

Original Research Article

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

Murat DEMİRAL<sup>1\*</sup>, Cangül KESKİN<sup>2</sup>, İsmail UZUN<sup>2</sup><sup>1</sup>Specialist Endodontist, Kucukcekmece Oral Health Center, Istanbul, Turkey<sup>2</sup>Ondokuz Mayıs University Faculty of Dentistry Department of Endodontics, Samsun, Turkey

### \*Corresponding author

Murat Demiral

Email: [dt.muratdemiral@hotmail.com](mailto:dt.muratdemiral@hotmail.com)

**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 discolouration 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 discolouration 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 discolouration in the case of improper coronal extension of root canal filling. It has also been reported that discolouration 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 discolouration [8], although potential discolouration 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 discolouration 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 discolouration 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 discolouration.

## MATERIAL AND METHODS

The study protocol was approved by university medical faculty clinical researches ethical board with approval number (KAEEK) 2016/254. Sixty human central and lateral maxillary incisor teeth free of caries, fracture, restorations and crown discolouration 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. Pulp chambers 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.

**Table-1: Composition of the experimental groups.**

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

Spectrophotometer (VITA Easy shade<sup>®</sup> 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'éclairage (CIE) system was used for colour change determination. The colour changes were calculated by using the following formula:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

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 discolouration 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 discolouration ( $P < 0.05$ ). All sealers induced clinically perceptible discolouration 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-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.**

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

## 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 discolourative potential on teeth has not been studied yet. The present study was the first in vitro investigation of the discolouration 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  $\Delta E$  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 discolouration 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 discolouration, 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 discolouration 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 discolouration with no significant difference among them. Based on these results, it might be speculated that other

mechanisms or ingredients might be responsible for tooth discolouration 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 discolouration 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 discolouration 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 discolouration 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 chromogenic 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 discolouration 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

1. van der Burgt TP, Eronat C, Plasschaert AJ. Staining patterns in teeth discolored by endodontic sealers. *Journal of endodontics*. 1986 Jan 1;12(5):187-91.
2. Watts A, Addy M. Tooth discolouration and staining: Tooth discolouration and staining: a review of the literature. *British dental journal*. 2001 Mar 24;190(6):309-16.
3. Davis MC, Walton RE, Rivera EM. Sealer distribution in coronal dentin. *Journal of endodontics*. 2002 Jun 30;28(6):464-6.
4. Kim RJ, Shin JH. Cytotoxicity of a novel mineral trioxide aggregated-based root canal sealer. *Dental materials journal*. 2014 May 30;33(3):313-8.
5. Allan NA, Walton RE, Schaffer M. Setting times for endodontic sealers under clinical usage and in vitro conditions. *Journal of Endodontics*. 2001 Jun 30;27(6):421-3.
6. Parsons JR, Walton RE, Ricks-Williamson L. In vitro longitudinal assessment of coronal discoloration from endodontic sealers. *Journal of endodontics*. 2001 Nov 30;27(11):699-702.
7. Song YS, Choi Y, Lim MJ, Yu MK, Hong CU, Lee KW, Min KS. In vitro evaluation of a newly produced resin-based endodontic sealer. *Restorative Dentistry & Endodontics*. 2016 Aug 1;41(3):189-95.
8. Ioannidis K, Mistakidis I, Beltes P, Karagiannis V. Spectrophotometric analysis of crown discoloration induced by MTA-and ZnOE-based sealers. *Journal of Applied Oral Science*. 2013 Apr;21(2):138-44.
9. Camilleri J. Mineral trioxide aggregate: present and future developments. *Endodontic Topics*. 2015 May 1;32(1):31-46.
10. Gürel MA, Kivanç BH, Ekici A, Alaçam T. Evaluation of crown discoloration induced by endodontic sealers and colour change ratio determination after bleaching. *Australian Endodontic Journal*. 2016 Dec 1;42(3):119-23.
11. Khokhar ZA, Razzoog ME, Yaman P. Color stability of restorative resins. *Quintessence international*. 1991 Sep 1;22(9).
12. Partovi M, Al - Havvaz AH, Soleimani B. In vitro computer analysis of crown discolouration from commonly used endodontic sealers. *Australian endodontic journal*. 2006 Dec 1;32(3):116-9.
13. Van der Burgt TP, Mullaney TP, Plasschaert AJ. Tooth discoloration induced by endodontic sealers. *Oral Surgery, Oral Medicine, Oral Pathology*. 1986 Jan 1;61(1):84-9.
14. Paul SJ, Peter A, Rodoni L, Pietrobon N. Conventional visual vs spectrophotometric shade taking for porcelain-fused-to-metal crowns: a clinical comparison. *The Journal of Prosthetic Dentistry*. 2004 Dec 1;92(6):577.
15. Guan YH, Lath DL, Lilley TH, Willmot DR, Marlow I, Brook AH. The measurement of tooth whiteness by image analysis and spectrophotometry: a comparison. *Journal of Oral Rehabilitation*. 2005 Jan 1;32(1):7-15.
16. Johnston WM, Kao EC. Assessment of appearance match by visual observation and clinical colorimetry. *Journal of Dental Research*. 1989 May 1;68(5):819-22.
17. O'Brien WJ, Groh CL, Boenke KM. A new, small-color-difference equation for dental shades. *Journal of Dental Research*. 1990 Nov;69(11):1762-4.
18. Torabinejad M, Hong CU, Ford TP, Kettering JD. Cytotoxicity of four root end filling materials. *Journal of Endodontics*. 1995 Oct 1;21(10):489-92.
19. Torabinejad M, Rastegar AF, Kettering JD, Ford TR. Bacterial leakage of mineral trioxide aggregate as a root-end filling material. *Journal of Endodontics*. 1995 Mar 1;21(3):109-12.
20. Lenherr P, Allgayer N, Weiger R, Filippi A, Attin T, Krastl G. Tooth discoloration induced by endodontic materials: a laboratory study. *International endodontic journal*. 2012 Oct 1;45(10):942-9.
21. Akbari M, Rouhani A, Samiee S, Jafarzadeh H. Effect of dentin bonding agent on the prevention of tooth discoloration produced by mineral trioxide aggregate. *International journal of dentistry*. 2011 Nov 3;2012.
22. Torabinejad M, White DJ, inventors; Loma Linda University, assignee. Tooth filling material and method of use. United States patent US 5,415,547. 1995 May 16.
23. Forghani M, Gharechahi M, Karimpour S. In vitro evaluation of tooth discolouration induced by mineral trioxide aggregate Fillapex and iRoot SP endodontic sealers. *Australian Endodontic Journal*. 2016 Feb 1.
24. Elkhazin M. Analysis of coronal discoloration from commonly used obturation materials (Doctoral dissertation, University of the Western Cape).
25. Yun DA, Park SJ, Lee SR, Min KS. Tooth discoloration induced by calcium-silicate-based pulp-capping materials. *European journal of dentistry*. 2015 Apr;9(2):165.
26. Kang SH, Shin YS, Lee HS, Kim SO, Shin Y, Jung IY, Song JS. Color changes of teeth after treatment with various mineral trioxide aggregate-based materials: an ex vivo study. *Journal of endodontics*. 2015 May 31;41(5):737-41.