Adhesion of Calcium Hydroxide-Containing Root Canal Sealers

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The adhesion of several calcium hydroxide-containing endodontic sealers, Sealer 26, CRCS, Apexit and Sealapex, was studied using Grossman sealer (Fillcanal) as control. Adhesion to dentin with and without the use of EDTA was measured. Sealapex and Apexit presented the lowest adhesions. Application of EDTA to the dentin increased sealer adhesion, with the exception of Sealapex.

Key Words: adhesion, calcium hydroxide, endodontic sealer.

Introduction

Root canal sealers always receive special attention from researchers in the attempt to obtain a sealer which merges necessary physical and biological properties. Endodontic sealers containing calcium hydroxide present these characteristics. Since its introduction by Herman (1920), calcium hydroxide has been used in Endodontics in various forms: pure, paste and in root canal sealers.

The biocompatibility of sealers containing calcium hydroxide has been reported by various researchers (Berbert, 1978; Holland et al., 1979; Tronstad et al., 1981, 1988; Leal et al., 1988; Yesilsoy et al., 1988; Tagger and Tagger, 1989; Soares et al., 1990). Ørstavik (1981, 1988) reported antimicrobial properties. Hyde (1986) reported that Sealapex presented high solubility and disintegration and low adhesion. Wennberg and Ørstavik (1990) reported that CRCS presented greater adhesion than Sealapex.

Adhesion is a desirable physical-chemical property of root canal sealers because the sealer is responsible for the union of gutta-percha to dentin. Gutta-percha is a vegetable resin which only adapts to dentin but does not adhere to it. An endodontic filling suffers force when part is removed for the preparation of the intra-radicular retention pin in cases of
extensive restorations. Good adhesion permits the dimensions of gutta-percha/dentin interface to remain constant, since the gutta-percha cone tends to adhere to the root canal walls avoiding the formation of flaws where microorganisms could install.

The objective of this study is to evaluate the adhesion to dentin of various root canal sealers containing calcium hydroxide, using Grossman sealer (Fillcanal) as control.

Material and Methods

Sealer 26 (Dentsply), CRCS (Dental Inc.), Sealapex (Sybron Kerr), Apexit (Vivadent) and Fillcanal (D.G.) were tested.

Sealer 26 is an AH 26 epoxy resin sealer containing calcium hydroxide. Sealapex and Apexit are paste sealers and CRCS and Fillcanal are basically Grossman-type sealers but CRCS contains calcium hydroxide.

Aluminum cylinders (10 mm high x 6 mm internal diameter) with stainless steel handles were used.

The entire occlusal surface of whole, recently extracted human molars was abraded to expose the dentin surface. The roots were fixed in an acrylic resin base and the teeth were placed in a chamber at 37°C, 95% relative humidity, until use.

Three experiments for each type of sealer were carried out. The teeth were divided into 2 groups: with and without EDTA application on the dentin surface. For the removal of the smear layer, 2 drops of EDTA were applied to the dentin surface for 5 minutes. This chelating agent was then removed by washing with distilled deionized water.

The cylinders were fixed to the dentin surface and filled with sealer. They were placed in a sterilizer at 37°C and 95% humidity for a period three times the hardening time for the material tested. They were then submitted to force using a wire and pulley system with a gradual alteration of the force by the increase of the mass deposited on the free end of the wire, until the cylinder containing the sealer ruptured from the dentin surface.

The second law of Newton was used to evaluate the force tension necessary for the rupture: \[ R = m \cdot g \cdot y, \] where \( R \) is the intensity of the result of the force, \( m \) is the mass applied to the free end of the wire and \( g \) the intensity of acceleration, in this case, of the gravity considered to be constant and equal to \( 10 \, \text{m/s}^2 \).

Adhesion was studied based on the tensile bond strength which is related to the force placed on a sample with the contact area between the sealer and the dentin, allowing the reproduction of the experiment with different samples.

The cylinders which contained the sealers presented an internal diameter of 6 mm (0.006 m). The area of transversal section was calculated which corresponds to the area of contact of sealer and dentin using the equation: \( S = \pi \cdot r^2 \), where \( S \) is the area of transversal section of the cylinder \( (2.82 \times 10^{-3} \, \text{m}^2) \), \( r \) is the internal radius of the cylinder \( (0.003 \, \text{m}) \) and \( \pi \) is 3.1416.

