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Coronal Discoloration Induced By Three Different Bio-Ceramic Sealers – A Spectrophotometric Evaluation

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Abstract

Aim: Evaluation of the coronal discoloration induced by three different bio-ceramic sealers - Guttaflow Bioseal, Angelus Bio C, Meta Ceraseal

Objectives

- To assess coronal discoloration induced by three different bio-ceramic sealers - Guttaflow Bioseal, Angelus Bio C, and Meta Ceraseal
- To compare the magnitude of coronal discoloration induced by three different bio-ceramic sealers – Guttaflow Bioseal, Angelus Bio C, and Meta Ceraseal
- To quantify the time required for the occurrence of the color change of the dental crown by Guttaflow Bioseal, Angelus Bio C, Meta Ceraseal

Methodology: 48 extracted single rooted mandibular 1st premolar teeth selected after examining the teeth visually and disinfected using chloramine T. All teeth then sectioned in the coronal third of the root complex 3 mm below the cemento-enamel junction providing an apical access. The coronal portion is taken for the study and radicular portion discarded. The pulp chamber cleaned chemo-mechanically with H-files (No. #35-80), irrigated with 17% EDTA, sodium hypochlorite (5.2% w/w) and normal saline. All teeth were sent for spectrophotometric

evaluation for baseline values. All specimens then randomly assigned to three groups (n = 16). Then filled with experimental sealers: group A (Gutta Flow Bioseal), group B (Angelus Bio C), group C (Meta Ceraseal). Sealers were prepared according to manufacturers' instructions and placed into the pulp chamber via the apical access. All specimens were incubated for 6 months at 37 º C. Colour coordinates (L*a*b*) values were measured with a spectrophotometer before endodontic treatment (baseline), 1st month, 3rd month, and 6th month after treatment. L*a*b* values were used to calculate color changes (ΔE). Data were statistically analyzed using ANOVA test.

Results: The greater discoloration is caused by Guttaflow Bioseal followed by Ceraseal and Bio C Sealer respectively. The difference in mean ΔE value recorded among the groups was found to be statistically significant ($P < 0.05$)

Conclusions: All root canal sealers have the potential to discolor teeth over a period of time.

Keywords: Coronal discoloration, Root canal sealers, and Spectrophotometer

Introduction

Tooth discoloration after root canal therapy is common and with an increase in public interest in aesthetics, it has become a matter of concern. Nicholls states that bleeding into the pulp chamber, endodontic medication, and filling materials are the primary causes of intrinsic tooth discoloration associated with endodontic treatment (1). Grossman states that the least amount of staining should result from an ideal sealer. Numerous research studies have demonstrated the discoloration potential of sealers based on resin, ZnOE, and calcium hydroxide. In these situations, bleaching is less effective. The best ways to prevent discoloration are to completely remove sealer remnants, cut the filling material below the cementoenamel junction, or use non-staining sealers. The discoloration may arise from penetration into dentinal tubules or from sealer remnants becoming darker over time. Nonetheless, it is frequently observed that filling materials remain in the pulp chamber and that sealer remnants are not completely removed. (2)

Materials that can be categorized as bioinert, bioactive, or biodegradable based on how they interact with surrounding tissues are included in the vast category of biomaterials known as bioceramics. Among them are glass ceramics, calcium silicates, hydroxyapatite, resorbable calcium phosphates, radiotherapy glasses, bioactive glass, and alumina and zirconia. Precipitation of calcium phosphate, which can promote bioactivity and tissue growth upon contact, is the outcome of the setting reaction of calcium silicates. (3)

Three new types of endodontic sealers have recently been introduced. Bio-C Sealer from Angelus in Brazil is a new sealer available on the market. It consists of tricalcium silicate, dicalcium silicate, tricalcium aluminate, calcium oxide, zirconia oxide, silicon oxide, polyethylene glycol, and iron oxide. This sealer offers biocompatibility, bioactivity, high pH, radiopacity, and good flow. GuttaFlow Bioseal from Coltene Whaledent GmBH in Switzerland is a hybrid sealer made from a combination of polydimethylsiloxane, gutta-percha powder, and calcium silicate particles. The manufacturer claims that this mixture can lead to the formation of hydroxyapatite crystals on the surface. Cera seal from Metabiomed in Korea is a calcium silicate-based bioceramic sealer that comes in a pre-mixed syringe. CeraSeal has a high pH, setting time of around 3.5 hours, and radiopacity of less than 8mm. It is composed

of tricalcium silicate, dicalcium silicate, calcium aluminate, and zirconium oxides. (2,4)

