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Analysis of Sealing Ability of Root Canal Sealers Using Scanning Electronic Microscopy Technique

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SUMMARY

Introduction An ideal endodontic sealer should adhere firmly both to dentin and to gutta-percha.

Objective The aim of this study was to evaluate the adhesion of the root canal filling to dentin and gutta-percha using scanning electronic microscopy (SEM).

Methods The sealing ability of endodontic sealers to dentinal walls of the root canal was assessed in recently extracted human single canal premolars. Twenty teeth were prepared using the crown-down technique and irrigated with 3% NaOCl. A total of 20 samples were divided into two groups. The root canals were obturated using Ketac-Endo Aplicap and GutaFlow. The sealing ability and adhesion properties at the sealer-dentin interface were studied using SEM and the results were rated from 1 to 3; extremely good adhesion (rated 1), good adhesion (rated 2) and a relatively good adhesion (rated 3).

Results The results showed extremely good adhesion on Ketac-Endo and GuttaFlow dentin interface. GuttaFlow has strong adhesion (rated 1) to gutta-percha in comparison with Ketac-Endo to gutta-percha interface (rated 2).

Conclusion New GuttaFlow filling material has a strong sealing ability and excellent adhesion to dentinal walls and gutta-percha cones. Ketac-Endo showed excellent bond to dentin with a slightly weaker adhesion capacity to the gutta-percha cones in comparison to GuttaFlow.

Keywords: SEM; adhesiveness; endodontic sealers

INTRODUCTION

The primary objective of root canal therapy is a complete obturation of the root canal space [1] with the aim of sealing as much of the cleaned and shaped root canal system as possible [2].

The major goal of root canal filling is to prevent infection (reinfection) of the root canal via leakage of mikroorganisms and their byproducts. The sealing ability, biocompatibility [3, 4, 5] and antimicrobial effect [6, 7] of root canal filling material is, therefore, an important factor in achieving this goal.

The majority of endodontic failures are caused by the incomplete sealing of the root canals. Thus, it is necessary to use materials which are able to create a hermetic seal between the root canal system and periapical tissue.

In attempts to successfully fill root canals various materials and techniques have been utilized. The most widely used root canal filling is gutta-percha due to its inertness, plasticity and solvent solubility [8, 9]. The gutta-percha has been used in dentistry for over 150 years [10]. The gutta-percha does not adhere to the dentinal wall completely and has to be used in conjunction with a sealer for root canal obturation. The gutta-percha provides the bulk of the obturating material, whereas the sealer fills the interface between the gutta-percha mass and root canal walls.

An ideal root canal sealer should have low viscosity and good wetting properties to flow easily into dental irregularities, accessory canals and multiple apical foramina and to fill the space between gutta-percha cones and surface of the root canal.

The glass ionomer-based sealer was introduced into root canal treatment because of its adhesion to the dental hard tissue [11, 12]. The characteristic properties of glass ionomer cement include bonding to dentine, antimicrobial activity, excellent flow and biocompatibility. Ketac-Endo Aplicap is specially formulated as a root canal sealer.

In 2004 Coltene, Whaledent Inc introduced a cold, flowable, self-curing obturation material for root canals that combines gutta-percha and sealer into injectable system named GuttaFlow. This material contains gutta-percha in particle form combined with a polydimethylsiloxane-based sealer. It is used in combination with a master gutta-percha cone and does not require any form of manual compaction for placement.

OBJECTIVE

The purpose of this in vitro study was to examine the sealing ability of two endodontic sealers (Ketac-Endo and GuttaFlow) to dentinal walls and gutta-percha cones, using scanning electron microscopy (SEM).

METHODS

Twenty recently extracted human mandibular premolars with single canal were used. All teeth

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had closed apices, no cracks and no signs of excessive aging. Bucolingual and mesiodistal radiographs of the teeth were taken to exclude the presence of the second canal. The teeth were decoronated at the cement-enamel junction by using a water cooled, high speed diamond bur.

A size 15 K-file was inserted in the root canal until it was just visible at the apical foramen. The root canals were prepared 1mm short of this length by using GT-rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) to a 0.06 taper master apical size of 30. After each instrument use, the canals were rinsed with 2 ml 3% sodium hypochlorite (NaOCl) (Histolite-Septodont, France).

After completed preparation, the first group was rinsed with 2ml 3% NaOCl, and then flushed with 10% of polyacrilic acid solution and finally with saline solution. The second group was also rinsed with 2 ml 3% NaOCl, and then flushed with 0.5 ml 17% ethylendiaminetetraacetatic acid solution for 1 minute (EDTA). Subsequently, the canals of the second group were rinsed with 2 ml NaOCl, deionized water and 80% ethanol, respectively, and dried with paper points.

