

The adaptation of mechanically softened gutta-percha to the canal walls in the presence or absence of smear layer: a scanning electron microscopic study

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Summary

The objective of this study was to compare the adaptation of mechanically softened gutta-percha to the root canal wall in the presence and absence of smear layer. The root canals of 20 freshly extracted human maxillary incisors were cleaned and shaped. Prior to obturation, 10 root canals were irrigated with 20 ml of 50% citric acid followed by 20 ml of 5.25% sodium hypochlorite. All canals were obturated with mechanical compaction of gutta-percha and AH-26 sealer. After 72 h, each tooth was fractured in half. Scanning electron microscopy demonstrated that the sealer had formed a continuous layer in contact with the canal walls, becoming progressively thinner towards the apex. The sealer penetrated into the dentinal tubules along with projections of gutta-percha only in those teeth without smear layer.

Keywords: mechanically softened gutta-percha, root canal obturation, smear layer

Introduction

McComb & Smith (1975) observed that the smear layer on the dentinal walls of biomechanically instrumented root canals occluded the dentinal tubules. Wayman *et al.* (1979) and Berg *et al.* (1986) suggested that the smear layer could prevent the penetration of obturating materials into the tubules. The presence of smear layer was also proposed as a potential substrate for bacterial growth (Pitt Ford & Roberts 1990). Yamada *et al.* (1983)

noted that a final canal irrigation with 10 ml EDTA followed by 10 ml of 5.25% sodium hypochlorite was effective in removing the smear layer, thus rendering the dentinal tubules more permeable. Others have observed a similar effect with a final irrigation of 20 ml of 50% citric acid followed by 20 ml of 5.25% sodium hypochlorite (Baumgartner *et al.* 1984, Ferrer 1992).

The lack of a three-dimensional obturation of the root canal system has been cited as one of the major causes of failure in endodontic treatment (Ingle & Bakland 1994). In recent years, alternative methods of obturation using thermoplasticized gutta-percha or mechanically softened gutta-percha have been developed to provide a more rapid and perhaps more effective means of filling root canals three-dimensionally.

JS Quick-fill™ (JS Dental, Ridgefield, CT, USA) is a root canal obturation system consisting of a sized titanium transporter that has been coated with gutta-percha. The transporter is attached to a slow-speed handpiece, and when introduced and rotated into the prepared root canal, the gutta-percha is mechanically softened because of the frictional heat that is generated.

The purpose of this study was to compare the adaptation of mechanically softened gutta-percha (JS Quick-fill™) and cement sealer (AH-26) to the dentinal walls of prepared root canals in the presence and absence of smear layer.

Materials and methods

Twenty freshly extracted human maxillary incisors were stored in water. Endodontic access cavities were made using a high-speed handpiece. Working length was determined by inserting a size 10 K-file until it was visible at the apical foramen and withdrawing it 0.5 mm.

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All canals were prepared with K-type files to a master file size 40, 0.5 mm short of the radiographic apex. Three millilitres of 5.25% sodium hypochlorite (NaOCl) were used as the intracanal irrigant after each instrument. All irrigating solutions were delivered via a 23-gauge needle inserted as far as possible into the canal without binding. Final shaping of the canals was accomplished using a step-back technique in 1-mm increments with Hedstrom files to a final size 70. Twenty millilitres of 5.25% NaOCl were used as a final flush. All canals were dried using paper points. The teeth were randomly divided into two groups:

- (1) Group I (with smear layer): In 10 incisors, AH 26 silver-free (DeTrey, Konstanz, Germany) was introduced with a size 35 file, and the canals were subsequently obturated with a JS Quick-fill™ two sizes smaller than the master file used (in accordance with the manufacturer's guidelines).
- (2) Group II (without smear layer): In the remaining 10 incisors, the smear layer was removed with a final irrigation of 20 ml of 50% citric acid followed by 20 ml of 5.25% sodium hypochlorite. The canals were dried with paper points. AH 26 was introduced with a size 35 file, and the canals were subsequently obturated with a JS Quick-fill™ two sizes smaller than the master file used.