Methods such as visual color assessment with shade guides, determination of dentine color changes in longitudinal tooth sections, digital imaging, colorimeters, and spectrophotometers are commonly used for evaluating tooth color. Spectrophotometry is considered the gold standard method due to its high sensitivity, data stability, and repeatability. While there may be some errors in measurement due to external factors like light source or temperature, the main advantage of this method is that it provides a comprehensive analysis of tooth reflection in the visual spectrum. The bioceramic root canal sealer has demonstrated the ability to create precipitates resembling hydroxyapatite, to be biocompatible, to seal well, and to promote healthy periapical tissue wound healing. The newest bioceramic sealers are Guttaflow Bioseal, Angelus Bio C Sealer, and Meta Ceraseal. However, staining occurs in all modern endodontic materials to some degree. There is a dearth of research on these root canal sealers' propensity to discolor

The purpose of this study is to evaluate and compare the effect of recent three different bio-ceramic sealers - Guttaflow Bioseal, Angelus Bio C, Meta Ceraseal on color alteration of the crown

Materials and Methods

In this in-vitro experimental study. 48 single-rooted extracted human mandibular first premolars were selected after examining the teeth visually. Inclusion criteria are single rooted mandibular 1 st premolar teeth, free of caries, free of developmental anomalies. Exclusion criteria are caries, previous endodontic treatment, restorations, morphological defects, cervical abrasion, hypoplastic teeth, teeth with cracks. All 48 specimens are randomly assigned to three groups (n = 16) to be filled with experimental sealers:

Selection and Standardization of teeth:

48 single rooted extracted human mandibular first premolars were selected after examining the teeth visually. The teeth with discoloration, decay, fractures or cracks, previous restoration and defects were discarded. Teeth were disinfected in thymol solution. The surface deposits were removed using scaling unit. Teeth were cleaned further using polishing paste and a rubber cup

Grouping of teeth:

The teeth were divided into 3 groups of 16 teeth each. In Group A - Gutta Flow Bioseal, group B - Angelus Bio C, Group C - Meta Ceraseal. All teeth were sectioned in the coronal third of the root complex 2-3 mm below the cemento-enamel junction providing apical access. The coronal portion were taken for the study and the radicular portion got discarded. The pulp chamber were cleaned chemo- mechanically with H-files (No. #35-80), irrigated with sodium hypochlorite (5.2% w/w), normal saline and 17% EDTA All teeth were sent for spectrophotometric evaluation for baseline values. All specimens then randomly assigned tothree groups. To be filled with experimental sealers: group A (Gutta Flow Bioseal), group B(Angelus Bio C), and group C (Meta Ceraseal). Sealers were prepared according to manufacturers' instructions and placed into the pulp chamber via the apical access (Figure: 1-3). A finger plugger used to coat the internal axial walls with the sealers. The apical access then sealed with composite. All specimens were incubated for 6 months at 37 º C.

Figure 1:

Figure 2:

Figure 3:

