INTRODUCTION

Complete obturation of the root canal system is considered to be an important part of endodontic treatment. A Basically Gutta percha and sealer are used in combination for the filling of root canals. Gutta percha has been the choice of core material for obturation since 1867 as it is least toxic, least tissue irritating and least allergic. B Gutta percha alone cannot produce the desired hermetic seal. The use of root canal sealer is required for complete and three-dimensional obturation. C The sealers lubricate the primary cone and facilitate its seating into the canal as gutta percha has little rigidity. D The leakage through an obturated root canal takes place at the interfaces between the sealer and dentin or the sealer and gutta percha, or through voids within the sealer. Therefore, the sealing quality of a root canal filling depends much on the sealing ability of the sealer used. E Many different techniques have been introduced in order to increase the quality of apical seal of the root canal. F However lateral condensation technique is the most widely used technique for obturation of the root canals.

Several investigators have found a thin layer of sludge on the instrumented surfaces of dentine. This layer of debris is called the smear layer. The smear layer is produced by the rasping action of the instruments on the dentine surface. Boyde and Knight (1970) reported that Boyde et al. in 1963 first observed the presence of smear layer on the cut surface of the tooth while McComb and Smith (1975) observed its presence on the walls of instrumented root canals.
The presence of smear layer has received considerable attention in the last decade. Some researchers recommend the removal of smear layer while others insist on an intact smear layer. According Shahrvan et al. Smear-free obturated canals leaked significantly less than groups with intact smear layer. However Galvan et al. reported that the presence of smear layer resulted in reduced apical leakage as compared to those without smear layer. Controversies still exists over the effect of smear layer on the apical sealing ability of various root canals sealers. There is no one solution for different situations. More understanding is required as to the influence of smear layer when different sealing materials are used in the presence or absence of smear layer.

The objectives of this study were to study the influence of the presence or absence of smear layer on the sealing ability of the three individual sealers and to compare the sealing ability of three sealers in the presence or absence of smear layer.

METHODOLOGY

Sixty freshly extracted mandibular first premolar teeth with single canal were selected for the study. The teeth had no caries or restorations and were those indicated for extraction for orthodontic treatment. The teeth were stored in 0.5% Chloramines solution.

The pulp tissue from the root was extirpated with a barbed broach (xxfine, Maillefer Switzerland). A size 15 K file (Colorinox, Dentsply, Maillefer, Switzerland) was inserted into the canal to verify the patency until it was visible at the apical foramen. The teeth were sectioned at cemento-enamel junction, where the rubber stop was adjusted in level with the coronal cut end of the root. Measurement was taken to obtain the root length. The working length was determined by subtracting 1 mm from the measurement previously obtained. The same procedure was followed for all the specimens.

Instrumentation was carried out using step-back technique. During instrumentation 5.25% NaOCl was used as irrigant for all specimens.

Before instrumentation and between each instrument, irrigation with 1ml of 5.25% NaOCl was done using a 25-gauge needle placed up to two thirds the length of the root canal. The canals were instrumented up to master apical file size 35.

After completion of the instrumentation, the specimens were divided into two groups with thirty specimens in each group. The groups were identified by labeling them as Group A (specimens with smear layer) and Group B (specimens with no smear layer).

Group A specimens were irrigated with a final flush of 5.25% NaOCl solution after instrumentation to keep the smear layer intact. While the Group B specimens irrigated with a final flush of 10ml of 17% EDTA solution and followed by 10ml of 5.25% NaOCl solution after instrumentation to remove the smear layer.

The specimens in Group A were divided into three sub groups as A1 (AH Plus sub-group), A2 (Ketac-endo sub-group), and A3 (Roth 801 sub-group) with each sub group consisting of ten (10) specimens.

The specimens in Group B were divided into three sub groups as B1 (AH Plus sub-group), B2 (Ketac-endo sub-group), and B3 (Roth 801 sub-group) with each sub-group consisting often (10) specimens.

All the specimens were kept in separate plastic containers along with a piece of gauze soaked in distilled water until obturation.

All the specimens in sub-groups were obturated with lateral condensation technique. The canal of each specimen was dried with absorbent paper points (Dentsply, Maillefer, Switzerland) before obturation. The sealers were mixed according to manufacturer recommendations. A standardized gutta percha cone (Color coded, Maillefer instruments SA, Switzerland) of the same size as the master apical file was placed into the root canal up to the working length and the tug back was verified, for each specimen. Post obturation radiographs were taken for all specimens in mesiodistal and buccolingual views to assess the quality of obturation and corrections were made where needed through reobturation or by addition of additional gutta percha cones. After completion of obturation, an endodontic plugger was heated and 2 to 3 mm of gutta percha from the coronal end was removed in all the specimens, to facilitate the placement of a restoration to seal the coronal access. Cavit-w (ESPE) restorations were done for all specimens.

