In Vitro Assessment of the Tooth Discolouration Induced by Well Root ST, Dia-Proseal and MTA Fill apex Root Canal Sealers

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Abstract: This in vitro spectrophotometric study aimed to investigate the tooth discolouration potential of Well Root ST, MTA Fill apex and Dia-Proseal root canal sealers. The crowns of sixty human maxillary central and lateral incisor teeth were sectioned and coronal pulps were removed. Pulp chambers were filled with selected root canal sealer except the control group (n = 15). The colour changes were determined using spectrophotometer at prior to filling, 1 week after filling, after 1 month and after 3 months. One-way ANOVA and Bonferroni post hoc tests were used for data analysis. All sealers caused clinically perceptible discolouration after 1 month showing significant differences from the control group (P < 0.05). There was no statistically significant difference among Well Root ST, Dia-Proseal and MTA Fill apex root canal sealers (P > 0.05). Within the limitations of this study our data indicate Well Root ST, Dia-Proseal and MTA Fill apex induce a similar amount of perceptible tooth discolouration.

Keywords: Tooth discolouration, MTA Fill apex, Well Root ST, Dia-Proseal

INTRODUCTION

Tooth discoloration induced by endodontic and/or restorative materials is an unpleasant situation for both patient and clinicians [1]. Following the completion of root canal treatment tooth may discolor due to incomplete removal of pulp tissue from coronal root canal system or presence of filling materials such as root canal sealers [2]. Root canal sealers are used combined with gutta-percha for three-dimensional obturation of root canal system by many techniques. During the delivery of sealers to root canals it is possible to leave sealer remnants in coronal access cavity. These materials’ remnants may discolor over time and transmit through enamel and dentin [3].

Root canal sealers are categorized according to their composition such as eugenol, zinc oxide, mineral trioxide aggregate, calcium hydroxide, and epoxy resin or calcium silicate-based materials [4]. Previous studies have reported that root canal sealers cause tooth discoloration due to presence of their components or corrosion of these components because of moisture within root canal system or chemical reaction with dentin [5, 6]. Moreover, the colour of sealer might cause discoloration in the case of improper coronal extension of root canal filling. It has also been reported that discoloration induced by root canal sealers is progressive is left untreated [1, 6].

Dia-Proseal (Diadent, Seoul, Korea) is a novel epoxy resin based root canal sealer. A previous study evaluated the physicochemical properties and biocompatibility of Dia-Proseal and reported the sealer presented acceptable features when compared to AH Plus [7]. Epoxy resin based root canal sealers have been reported to induce moderate to severe discoloration [8], although potential discoloration induced by Dia-Proseal specifically is not reported yet. MTA Fill apex (Angelus, Londrina, Parana, Brazil) is a combination of resin and mineral trioxide aggregate (MTA), which is composed of resin, bismuth, silica and MTA that contains tricalcium silicate, tricalcium aluminate, tricalcium oxidated, and silicate oxide according to the manufacturer [9]. MTA Fill apex has been correlated with perceptible tooth discoloration in a recent study [10].

Well Root ST (Vericom Dental, Korea) is a novel injectable bioactive calcium silicate paste sealer, which is composed of calcium silicate, zirconium oxide, unidentified fillers and thickening agents as reported by the manufacturer. According to our literature research, there is no study regarding the discolouration potential of Well Root ST. This in vitro study aimed to investigate the tooth discoloration effect of Well Root ST root canal sealer in comparison with Dia-Proseal
and MTA Fill apex sealers. The null hypothesis was that there is no significant difference among groups regarding tooth discoloration.

MATERIAL AND METHODS

The study protocol was approved by university medical faculty clinical researches ethical board with approval number (KAEK) 2016/254. Sixty human central and lateral maxillary incisor teeth free of caries, fracture, restorations and crown discoloration were selected. The crowns’ surfaces were cleaned with polishing burs to remove any extrinsic stains and debris. The roots were removed using Isomet saw (Buehler, IL, USA) under cooling 2 mm below the cement enamel junction. Pulps within pulp chamber were extirpated using excavator and H files from apical access and the pulp chambers were flushed with 5.25% Naocl followed by distilled water. The cavities were dried using paper points and air spray. The specimens were randomly divided into 4 groups according to the tested root canal sealer (n = 15): Control group, which no sealer was used, Dia-Proseal, MTA Fill apex and Well Root ST group. Compositions of the sealers are presented in Table 1. Dia-Proseal and MTA Fill apex were mixed according to the manufacturers’ instructions. Well Root ST was injected onto a glass slide. Pulp chambers were filled with selected sealer using a #25 spreader with special care to seal all axial walls with sealer. Apical access cavities were sealed with resin modified glass ionomer cement (SDI Riva Light cure, SDI, Australia). The specimens were stored in Eppendorf tubes at 100% humidity and 37°C for 3 months.