The first group was obturated using Ketac-Endo-Aplicap (ESPE, Seefield, Germany), a glass ionomer-based sealer. The second group was obturated using GuttaFlow, a resin-based sealer with particles of gutta-percha.

Definitive obturation was performed following manufacturer's instructions. Both materials were capsulated. The sealer capsule was activated and triturated for 10 seconds with Ketac-Endo and for 30 seconds with GuttaFlow (Silamat S5-Vivadent, Schaan, Lichenstein).The plastic tip was attached to the canal up to the filling depth starting point and the material was dispensed until it could be seen moving up the canal around the tip. A size 30 gutta-percha master cone applied at working length and then the two sized 25 gutta-percha cones were inserted passively (modified single cone technique obturation). Excessive gutta-percha cones were removed followed by the placement of provisional restoration Cavit (3M ESPE).

The teeth were placed in the incubator, and the materials were allowed to self-cure for 50 minutes.

The adhesion of the sealers to the root canal walls were examined in the coronal, middle and apical thirds at different magnifications, ranging from ×100 to ×1000. Representative photomicrographs were recorded.

Ray and Seltzer criteria for results evaluation were chosen [13] and modified for this study as follows:

1. Extremely good adhesion; a smooth contact line on sealer-dentine interface without gaps, and with massive penetration of the sealers inside the tubules.
2. Good adhesion; a slightly curved contact line on sealer-dentin interface with some gaps between sealers and dentine walls.
3. Relatively good adhesion; gaps were often found between sealers and dentine walls with an unclear and curved contact line in sealers-dentine interface.

RESULTS

The specimens obturated with both Ketac-Endo showed extremely good adhesion to dentinal walls and were rated 1 (Figure 1). Ketac-Endo showed good adhesion to the gutta-percha cone and was rated 2 (Figure 2).

The specimens filled with Ketac-Endo showed a smooth contact line on the sealer-dentin interface (Figure 3). The margin between Ketac-Endo and the dentinal walls was clearly observed.

The specimens filled with GuttaFlow showed extremely good adhesion to the dentinal walls, with clearly visible

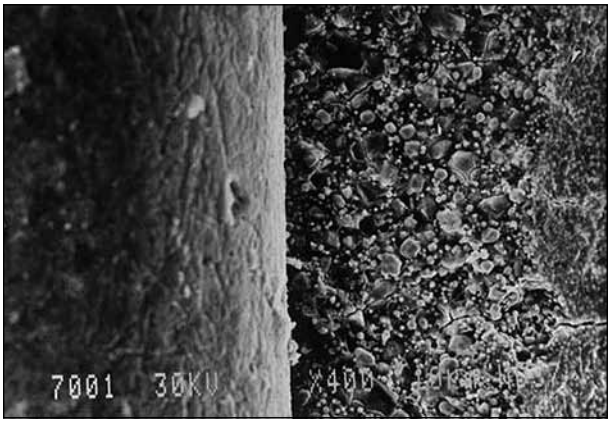

Figure 2. Gutta-percha cone with Ketac-Endo interface (×400)

Figure 1. Longitudinal section shows smooth contact line on Ketac-Endo dentin interface (×1000)

Figure 3. Scanning electron microscopy of cross-sectional view of interface between dentin. Ketac-Endo and gutta-percha cone shows a good adhesion (×1000)

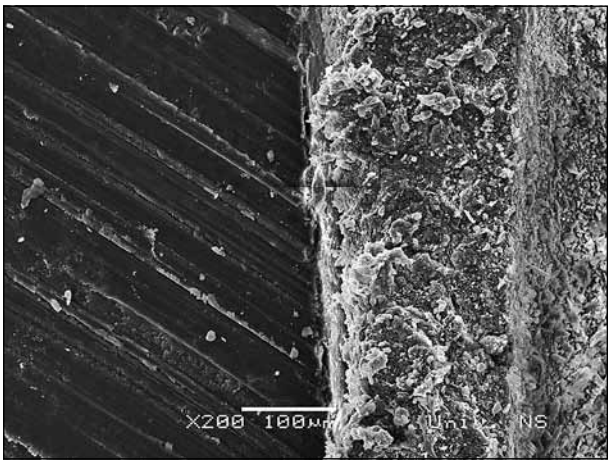

Figure 4. Smooth contact line on GuttaFlow dentine interface. Extremely good adhesion to gutta-percha cone. Longitudinal section (×200)