All the specimens were placed in separate containers with wet gauze to maintain 100% humidity and maintained at 37°C in an incubator (Memmert GmbH+ Co, Schwabach, W-Germany) for seven (7) days during the complete setting of the sealers.

After seven days each specimen was blotted dry and coated with nail polish (Express finish, Maybelline, USA), except for the apical 2 mm which was covered with college wax (Stretch-toughened Modelling wax, Metrodent limited, England). Three coats were given to each specimen.

The specimens were then suspended upright in airtight containers containing 10 ml of 2% solution of...
Methylene blue and kept in an incubator at 37°C for one week. The specimens were removed from the dye, and washed under running tap water. The specimens were then dried with air syringe and the nail polish scrapped off with a scalpel. The roots were then grooved labially and lingually with a diamond disc with intermittent cutting under water spray without involving the root canal. The specimens were then split gently with a chisel.

The filling within the specimens were removed with a sharp explorer. Both the root sections of each specimen were viewed under a stereomicroscope (Olympus, Japan) with X30 magnification using electronic digital caliper. Linear measurements of the most coronal extent of dye penetration on the canal walls were recorded in millimeter up to 2 decimals. Measurements from all the specimens in all groups were tabulated. Statistical analysis of the leakage values obtained was done using the Analysis of Variance (ANOVA), Student’s t test and Scheffé test at 95% confidence interval. ANOVA (Analysis of Variance) was carried out to determine the significance of the values recorded. Where there was significant difference Post-hoc analysis (Scheffé test) was carried out to determine the difference between groups.

RESULTS

In this study, dye penetration technique with methylene blue was used to compare the apical leakage. Linear measurement of the most coronal extent of dye penetration on the wall was used to evaluate the

<table>
<thead>
<tr>
<th>Sub- group</th>
<th>Apical leakage measurement (mm)</th>
<th>S.D</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
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<tr>
<td>With smear layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>0.00</td>
<td>4.84</td>
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<td>A2</td>
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<td>A3</td>
<td>1.30</td>
<td>8.85</td>
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<tr>
<td>Without smear layer</td>
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<td></td>
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<td>3.75</td>
</tr>
<tr>
<td>B2</td>
<td>1.1</td>
<td>6.91</td>
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<tr>
<td>B3</td>
<td>0.00</td>
<td>8.41</td>
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Fig 1: Comparison of the mean leakage values of the three sealers in the presence or absence of smear layer

In group B, without smear layer, statistically the mean values of apical leakage for the three sub-groups showed no significant difference (P>0.05).

Student’s t test was carried out to determine the effect of the presence or absence of smear layer on the apical leakage of the three sealers used in this study. Ketac-endo was the only sealer that showed a statistically significant difference in their mean leakage values (P<0.05) in the presence or absence of smear layer. For AH Plus and Roth 801 sealers the difference in the mean leakage values for sub-groups with smear layer and without smear layer was not statistically significant (P>0.05).

DISCUSSION

In this study, dye penetration technique with methylene blue was used to compare the apical leakage. Linear measurement of the most coronal extent of dye penetration on the wall was used to evaluate the
sealing ability of the root canal sealers.\textsuperscript{12,13} The \textit{in vitro} techniques to evaluate obturating materials are based on the assessment of microleakage along the obturated root canal.\textsuperscript{14} These include bacterial penetration\textsuperscript{15,16}, dye penetration\textsuperscript{9,17,18,19}, isotope penetration\textsuperscript{10,13}, scanning electron microscopy\textsuperscript{20}, electrochemical techniques\textsuperscript{21}, fluorometry\textsuperscript{22}, staining technique\textsuperscript{23} and liquid pressure technique.\textsuperscript{24} Among these techniques, dye penetration is the method most widely used (due to its simplicity) to evaluate the apical seal of root canals.

