A Comparison of Apical Seal Produced By Zinc Oxide Eugenol, Metapex, Ketac Endo and AH Plus Root Canal Sealers

Nisha Garg¹, Amit Garg², R.S.Kang³, J. S. Mann⁴, Saru Kumar Manchanda⁵, Bhoomika Ahuja⁶

¹²Department of Conservative Dentistry and Endodontics, Sri Sukhmani Dental College and Hospital, Dera Bassi, Mohali, Punjab, India
³⁴Govt. Dental College, Patiala, Punjab, ⁵Consultant, Faridabad, Haryana
⁶Dept. of Pedodontics, PDM Dental College, Bahadurgarh, Haryana, India

Email: dmishagarg1@gmail.com

Abstract:
Aim: The purpose of the study was to compare the apical seal produced by Zinc oxide eugenol sealer, calcium hydroxide based sealer (Metapex), Glass ionomer root canal sealer (Ketac Endo) and epoxy resin root canal sealer (AH Plus).
Materials and methods: Biomechanical preparation using step back technique and irrigation with 5.25% sodium hypochlorite was done on 120 extracted, single rooted, non carious anterior teeth. The teeth were divided into four groups of 30 teeth each and roots filled with Zinc oxide eugenol, Metapex, Ketac Endo or AH Plus sealer. After decalcification and clearing process, level of dye leakage was measured using stereomicroscope and statistically analysed.
Results: The results of the study revealed that all the specimens showed some leakage. The mean dye penetration values of Group I (Zinc oxide eu2enol), Group II (Metapex), Group III (Ketac Endo) and Group IV (AR Plus) were 1.39 mm, 1.15 mm, 0.422 mm and 0.60 mm respectively.
Conclusion: The present study concluded that Ketac Endo provides the best seal when compared with Zinc oxide eugenol, Metapex and AH Plus root canal sealers.
Clinical Significance: The primary goal of successful endodontic therapy is complete obliteration of the root canal space which can be achieved by three dimensional obturation of the canal space. Previous studies have shown that lateral condensation of gutta percha and sealer can provide an adequate apical seal. The study enabled us to know the comparative sealing efficacy of different sealing materials employed and hence guide us towards better treatment results.

Key words: Obturation, apical seal, zinc oxide eugenol, AH Plus, Ketac Endo, Metapex, root canal sealer

Introduction:
Main objective of obturation in endodontics is total obliteration of root canal system and development of a fluid tight seal at the apical foramen, which provides a biological environment for healing of periapical tissue.¹ Many filling materials have been used in root canal filling material currently available for obturation. The method most frequently used to fill the root canals employs a semisolid, solid or a rigid core material cemented in the canal with a root canal sealer. Inadequate sealing with an endodontic sealer can have detrimental effects such as prolongation of inflammation and infection.²

Amongst the various root canal filling materials used, gutta percha is by far the most frequently used. Various authors have shown that teeth obturated with gutta percha points and sealer display less leakage than those without sealer.¹⁵ For many years root canal sealers based on zinc oxide eugenol served the dental profession but their irritation potential, cytotoxicity,⁶ and solubility in oral fluids is also well known.⁹,¹⁰ Most of the non eugenol sealers are calcium hydroxide based. It is postulated that calcium hydroxide as sealer may stimulate a sterile biological closure of apical region thus enhancing the seal and success of treatment.¹¹⁻¹³

Research continued for a sealer which would have chemical bond with the canal walls and hence give a hermetic seal. Pittford(1979)¹⁴ was first to realize the endodontic possibilities of a glass ionomer based sealer which appeared to bond chemically to dentin of the root canal walls and gives an added advantage by preventing percolation at the sealer dentin interface.¹⁵ However, it was only in 1990 that a glass ionomer based sealer, Ketac Endo was made commercially available to the profession. It is postulated that this sealer is biocompatible and is resistant to resorption by tissue fluids.¹⁶

Epoxy resin based sealers are used in the endodontic practice because of their favourable characteristics such as adhesion to tooth structure, long working time, ease of mixing and good sealing ability. Recently, a new epoxy resin sealer AH Plus has been introduced which is claimed to be less cytotoxic, less mutagenic and more biocompatible than AH26. A time tested method of evaluating any material is to check the amount of microleakage it will allow against the marked fluids.¹⁷,¹⁸

The purpose of this study was to compare the apical seal produced by four root canal sealers

References:

A Comparison of Apical Seal Produced By Zinc Oxide Eugenol, Metapex, Ketac Endo and AH Plus Root Canal Sealers

namely Zinc oxide eugenol sealer, calcium hydroxide sealer (Metapex), glass ionomer sealer (Ketac Endo) and epoxy resin based sealer (AHPlus) when used with laterally compacted gutta percha.