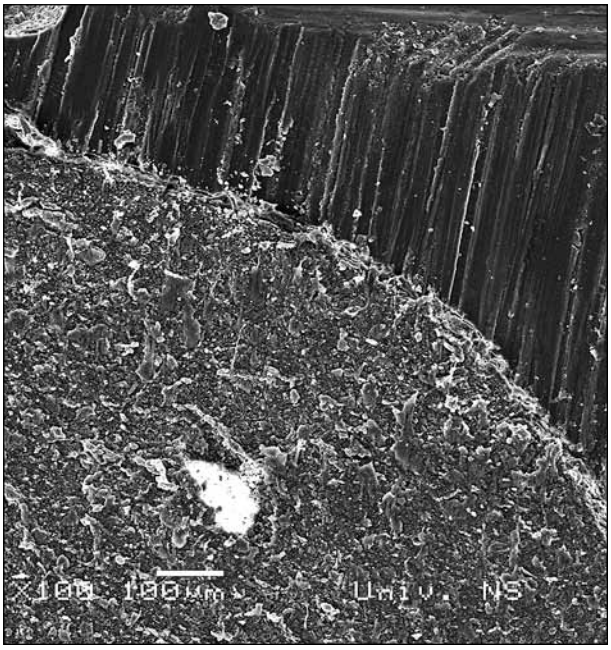

Figure 5. Cross section shows penetration of sealer (GuttaFlow) into dentinal tubules (×100)

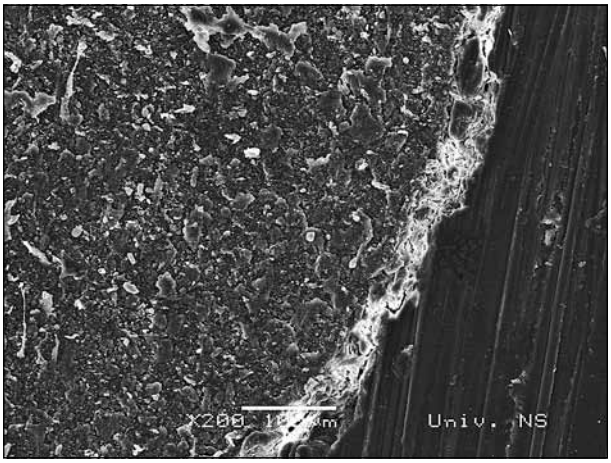

Figure 6. Margin between GuttaFlow and gutta-percha cones is clearly seen. Cross section specimen (×200)

bonding surface representing the contact line. Some longitudinal and cross sections showed that GuttaFlow penetrated into the dentinal tubules (Figures 4 and 5).

GuttaFlow was bonded extremely well to the gutta-percha cones, rated 1 (Figure 6).

DISCUSSION

A complete sealing of the canal seems difficult when using a combination of gutta-percha and a root canal sealer that is in a general use clinically [14].

Various methods have been used for evaluating the apical sealing property of root canal filling materials. Examples of such methods are dye penetration test [15, 16], fluid filtration methods [12], radioactive isotope studies, electrochemical leakage tests, scanning electronic microscopic analysis [13, 17] and bacterial penetration test [18].

Scanning electronic microscopic methodology evaluates the sealing ability and adhesiveness of the sealer to dentine walls or sealer-gutta-percha interface on the various levels of sectioning.

According to SEM findings in this research, the samples obturated with Ketac-Endo and GuttaFlow showed extremely good adhesion to the dentine walls (rated 1), with tight sealer-dentin interface, no spaces or ruptures between the sealer and canal walls. GuttaFlow showed extremely good adhesion to gutta-percha rated 1, whilst Ketac-Endo showed good adhesion to the gutta-percha cones and was rated 2.

Some in vitro studies demonstrated better sealing with Ketac-Endo than ZnOE based root canal sealers [18, 19, 20]. On the other hand, Camps and Pashley [15], Ozata et al [16], Barthel et al. [18], De Almeida et al. [21] noted that resin-based sealers showed better apical seal than Ketac-Endo. Miletić et al. [20], Vujašković [22] found no differences between Ketac-Endo and ZnOE and resin-based sealers.

Differences in adhesive properties of endodontic sealers were expected, because of their physical and chemical composition.