In both groups, the JS Quick-fill™ was rotated clockwise at a speed of 4500 rpm using a slow-speed handpiece. In all cases, the titanium carrier was withdrawn from the canal while rotation continued.

Following obturation, all teeth were stored in water for 72 h. After this period, the teeth were grooved using a disc at slow speed and fractured into two halves with pliers. The halves were dehydrated via critical point drying, and subsequently sputter-coated in gold and evaluated under the scanning electron microscope (SEM) (Hitachi S-4100, Tokyo, Japan) at various magnifications.

Results

The cement sealer was located adjacent to the dentinal walls in all of the specimens. The sealer did not appear to be embedded within the gutta-percha and seemed to form a layer which became progressively thinner; the cement was thicker in the coronal third (Fig. 1), and thinner ($7\text{--}8\ \mu\text{m}$ thick) towards the apical third (Fig. 2).

Neither the gutta-percha nor root canal sealer penetrated the dentinal tubules of the root canals with the smear layer. The gutta-percha surface exhibited a

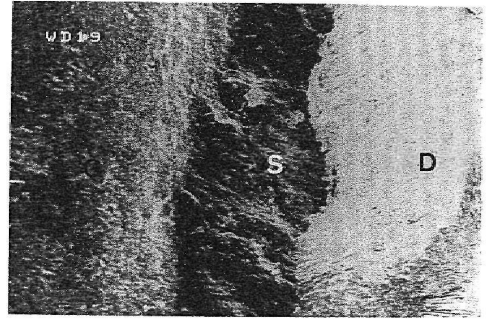


Fig. 1. The coronal third: sealer (s) thickness, $150\ \mu\text{m}$ between dentin (d) and gutta-percha (g) (original magnification, $\times 200$).

wave-like appearance in a direction opposite to the axis of rotation (Fig. 3); this was apparently caused by the rubbing or frictional action of the gutta-percha against the canal walls with subsequent softening of the gutta-percha.

The sealer penetrated the dentinal tubules of those root canals which had the smear layer removed. In all cases, the penetrating sealer emanated from the surface layer of sealer. Depth of penetration varied from 10 to $15\ \mu\text{m}$ in most cases. However, in one particular case, a depth of $60\ \mu\text{m}$ was observed. Surface protuberances were evident from the gutta-percha surface because of the entry of the material into the dentinal tubules (Fig. 4).

In some areas of the canal, there were spaces between the gutta-percha and cement sealer (Fig. 5). Since the irregularities of the dentinal wall were well reproduced on the gutta-percha, these spaces were possibly artifacts caused during specimen exposure to vacuum during SEM examination (Zmener & Gimenes Frias 1991).

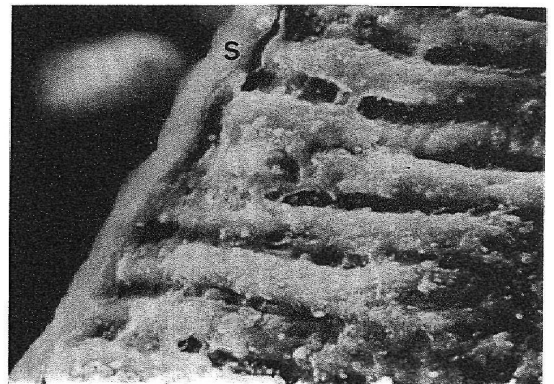


Fig. 2. The apical third: sealer thickness, $8\text{--}10\ \mu\text{m}$. Sealer has penetrated the dentinal tubules (original magnification, $\times 2500$).

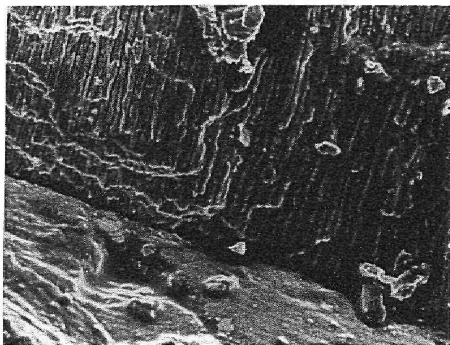


Fig. 3 The wave-like appearance of the gutta-percha surface in root canals with smear layer. Sealer cannot be detected within the tubules.