Results

Statistical technique used: Analysis of Variance (ANOVA) followed by post- hoc analysis using Bonferroni test. Higher mean ΔE value was recorded in Guttaflow Bioseal followed by Bio C Sealer and Ceraseal respectively in baseline to 1 month time interval. The difference in mean ΔE value recorded among the groups was found to be statistically significant (P < 0.05). (Table – 1) Higher mean ΔE value was recorded in Guttaflow Bioseal followed by Bio C Sealer and Ceraseal respectively in baseline to 3 months time interval. The difference in mean ΔE value recorded among the groups was found to be statistically significant (P<0.05).(Table-2) Higher mean ΔE value was recorded in Guttaflow Bioseal followed by Bio C Sealer and Ceraseal respectively in baseline to 6 months' time interval. The difference in mean ΔE value recorded among the groups was found to be statistically significant (P<0.05).(Table – 3) Guttaflow Bioseal - Higher mean ΔE value was recorded in 3 months – 6 months Time Interval when compared to 1 month – 3 months' Time Interval. The difference in mean ΔE value recorded between the 4 Time Interval groups was statistically significant (P<0.05). Ceraseal - Higher mean ΔE value was recorded in both Baseline – 6 months and 3 months – 6 months' Time Interval when compared to Baseline - 1 month – 3 months' Time Interval. The difference in mean ΔE value recorded between the Baseline – 6 months and 3 months – 6 months' Time Interval groups was statistically significant. Bio C sealer - Higher mean ΔE value was recorded in 3 months – 6 months Time Interval when compared to 1 month – 3 months' Time Interval. The difference in mean ΔE value recorded between the Baseline – 6 months and 3 months – 6 months Time Interval groups was statistically significant (P<0.05).(Figure – 4)

Figure 4: Mean comparison

Table 1: Overall and individual pair-wise inter-group comparison in baseline to 1 month time interval

		N	Mean	Standard Deviation	p-value
After 1 Month – Baseline	Ceraseal	16	1.246	1.017	< 0.001*
	Bio C Sealer	16	2.223	2.238	
	Guttaflow	16	5.221	2.909	
Ceraseal	Bio C Sealer			0.976	0.647
	Guttaflow			3.974	< 0.001*
Bio C Sealer	Guttaflow			2.997	0.001*

Table 2: Overall and individual pair-wise inter-group comparison in baseline to 3 months time interval

		N	Mean	Standard Deviation	p-value
After 3 Months – Baseline	Ceraseal	16	2.015	1.924	< 0.001*
	Bio C Sealer	16	2.896	2.250	
	Guttaflow	16	5.788	3.029	
Ceraseal	Bio C Sealer			0.881	0.940
	Guttaflow			3.773	< 0.001*
Bio C Sealer	Guttaflow			2.892	< 0.001*

Table 3: Overall and individual pair-wise inter-group comparison in baseline to 6 month time interval

		N	Mean	Standard Deviation	p-value
After 6 Months – Baseline	Ceraseal	16	2.861	2.350	< 0.001*
	Bio C Sealer	16	3.692	2.288	
	Guttaflow	16	7.188	3.615	
Ceraseal	Bio C Sealer			0.831	1.000
	Guttaflow			4.327	< 0.001*
Bio C Sealer	Guttaflow			3.496	0.003*

p-value based on Analysis of Variance (ANOVA) followed by post-hoc analysis using Bonferroni test after adjusting for multiple comparisons
* = Statistically Significant ($p < 0.05$)

Discussion

The evaluation of Guttaflow Bioseal, Ceraseal, and Bio C sealer root canal sealers' discoloration potential was conducted in this study. The recently released Guttaflow Bioseal, Ceraseal, and Bio C sealers share a composition that, despite their great qualities, unintentionally changes the color of teeth. Though their potential for discoloration has not yet been investigated, both sealers have demonstrated appropriate physical and antimicrobial qualities. This was the first in vitro investigation on chromatic alteration, using a spectrophotometer.

In the modern world, a dentist's main objective is to satisfy patients' needs and wants for a beautiful, white smile. Remarkably, it has been documented that a treated tooth's unappealing appearance has a major negative impact on the patient's quality of life (Dugas 2002). Teeth discoloration, particularly in the anterior region, is a common reason for patients to seek dental care. The patients' appearance is compromised by these changes. For both the patient and the dentist, crown discoloration following endodontic therapy is regarded as a common aesthetic issue, especially with anterior teeth(5)

Good adhesion, an adequate seal, radiopacity, dimensional stability during setting, tissue tolerance, antibacterial effect, unsolvability in tissue fluids, and no discoloration of the tooth structure are all desirable qualities in a root canal sealer. However, studies have shown that sealer remnants left in the pulp chamber can cause some discoloration in clinical practice. (Van der Burgt et al. 1986, Parsons et al. 2001, Davis et al 2002, Partovi et al. 2006) (6)

