interacts with the inorganic part of the dentin, specifically with calcium phosphate, therefore, there will be a chemical affinity with MTA due to the fact that one of its functions is to have the necessary ions to regenerate hydroxyapatite.

5..- Clearfil SE Bond, being a 2-component adhesive that is installed in 4 clinical steps, would reduce working time, and would exclude the use of water and air which would represent a lower risk of cavity contamination.

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