Spectrophotometer (VITA Easy shade® compact; VITA Zahnfabrik, Bad Sackingen, Germany) was used to measure colour under constant laboratory light by and experienced operator who was blind to the assigned group of each specimens. The spectrophotometric analysis was conducted; before placement of sealer (t0), 1 week after the placement of the sealers (t1), after 1 month (t2) and after 3 months (t3). The device was calibrated before each measurement, which was repeated three times. The Commission Internationale de l’Eclairage (CIE) system was used for colour change determination. The colour changes were calculated by using the following formula:

\[ \Delta E = \sqrt{[(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]/2} \]

In this formula \( \Delta L \) represents the change in luminosity, \( \Delta a \) represents the change in red-green parameter and \( \Delta b \) represents the change in yellow-blue parameter. \( \Delta E \) values, which were equal to or greater than 3.3 were accepted as clinically perceptible discoloration as suggested by Khokhar et al.; [11].

Statistical analyses were performed with SPSS software 21.0 version (SPSS Inc, Chicago, IL, USA). Shapiro-Wilk test confirmed the normal distribution of the data, which was further, analyzed using one-way analysis of variance with repeated measurements and Bonferroni post hoc tests. The level of statistical significance was set at \( P < 0.05 \).

RESULTS

There was statistically significant difference between the control group and sealer groups at t1, t2 and t3 measurements regarding discoloration \( (P < 0.05) \). All sealers induced clinically perceptible discoloration after 1 week. The colour changes according to the time intervals are presented in Table 2. There was no significant difference among Dia-Proseal, MTA Fill apex and Well Root ST groups \( (P > 0.05) \).

Table-1: Composition of the experimental groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Manufacturer</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia-Proseal</td>
<td>Diadent, Seoul, Korea</td>
<td>Epoxy resin, zirconium oxide, calcium hydroxide, calcium tungstate,</td>
</tr>
<tr>
<td>MTA Fill apex</td>
<td>Angelus, Londrina, Parana, Brazil</td>
<td>Resins (salicylate, diluting, natural), bismuth trioxide, nanoparticulate silica, mineral trioxide aggregate, pigments</td>
</tr>
<tr>
<td>Well Root ST</td>
<td>Vericom Dental, Korea</td>
<td>Calcium silicate, zirconium oxide, filler and thickening agent</td>
</tr>
</tbody>
</table>

Table-2: Changes in the mean (standard deviation) \( \Delta E \) values of in groups of teeth filled with 1 of the 3 tested sealer and a control group during 3 months. t0, is the baseline; t1, is 1 week after placement of the sealers; t2, is 1 month after; t3 is 3 months after placement of the sealers.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number</th>
<th>t0-t1</th>
<th>t0-t2</th>
<th>t0-t3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia-Proseal</td>
<td>15</td>
<td>5.39 (1.18)</td>
<td>7.46 (1.90)</td>
<td>8.73 (3.41)</td>
</tr>
<tr>
<td>MTA Fill apex</td>
<td>15</td>
<td>3.72 (1.07)</td>
<td>7.26 (2.00)</td>
<td>8.84 (3.55)</td>
</tr>
<tr>
<td>Well Root ST</td>
<td>15</td>
<td>4.09 (1.14)</td>
<td>5.89 (1.89)</td>
<td>9.11 (1.77)</td>
</tr>
<tr>
<td>Control</td>
<td>15</td>
<td>1.01 (0.20)</td>
<td>0.81 (0.10)</td>
<td>1.51 (0.13)</td>
</tr>
</tbody>
</table>

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DISCUSSION
Dia-Proseal and Well Root ST are two different types of root canal sealers newly introduced to the market. Dia-Proseal is an epoxy resin based sealer whereas Well Root ST is a bioactive calcium silicate root canal filling material. However, their discolorative potential on teeth has not been studied yet. The present study was the first in vitro investigation of the discoloration potential of Dia-Proseal and Well Root ST root canal sealers.