Materials and Methods:

The study was conducted in vitro on one hundred and twenty recently extracted mandibular and maxillary human anterior teeth which were collected from the department of Oral Surgery, Govt. Dental College and Hospital, Patiala. The teeth selected for study were free from root defects, fractures and had mature apex. The specimen teeth were stored in 5.25% sodium hypochlorite for 24 hours to dissolve any soft tissue present on roots and remaining periodontal tissue and calculus were removed with scalers. To facilitate instrumentation the anatomical crowns were removed at the cement-enamel junction using a #170 L carbide bur in a high speed handpiece with cooling system (3,50,000 r.p.m.)

Preparation of specimens

A no. 15 K-Flexofile (Mallifer, Dentsply) was introduced into the canal of each root until it was visible at the apical foramen. Working length was determined one mm short of that position. All the canals were instrumented to #40 K-Flexofile at working length and the remaining portion of canals was prepared using step back technique as described by Weine. The canals were irrigated with 5.25% sodium hypochlorite solution (Dentpro, India) and recapitulation was done with master apical file before using next larger instrument. Instrumented roots were randomly divided into four groups of 30 teeth each. Each group was obturated with laterally condensed gutta percha by using the following root canals sealers:

Group I: Zinc oxide eugenol (Dentpro, India)
Group II: Metapex (Meta dental Co. Ltd., Korea)
Group III: Ketac Endo (ESPE Gmbh, Seefeld, Germany)
Group IV: AH Plus (Detrey/ Dentsply, Switzerland, Germany)

Obturation of roots

Group I: Powder and liquid of Zinc oxide eugenol sealer were dispensed on a clean and dry glass slab and mixed with stainless steel spatula to a stringy consistency. Then the root canals were obturated with gutta percha points and zinc oxide eugenol sealer using lateral condensation technique. Root canal opening at coronal end was sealed with cavit (ESPE, Germany).

Group II: In this group, calcium hydroxide base Metapex was used as root canal sealer. Metapex paste was dispensed on a clean and dry glass slab and introduced in the root canal along with gutta percha points using lateral condensation.

Group III: In this, Ketac Endo capsule was activated with Applicap activator for 2 seconds and was mixed in a high speed mixer Silamat (Vivadent) for 10-15 seconds. It was then dispensed onto mixing pad with Applicap applier for use in the root canal.
A Comparison of Apical Seal Produced By Zinc Oxide Eugenol, Metapex, Ketac Endo and AH Plus Root Canal Sealers

**Dye Immersion**

After removal from the incubator, the roots were dried and given two coats of nail polish. The specimens were immersed in 2% methylene blue dye for seven days in a closed container. After removal from dye, roots were rinsed in running tap water and the nail polish was removed with the help of acetone (Loba Chemie Pvt. Ltd.).

**Clearing**

The roots were decalcified by placing them in 5% nitric acid (Ranbaxy Fine Chem. Ltd. India) for five days changing the acid solution daily. The roots were determined as completely calcified when a small needle could be passed through the thickest portion of the root without resistance. At end of decalcification, roots were rinsed in tap water. After this roots were dehydrated by placing in 100% methanol (S.D.Fine Chem Ltd. India) for three days. The methanol was changed daily for first two days and hourly on the third day. Finally the roots were stored in methyl salicylate (S.D.Fine Chem Ltd. India) to complete the clearing process.

**Stereomicroscope observation**

Level of linear dye leakage was measured in cleared roots to the maximum point of penetration using a stereomicroscope X10 magnification (Nissho Optical Co. Ltd, Japan) with a built in millimeter scale to the nearest 0.1 mm. The data collected was compiled, tabulated and put to statistical analysis.

**Results:**

Photographs 1-4 show linear dye penetration in all four groups respectively. The Table 1 shows the distribution of dye penetration scores in all groups. Mean microleakage score of group I and group II was 1.39 ± 1.090 and 1.15 ± 0.845 respectively (Table 2). When group I and group II were compared, results were not statistically significant (p>0.05) (Table 3). Mean microleakage score of group III and group IV was 0.422 ± 0.395 and 0.60 ± 0.70 respectively. When group III and group IV were compared, results were statistically insignificant (p>0.05) (Table 2). When groups Ia and IIa were compared, results were significant (p<0.05). (Table 2) Comparison of group Ib and IIb was statistically insignificant (p<0.05). However, when Group I and II were compared, results were statistically significant (p<0.05). (Table 2) P90 showed less microleakage than Ceram X irrespective of the placement technique used.