For the calculation of tensile bond strength, the following equation was used: \( \sigma = \frac{T}{S} \), where \( \sigma \) is the bond strength in Mega-Pascal (MPa), \( T \) the force in Newton (N) and \( S \) the area in \( \text{m}^2 \). One Pascal is equivalent to one Newton per square meter.
Results

Figure 1 shows the results of the tensile bond strength of endodontic sealers applied to the dentin surface with and without EDTA to remove the smear layer. The Kruskal-Wallis test was used for statistical analysis which indicated a significant difference at the level of 1%.

Comparison of the means of the samples without EDTA, two by two, showed that CRCS presented the greatest adhesion of the materials tested. Adhesion of sealers Fillcanal and Sealapex was statistically similar, greater than that of Apexit and less than Sealer 26 which had a lower adhesion than CRCS. Comparison of the means of the samples with the use of EDTA, two by two, showed that Sealer 26 presented the greatest adhesion, followed by CRCS, Fillcanal, Sealapex and Apexit.

The effect of the chelating agent EDTA on the adhesion of these sealers to dentin was compared using the Mann-Whitney test. Sealapex was the only sealer which did not present increased adhesion when applied to dentin where EDTA had been used to remove the smear layer.

Discussion

The force of stress is a vector factor of intensity, direction and course. Tensile strength is a numerical factor only of intensity. Force of adhesion (vector factor) is the result of attractive forces between molecules of different materials. This has the same intensity and direction when the system is at rest. The only difference is in the course, which is opposite. In this experiment, the force was applied perpendicularly to the interface sealer/dentin, therefore, it is not a test of shear strength.

The method used in this study was based on the proposal of Grossman (1976) with modifications because he studied the adhesion of sealers to glass slides.
Considering the fact that sealer adhesion to dentin is proportional to the tension of force, it can be affirmed that adhesion will be greater when the tension of force necessary for the rupture of the sample containing the sealer is greater.

It is known that no test of adhesion of root canal sealers has yet been accepted as a standard by the American Dental Association, however, several researchers have proposed methods of evaluation of endodontic sealer adhesion (Grossman, 1976; Kemper and Kilian, 1976; McComb and Smith, 1976; Ørstavik et al., 1983; Wennberg and Ørstavik, 1990).

Hyde (1986) found high adhesion for CRCS and was unable to measure adhesion of Sealapex since this sealer did not harden sufficiently. Wennberg and Ørstavik (1990) observed that AH 26 sealer (De Trey, Switzerland) presented high adhesion to dentin with or without a smear layer. Our results showed that Sealer 26 had low adhesion when placed on dentin with a smear layer and high adhesion to dentin when treated previously with EDTA. Sealer 26 (Dentsply) has a formula similar to AH 26 Silver Free, however, with 10% calcium hydroxide. The quantity of calcium hydroxide added was not sufficient to alter the adhesion of this sealer as long as the dentin did not have a smear layer.

In clinical conditions, it is very difficult to obtain a thin uniform layer of endodontic sealer and when this is not possible the sealer presents significant dimensional alterations which creates stress of varied intensity and direction. There also exists force which acts on the endodontic sealer when partially removed for the making of a intra-radicular retention pin. These forces can dislodge the endodontic filling if the sealer does not have adequate adhesion.

Therefore, for endodontic filling to remain unaltered over time, it is extremely important that the sealer present good adhesion to the dentin. Both Apexit and Sealapex are sealers which present low adhesion which their manufacturers need to improve since they do present good biological properties.

Conclusions

1. It was possible to measure adhesion to dentin for all of the sealers studied.
2. In the tests using EDTA, Sealer 26 presented the greatest adhesion, however, when EDTA was not used, CRCS presented the greatest adhesion.
3. Fillcanal, Sealapex and Apexit without EDTA presented the lowest levels of adhesion. With the application of EDTA, Sealapex and Apexit presented the lowest adhesion.
4. With the application of the chelating agent EDTA, most of the sealers showed an increase in their adhesion, with the exception of Sealapex.

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