Different methodologies have been suggested for the measurement of discolouration such as visual technique, computer analysis of digital photos, the use of spectrophotometers [6, 12, 13]. Spectrophotometers have been reported to be accurate and objective instruments for colour determination in dentistry and utilized in many studies [14, 15]. CIE, which is one of the most commonly used system provides calculation of ΔE values using L*a*b* values [16, 17]. The present study used spectrophotometers and CIE system for colour change calculations. All tested sealers induced clinically perceptible colour change, which were significantly higher than the control group.

Since its introduction to dentistry, MTA has gained popularity in many endodontic procedures by showing high biocompatibility, bioactivity and sealability [18, 19]. Therefore, many MTA-based or calcium silicate-based materials have been developed and introduced. Tooth discoloration is the most pronounced disadvantage of MTA, so it is a necessity to evaluate new materials with similar composition to MTA [20, 21]. MTA Fill apex is a combination of resin and MTA, which consists tricalcium silicate, tricalcium aluminate, tricalcium oxidated, silicate oxide and bismuth oxide [22]. Previous in vitro studies have investigated the discolourative potential of MTA Fill apex and reported conflicting results [8, 10, 23]. Ioannidis et al.; reported that MTA Fill apex presented acceptable aesthetical properties with no perceptible discoloration, whereas Gürel et al.; and Forghani et al.; reported that MTA Fill apex induced clinically perceptible colour change [8, 10, 23]. The results of the present study are in line with the findings of Gürel et al.; and Forghani et al.; [10, 23]. Differences among studies might be attributed to different dentin thickness and sealer quantity due to the selection of different specimens, as Ioannidis et al.; studied on molar teeth, Forghani et al.; studied on premolar teeth, and Gürel et al.; utilized mandibular incisor teeth [8, 10, 23]. In the present study, maxillary incisor teeth were used. Bismuth oxide has been considered responsible for tooth discoloration induced by MTA. MTA Fill apex also contains bismuth trioxide as radio pacifier; however both Dia-Proseal and Well Root ST contain zirconium oxide (Table 1). In this study, all tested sealers induced clinically perceptible discoloration with no significant difference among them. Based on these results, it might be speculated that other mechanisms or ingredients might be responsible for tooth discoloration besides the presence of bismuth oxide.

Dia-Proseal is a novel epoxy resin based root canal sealer with similar composition to AH Plus. Lenherr et al. reported that AH plus exhibits satisfactory colour stability in contrast to the findings reported by Elkhazin et al., who reported clinically perceptible discoloration after 6 weeks [20, 24]. In the present study, Dia-Proseal induced clinically perceptible colour change in 4 weeks. Dia-Proseal contains calcium hydroxide as distinct from AH plus however, calcium hydroxide has not been shown to cause tooth discoloration [20].

Well Root ST is a premixed, injectable sealer and delivered to root canals by injection without contaminating the access cavity. Well Root ST contains zirconium oxide as radio pacifier, calcium silicate and thickening-filling agents. Previous studies reported that bismuth oxide containing MTA-based products induced more discolorations when compared to zirconium oxide containing MTA-based products [25, 26]. The present study showed that Well Root ST caused clinically perceptible discoloration in 4 weeks, similar to MTA Fill apex and Dia-Proseal.

In this study extracted maxillary incisor teeth were selected and access cavities were prepared from apical surfaces without harming the occlusal surfaces. Intact occlusal surfaces prevented alterations in the specimens’ optical properties by structure loss, placement of restorative materials and microleakage. Therefore, in the present study apical access cavities were prepared as suggested by previous literature [10, 23].

The sealer remnants inside the pulp chamber are one of the main reasons for crown discoloration induced by root canal sealers. In this study, the whole pulp chamber of the specimens was filled with sealer as opposed to optimal clinical scenario, which in the sealer should be cleaned completely from the pulp chamber prior to restoration of cavity. The placement of a bulk of sealer in pulp chamber exaggerates the discolourative potential of the sealer definitely, but also has been utilized in previous in vitro studies to present the chromogenetic potential of the sealer by increasing the contact with axial dentinal walls [8, 10]. Consequently, the results of the present study do not directly relate the in vivo tooth discoloration in clinical practice.

CONCLUSION
Sealer remnants should be completely removed from the pulp chamber following root canal obturation and prior to post-endodontic restoration. Further studies are required to reveal in vivo discolourative potential of the tested sealers.
REFERENCES
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