An objective (instrumental) substitute for the subjective (visual) means of evaluating color is spectrophotometry. With the help of this gadget, the color matching process is made more accurate by removing uncontrollable variables. Secondly. Regarding light, vision, and color, the ISO has recognized CIE as an international standardization body. A three-dimensional, uniform color space called the CIE L*a*b* system was created to simulate how the human eye would perceive every color. Three chromatic parameters are used to define a color's location in the CIE L*a*b* color space. Lightness is indicated by the value of L* (L* = 0 [black] and L* = 100 [white]). The positions on the green (-a) to red (+a) and blue (-b) to yellow (+b) gradients, respectively, are indicated by the a* and b* values. The whole color

difference between two objects can be quantitatively expressed in terms of their Euclidean distance, or in ΔE values. In a broad way previous studies suggest that ΔE 3.3 is detectable by the lay people. ΔE>3.3 is not clinically acceptable.(7,8)

This study has been conducted on human premolars because it is common to find intact premolars extracted for orthodontic purposes, similar to many previous studies. In this study, all specimens were stored in relative humidity. In both laboratory and clinical settings, the dehydration of dental tissues and enamel induces reversible alterations in their optical properties. This dehydration process often results in an increase in reflectance properties, consequently leading to a perceived increase in lightness.(9)

Sealers have the potential to discolor when large amounts of sealer come into contact with the walls of the pulp chamber. In clinical settings, the pulp chamber space is not usually cleared of the smear layer, and tooth discoloration has been documented even when the smear layer is present. Enamel has no tubular morphology, its organic structural features at the dentinoenamel junction may play a role in the discoloration process. Studies suggest that the dentin and enamel have the ability to transmit the color of the material placed in the pulp chamber. Research indicates that the most pronounced staining from dental materials occurs in the cervical third of the crown, which is why the area of measurement for this study was confined to the midbuccal of the cervical third.(10)

The newer concept is minimum GP and predominant sealer using bioceramic sealer. (11) Bioceramic sealers can be classified as calcium silicate based sealers (Mineral Trioxide Aggregate (MTA) based and non-MTA based) and calcium phosphate based sealers. Bioceramic-based sealers are further classified into two groups based on their interaction with living tissues: bioactive and bioinert materials. GuttaFlow bioseal (Coltene/Whaledent, Switzerland) is a recently developed, silicone-based, coldfilling sealer containing GP powder and bioactive glass.(12)

Both Bio-C and CeraSeal bioceramic sealers are based on calcium silicates which hydrate to calcium silicate gel and form calcium hydroxide and ultimately release various ions including Si4+, Ca++, and OH ions during setting. Zirconium dioxide is the radiopacifier (45–50%) (13)

Greater color change after 1 month was seen in this study with Gutta Flow Bioseal(ΔE = 5.221) which was evident clinically and statistically significant and least color change was seen with Ceraseal (ΔE=1.246) which was not evident clinically and there is no statistically significant difference between bio c sealer and Ceraseal between baseline and 1 month time interval. Greater discoloration was seen with Gutta Flow Bioseal after 3 months (ΔE = 5.788) when compared with other sealers which are significant stastistically. These results could be because there is a relationship between the radiopacifier, causing tooth discoloration (Marina et al 2015). The outcomes could be influenced in part by the Gutta Flow sealers' high radiopacity. No study has measured crown discoloration induced by Guttaflow Bioseal. In another study, Ioannidis et al. evaluated coronal discoloration due to AH 26, GuttaFlow, Roth's 811 and Epiphany sealers at 1 week, 1 month, 3 months and 6 months using a spectrophotometer and found that Roth's 811 ZOE based sealer caused the greatest discoloration. (14)

The thixotropic property of GuttaFlow Bioseal may play a role in the low occurrence of gaps and voids.