**Group IV:** In this the root canal space was filled by AH Plus. Equal volumes of paste A and paste B were placed on paper pad. These were mixed by using a metal spatula to a homogenous consistency and introduced in the root canal with the help of laterally condensed gutta percha.
A Comparison of Apical Seal Produced By Zinc Oxide Eugenol, Metapex, Ketac Endo and AH Plus Root Canal Sealers

Table I:

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NO. OF TEETH</th>
<th>RANGE</th>
<th>MEAN</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Zinc oxide eugenol)</td>
<td>30</td>
<td>0-3.8</td>
<td>1.39</td>
<td>1.090</td>
</tr>
<tr>
<td>II (Metapex)</td>
<td>30</td>
<td>0-2.7</td>
<td>1.15</td>
<td>0.845</td>
</tr>
<tr>
<td>III (Ketac Endo)</td>
<td>30</td>
<td>0-1.6</td>
<td>0.422</td>
<td>0.395</td>
</tr>
<tr>
<td>IV (AH Plus)</td>
<td>30</td>
<td>0-2.4</td>
<td>0.60</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Comparison

<table>
<thead>
<tr>
<th>'t' value</th>
<th>'p' value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-II</td>
<td>0.997</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>I-III</td>
<td>4.502</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>I-IV</td>
<td>3.39</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>II-III</td>
<td>4.260</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>II-IV</td>
<td>2.74</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>III-IV</td>
<td>1.22</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

Discussion:

Leakage into the root canal system can occur via four possible routes: (a) through the apical foramen can root filling material and the root canal wall, (b) through the apical foramen by infusion into the material, (c) from the outside of tooth through exposed dentin, accessory canals etc and (d) through the coronal access cavity. In this study most of the specimens showed leakage via the first two routes.
possess the sealing ability to give water tight seal at the periapex. Hence a sealer must be used to attain the three dimensional seal. It has been shown by various authors that teeth obturated with gutta percha and sealer display a better seal than those obturated without sealer. Different types of sealers have been used in conjunction with gutta percha for root canal obturation with varied success rates. However, till date there is no sealer which fulfills all the specifications and criteria of an ideal root canal sealer.1,5

The four root canal sealers used in this study were Zinc oxide eugenol, Metapex, Ketac Endo and AH Plus. The sealers with the widest use today are zinc oxide eugenol based materials. But these do not fulfill all the ideal characteristics advocated for endodontic sealers. Zinc oxide and eugenol has been found universally to be cytotoxic agent. Removal of eugenol from mixture greatly reduces the toxicity.

Calcium hydroxide has been widely used in root canal therapy as an intracanal medicament and to promote periapical hard tissue formation. It has been used as a major component of the root canal sealers, Metapex (introduced by Meta Dental Co. Ltd., Korea) is calcium hydroxide based sealer which contains iodoform as one of its components. Iodoform serves as an antibacterial agent and makes the paste radiopaque.

The use of glass ionomer cements in endodontics has been suggested by several investigations.14 When used as sealer, glass ionomer material provided a superior adaptation to the canal walls and thus a better apical seal.15 The reaction of glass ionomer cement and the tooth structure is a simple inorganic reaction in which calcium ions of the tooth are released by epoxycrylate acid component of cement. The released free ions complex with the tartaric acid of the cement, facilitating the cross linkage of polyacrylate chains.15

The newly developed glass ionomer sealer, Ketac Endo (introduced by ESPE GmbH, Seefeld, Germany) shows low solubility in oral fluids, sufficient working time (7 minutes), setting time (24 minutes) and biocompatibility.21 Greatest problem with Ketac Endo is its removal in the event of root canal retreatment since there is no known solvent for glass ionomers. However, a Toronto/Israel group reported that Ketac Endo sealer “can be efficiently removed by hand instruments and chloroform solvent followed by one minute instrumentation with an ultrasonic No. 25 file”.22

Epoxy resin based sealers have been used in endodontic practice because of their adhesion to tooth structure, long working time, ease of mixing and good sealing ability. AH 26 is commonly used root canal sealer. It contains bismuth oxide and hexamethylene tetramine (HMT) as powder and bisphenol-a-diglycidyl ether as resin. After mixing two components HMT decomposes and yields ammonia and formaldehyde which is responsible for its cytotoxic effects. AH Plus is substitute for AH26 which has advantageous properties of AH 26, but preserves the chemistry of epoxy amine in better way so that material no longer releases formaldehyde.23,24

In this study level of dye penetration of each root was measured and tabulated (Table 1). The mean microleakage of various sealers in ascending order was as follows: Ketac Endo (0.4223mm)<AH Plus (0.60mm)<Metapex (1.15mm)<Zinc oxide eugenol sealer (1.39mm) respectively (Table II).