Two percent (2\%) solution of methylene blue dye was used as a leakage marker because it is readily detectable under visible light, very soluble in water, able to diffuse easily, and is not absorbed by dentine matrix apatite crystals.\textsuperscript{12} Kersten and Moorer have also suggested that methylene blue dye had a comparable leakage to butyric acid (metabolic product of microorganisms).\textsuperscript{25}

In 82\% of leakage studies in endodontics, dye or radioisotope penetration methods have been used.\textsuperscript{24} Matloff \textit{et al.} showed that methylene blue dye penetrates far further into the canal than isotope tracers, thus giving a better representation of apical leakage.\textsuperscript{3} According to Ahlberg \textit{et al.} methylene blue dye may serve as an adequate indicator of microleakage of microorganisms and large size endotoxins as well as toxic agents of low molecular weight.\textsuperscript{26} However, it is still not explained as to how dye movement compares with tissue fluid movement and bacterial migration \textit{in vivo}. It seems reasonable to choose a technique that has been demonstrated to be the most effective among \textit{in vitro} tests.\textsuperscript{12}

The sealers used were epoxy amine resin-based, glass ionomer-based and zinc oxide eugenol-based sealers. The latest materials of the three types namely AH Plus, Ketac-endo and Roth 801 were selected. The root canals were obturated using lateral condensation technique and the specimens were placed in an incubator for one week with 100\% humidity at 37 °C to ensure that the sealer set in an environment that simulated the clinical situation in which they are designed to be used.\textsuperscript{12,13}

The method of producing longitudinal sections was used to split the specimens to examine the exposed filling and any dye penetration into the material and root canal wall interface. This technique would give a much true picture of the leakage pattern as compared to transverse sectioning method because it is possible to examine the exposed root filling and any dye penetration into the material and at the canal wall-root filling interface, minimizing the risk of the dye washing away.\textsuperscript{26} Transverse sectioning of the roots is associated with the disadvantage of loss of some of the tooth structure in each cut, due to the thickness of the blade, which may affect the accuracy of the measurement of dye penetration.\textsuperscript{12}

The possible routes of dye penetration through filled root canals are; between the sealer and the dentine; between the core material (gutta percha) and the sealer; through the core material and through the sealer.\textsuperscript{13} Stereomicroscope examination of the sectioned specimens showed that leakage occurred through apical foramen, between the sealer and the root canal wall, between the gutta percha and sealer and also through the sealer. Absorption of the dye by the sealers may also represent cohesive failure in the body of the sealer, creating another pathway for leakage. This study support the findings of other investigators that all root canals fillings leak\textsuperscript{12,27} except for two specimens, (one in sub-group A1and one in sub-group B3) which showed no leakage. This could have occurred due to inadvertent blockage of the apical foramen. Specimens that allowed leakage indicated that all had voids through the sealer or along the sealer- dentine interface. Hundred percent hermetic seal of canals occur rarely, if ever.\textsuperscript{3} The variations in the leakage values for the individual specimens in all the groups could be attributed to any entrapment of air in those specimens where leakage was minimal.\textsuperscript{15}

In this study in the presence of smear layer, Roth 801 sealer leaked significantly more than Ketac-Endo sealer. Similar result was found by Koch \textit{et al.}\textsuperscript{28} The quick setting of zinc oxide eugenol material (transition from paste to solid mass) may be responsible for debonding from dentinal walls or cohesive fracture caused by stresses due to the setting shrinkage, which may explain the leakage.\textsuperscript{3} The lesser leakage with the glass ionomer sealer can be attributed to its basic properties such as adaptability and ability to bind to dentine\textsuperscript{29}, which allows less dye penetration through the interface between the canal walls, cements and gutta percha.\textsuperscript{28}

In the absence of smear layer, there was no significant difference in the sealing ability of AH Plus, Ketac-Endo and Roth 801. This finding is supported by Oliver and Abbott, Timpawat and Sripanaratanakul and Tzanetakis \textit{et al.}\textsuperscript{13,30,31}

The mean leakage in case of Ketac-endo was almost double in the absence of the smear layer as compared to the presence of smear layer. This difference was statistically significant. When the smear layer was removed, orifices of the dentinal tubules opened which resulted in the reduction of adhesive properties for Ketac-endo.\textsuperscript{25} The opened tubules may also act as stress raisers, which would cause failure in the adhesive joint.\textsuperscript{8} It was also found that with the removal of smear layer with conditioning of dentine \textit{in vitro}, bond strength of glass ionomer decreased prob-
ably due to removal of Ca\(^{++}\) ions, which leads to increased microleakage.\(^3\) After the use of EDTA, the dentine is partially decalcified resulting in diminution of bond strength.\(^8\) This may be the cause in the present study, as EDTA was used which demineralized the dentine and there would have been lesser Ca\(^{++}\) ions for reaction with carboxyl groups resulting in increased leakage for Ketac-endo.

Due to better sealing in presence of smear layer it may be recommended that when Ketac-endo is used as sealer, it is better to leave the smear layer intact. The propensity of methylene blue dye to bond or react to the smear layer or any of the experimental sealers studied could be tested to rule out the possibility of misinterpretation of the amount of leakage.

REFERENCES