Lee et al. [23] stated that the glass ionomer sealer is known to bond to dentin, but may also bond to the gutta-percha, because the polycarboxylic groups of the glass ionomer may react with the zinc component of gutta-percha. In vitro study demonstrated that Ketac-Endo bonded to dentin more strongly than to gutta-percha. The polyacrylic acid matrix of glass ionomer cement contains multiple ionized carboxylate groups that can chelate with calcium in the mineral phase of dentin.

Besides physical factors, film thickness and the presence of smear layer and chemical factor should be considered [24]. Ketac-Endo chemically bonds to dentin and may reinforce the root against vertical fracture [25]. However, the sensitivity of glass ionomer cements to the presence of water during setting may explain their low bond strength [24]. Carvalho et al. [26] reported that Ketac-Endo sealer presented higher disintegration in contact with humidity before its complete setting. The good control of canal mois-

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ture is a prerequisite for use of Ketac-Endo [26]. The sealing ability of Ketac-Endo depends on the pre-treatment of dentin [22]. The use of chelating agents such as citric acid, polyacrilic acid or taninic acid is essential for cleaning and removing the smear layer and also to strengthen the adhesive and sealing properties of Ketac-Endo to dentin [19, 22, 27].

The findings obtained during SEM observation in this research suggest that the physical integrity of the sealer matrix is also important. As a resin-based sealer, GuttaFlow has a homogeneous structure with particles of gutta-percha and appears to fill the dentinal tubules well with extremely good adhesion to gutta-percha cones (rated 1). Ketac-Endo is composed of glass particles and appears porous with slight shrinkage after setting. This could be the reason for a lower adhesion to gutta-percha (rated 2) when compared to GuttaFlow, with presence of gaps on Ketac-Endo material- gutta-percha cone interface.

The flow quality of GuttaFlow observed in this study is in agreement with previous research findings. In 2005 El Ayouti et al. [28] reported that despite the presence of voids within the material, GuttaFlow showed good adaptability to root canal walls. The material is believed to flow into lateral canals and completely fill the space between the root canal wall and the master cone. In addition, because no heat is used with placement of the material, no shrinkage is believed to occur, and the manufacturer reports that the material expands 0.2% upon curing [29]. This expansion combined with close adaptation of the gutta-percha cone against the prepared canal wall may enhance sealer flow and adhesion against the dentinal tubule walls. That is comparable with research findings of warm vertical compaction of gutta-percha and AH Plus sealer [30].

CONCLUSION

New GuttaFlow filling material has a strong sealing ability and excellent adhesion to dentinal walls and gutta-percha cones and was rated 1 in this research. Ketac-Endo showed excellent bond to dentin (rated 1) with a slightly weaker adhesion capacity to gutta-percha cones in comparison to GuttaFlow.

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Анализа адхезивности материјала за трајно пуњење канала корена зуба применом скенинг-електронске микроскопије

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КРАТАК САДРЖАЈ

Увод Основне особине материјала за трајно пуњење канала корена зуба подразумевају идеално заптивање, како тврдог зубног ткива, тако и гутаперка-поена.

Циљ рада Циљ рада је био да се испита адхезивност материјала за трајно пуњење канала корена за дентин и гутаперка-кочиће коришћењем скенинг-електронске микроскопије (СЕМ).

Методе рада Способност заптивања дентинске површине обрађеног зида ендодонтским силерима испитана је на свеже извађеним једнокореним премоларима. Двадесет зуба је препарисано крунично-апексном техником уз испирање тропроцентним раствором натријум-хипохлорита (*NaOCl*). Узорци су сврстани у две групе: прва је оптурисана са материјалом *Ketac-Endo*, а друга са *GuttaFlow*. Способност заптивања и адезивност на граници додира силера и дентина, односно силера и гутаперке, анализирана је применом СЕМ. Адхезивност је означена као: екстремно добра (оцена 1), добра (оцена 2) и релативно добра (оцена 3).

Резултати Добијени резултати су показали изузетно добру адхезивност материјала *Ketac-Endo* и *GuttaFlow* за дентинску површину испрепарисаних зидова канала корена зуба. *GuttaFlow* је показао веома добру везу за гутаперка-кочић (оцена 1) у односу на *Ketac-Endo* (оцена 2).

Закључак Нови материјал *GuttaFlow* има изузетно добру адхезивност, како за дентин канала корена, тако и за гутаперка-поене. *Ketac-Endo* остварује веома добру способност заптивања за дентин и добру адхезивност, али нешто слабију за гутаперку у односу на *GuttaFlow*.

Кључне речи: СЕМ; адхезивност; материјали за трајно пуњење канала корена зуба

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