The results of the present study were put to statistical analysis using student's 't' test to compare their sealing ability. The mean microleakage of Ketac Endo was significantly lesser than that of Zinc oxide eugenol, Metapex and AH Plus root canal sealers. Hence it can be stated that Ketac Endo is far superior to other three sealers in its sealing ability. This may be attributed to the ability of glass ionomer based Ketac-Endo sealer to chemically bind the dentinal walls of the root canals. The findings of this study concur with those established by Ray and Seltzar (1991)15 who in their study found that Ketac Endo has better adhesion to dentinal walls than Grossman's sealer when observed under electron microscope. Friedman S. et al (1995)22, Kolokuris I et al (1996)16 and Belles P et al (1997)25 in their respective studies have also shown that glass ionomer containing root canal sealers have good sealing ability and biocompatibility.

However results of present study are at variance with those of Smith Nut and Steiman HR (1994)26 who in their study showed that Zinc oxide eugenol based sealers viz., Tubliseal (old formula), Tubliseal (new formula), Roth’s 801 sealer to be better than glass ionomer based sealer i.e. Ketac Endo. But it could be due to some dehydration of material which occurred during obturation, thus ideal properties of sealer hampered leading to inaccurate results.

Mean microleakage of AH Plus, Metapex and Zinc oxide eugenol was compared and the difference of their mean was statistically significant showing AH Plus better in sealing ability than Metapex and Zinc oxide eugenol. The results of this study are in accordance with those of Limkangwalmongkol S et al (1991)2 who in their study revealed that a root canal sealer should be used in conjunction with laterally condensed gutta percha and AH 26 (a resin based sealer) provides significantly better apical seal when compared with Apexit, Sealapex (calcium hydroxide based sealers) and Tubliseal (a zinc oxide eugenol based sealer).

When mean microleakage of Metapex and Zinc oxide eugenol sealer was compared, lesser of apical leakage was found with Metapex but the difference was not statistically significant indicating
that both of them have comparable sealing ability. Same results were found in study conducted by Alexander JB and Gordon TM (1985)27. They showed that Sealapex (a calcium hydroxide based sealer) produced apical seal equal to that produced by Grossman type sealer. Pitt Ford TR and Rowe AHR (1989)28 in their study also found that the sealing ability and biocompatibility of calcium hydroxide based sealer was similar to that of zinc oxide eugenol sealer.

The results of present study are in concurrence to those of Limkangwalmongkol et al (1991)29, because their study revealed the apical leakage of Sealapex to be 2.28 mm and that of Tubiseal to be 1.95 mm. The difference in mean dye penetration of the two was also found to be statistically non significant as proved in the present study. Goldberg F and Gurfinkel J (1979)30, Weisenseel JA et al (1987)30, Madison et al (1987)31 Saad AY and Carlo (1988)32, Caicedo R and Fraunhofer JA (1988)33, Barkhordar et al (1989)34 and Soares I et al (1990)35 in their respective studies showed that calcium hydroxide containing sealers have comparable sealing ability to that of zinc oxide eugenol sealers.

However, the results of present study are different from that of study found that significantly lesser Rothier et al (1987)36 who in their leakage occurred with calcium hydroxide sealers than with traditional zinc oxide eugenol sealers. The difference may be because they used commercially available preparations of zinc oxide eugenol cements, whereas in present study simple zinc oxide powder was mixed with eugenol to give a stringy consistency. The present study showed that Ketac Endo is best amongst all the four sealers tested viz; Zinc oxide eugenol, Metapex, Ketac Endo and AH Plus as far as its sealing ability is concerned. Chemical bonding of Ketac Endo gives superior apical seal and prevents percolation of fluids at the sealer dentin interface. Its use as sealer can enhance the success of the endodontic treatment.

Conclusion:
The three dimensional sealing of root canal space is one of the major objectives in root canal treatment. The most common cause of failure involving endodontic therapy can be attributed to leakage at apex. The present study concluded that Ketac Endo provides the best seal when compared with Zinc oxide eugenol, Metapex and AH Plus root canal sealers. Chemical bonding of glass ionomer sealer, Ketac Endo to dentin provides a superior adaptation to the canal walls, low solubility in presence of oral fluids, sufficient working time, setting and biocompatibility. Thus Ketac Endo may be suggested as the potential root canal sealer material. However, before drawing a definite conclusion, further studies on large sized samples as well as longer duration of observations are required in vitro as well as in vivo.

References:
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