Another possible explanation for these spaces may be related to a potentially weak union interface between the gutta-percha and sealer. When a specimen is fractured in halves, the interface could be an area where cracking occurs. In some cases, gutta-percha was trapped in the coronal canal in one root segment during fracturing but remained in the apical canal in the complementary root segment. This phenomenon could have also explained the artifactual cracks between sealer and gutta-percha.

Discussion

An unexpected finding was related to the distribution of the AH-26 sealer: in all the specimens, the sealer was found to be in intimate contact with the canal walls and did not appear to be embedded in the mass of gutta-percha. This may be explained by the nature of the kinetic energy that was generated during the rotational

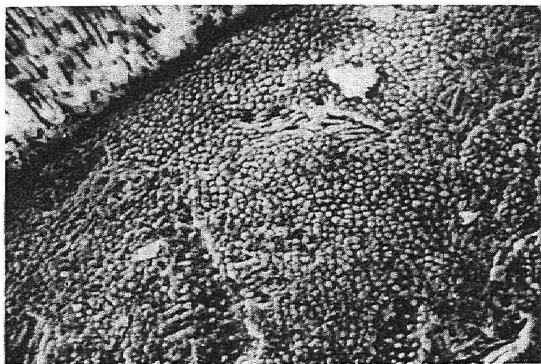


Fig. 4 The pointed appearance of the gutta-percha surface which had been in contact with the canal walls in teeth without smear layer.

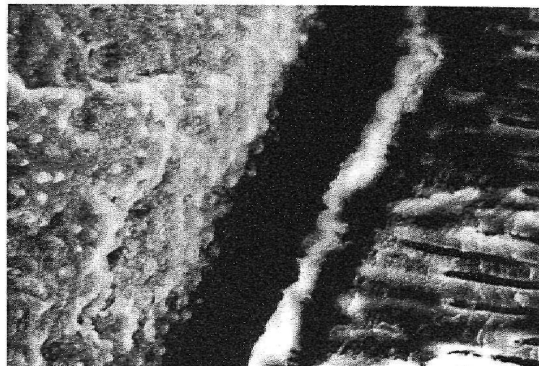


Fig. 5 Cracks between sealer and gutta-percha can be observed in some areas.

movement of the instrument within the canal, centrifugally pushing sealer particles to the periphery of the dentinal wall. This could have also aided the penetration of the cement sealer into the tubules of canals without the smear layer.

Mader *et al.* (1984) observed that, because of the impulsion-traction movements that occur during root canal instrumentation, the particulate smear layer can penetrate up to 40 μm into the dentinal tubules. In the present study, penetrations of up to 60 μm were observed with the cement sealer. Although Abramovich & Goldberg (1976) reported a poor penetration of AH-26 into the tubules, the presence of smear layer was not considered. Oksan *et al.* (1993) also noted that the presence of smear layer impeded the cement sealer from entering the tubules. They also stated that the physical and chemical properties of a cement sealer could limit its penetration even in the absence of smear layer. The present study suggests that rotational movements could be an additional factor that could affect sealer penetration.

In those teeth without smear layer, protuberances and indentations of the gutta-percha were observed where the material had been in close contact with the tubules. This phenomenon was also observed by Gutmann (1993) during his evaluation of high temperature, heat-softened gutta-percha in the absence of smear layer. Gencoglu *et al.* (1993) also confirmed this finding in their study of low-temperature heat-softend gutta-percha and Thermafil.

In some cases, spaces were observed between the gutta-percha and cement sealer. These could have been caused by the contraction of the gutta-percha upon cooling or vacuum exposure during SEM. However, this finding could have also been attributed to a procedural

retraction that was exerted on the gutta-percha when the teeth were fractured.

Conclusions

The results of this study demonstrated a better mechanical adaptation of mechanically softened gutta-percha to the walls of the canal when the smear layer was removed. In these teeth, the cement sealer formed a layer between the gutta-percha and the canal walls, penetrating several microns into the dentinal tubules.

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