Thixotropic sealers become less viscous under pressure and penetrate narrow canals and the tiny ramifications. Following root canal obturation, a tiny quantity of dental fluid is in contact with the dentin by means of a Bioactive Glass-Based Root Canal Sealer. The non-bioactive glass component of the sealing paste is among the components that are released from the matrix as it hardens. Since this is the ideal pH for the surface formation of hydroxyapatite, the evolution of these ions keeps the surrounding dentinal fluid at or near 10. Important concentrations of soluble Si, Ca, P, and Na ions are then released when the Bioactive Glass in the sealer mixture reacts with the dental fluid. The Bioactive Glass surface then forms a silica-rich gel, which reacts with the ions that are now in the dentinal fluid. Consequently, the surface of BGs develops HAp-like crystal layers. At last, dentin tubules are interstitially formed by HAp-like crystal tags growing. When these HAp layers and tags develop inside the dentin tubules, the overall bonding with the dentin wall is created. (15)

Color change in Guttaflow Bioseal formulation is related to the concentration of different metals, including silver, zirconium dioxide, and platinum. It has been suggested that discoloration may result from materials seeping into the dentinal tubules or from transmission through the enamel dentin that remains (16). The chromogenic potential of the silver-containing Guttaflow Bioseal sealer is likely the result of silver ions being released during and after setting. Variations in the material's chromic value can affect the tooth's color. GuttaFlow bioseal, which is brownish in color, combines free-flow gutta-percha in a dual-barrel syringe at room temperature. Also research has documented that NaOCl has a very significant impact on the pigmentation. When NaOCl came into contact with bismuth and other heavy metal oxides in the sealer, a black precipitation appeared. (17)

Over a six-month period following specimen preparation and obturation using the approved sealers, changes in crown color were evaluated. As stated by Akhavan et al. Since there is no consensus on when tooth discoloration should occur after endodontic treatment, a 6-month period was deemed appropriate for this investigation. Especially as Prason et al. demonstrated that majority of tooth discoloration occurs during the first three months of RCT. Moreover, coronal tooth discoloration caused by endodontic materials has been shown in prior research to occur seven weeks to several months following obturation (van der Burgt et al. 1986 and Parsons et al. 2001, Davis et al. 2002) (18). A number of variables, such as the thickness of the remaining dentine, the type and quantity of sealer, and the existence of the smear layer, affect how long it takes for discoloration to become clinically noticeable (Grossman et al., 1988). In current study, tooth discoloration developed gradually over the first three months and then got increased until the experiment's end. At the conclusion of the trial, the discoloration brought on by Gutta flow Bioseal was at its worst. Findings from the present study showed that over the course of the 6-month study period, every tested sealer significantly increased the amount of discoloration. So as the null hypothesis got rejected. For one month, three months, and six months, respectively, the average color change for the three groups were ΔE = 2.89, 3.56, and 4.57. In line with Paravina et al. (19)

Using a calcium silicate-based sealer, Bio C Sealer color changes were observed in this study at 1 month, 3 months, and 6 months, respectively, and were 2.22, 2.89, and 3.69. The values obtained for Ceraseal were 1.24, 2.01 and 2.86 after one month, three months, and six

months, respectively. The bioceramic sealer from previous studies determined a grey color of the dentin, mainly due to the tricalcium silicate, bismuth oxide and dicalcium silicate. Least discoloration for our calcium silicate sealers in our study may be because of the absence of bismuth oxide as a radio opacifier. However, there was no discernible difference between the two sealers.(20, 21) The current study clearly shows that all root canal sealers have the potential to discolor with time. The clinician should always make sure that all sealer remnants are completely removed, even though new generation root canal sealers, such as Guttaflow Bioseal, Ceraseal, and Bio C sealer, have less staining effects than traditional sealers. It is possible that the chromogenic potential of sealers, in addition to fundamental characteristics like biocompatibility and strong sealing ability, is a significant factor in choosing the right root canal filling materials.

Conclusion

It can be inferred, within the constraints of the present investigation, that sealers utilized in endodontic therapy may have a significant staining potential for teeth that gradually increases. When comparing calcium silicate-based sealers to bioactive glass-based sealers, significant discoloration potential was observed during the 6-month study period.

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