RESEARCH

The influence of different irrigation solutions on the color stability of several calcium silicate–based materials*

Koray Yılmaz(0000-0001-6096-7385)[α], Pelin Tüfenkçi(0000-0001-9881-5395)[α], Mehmet Adıgüzel(0000-0002-9363-6264)[α]

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ABSTRACT

The influence of different irrigation solutions on the color stability of several calcium silicate–based materials

Background: To compare the color stabilities of wMTA Angelus, Biodentine, EndoSequence Root Repair Material, and BIO MTA+. Calcium silicate-based materials in response to the exposure to different irrigation solutions.

Methods: Four groups of materials (4 samples in each) were involved in the present study. Each of materials was homogenously mixed and placed in each container.After the setting time, all of the samples colors before the contact with solutions were determined by using a spectrophotometer. Then one sample from each material was kept in each of 4 irrigation solutions for 24 hours: distilled water, 5.25% NaOCl, 2% chlorhexidine gluconate (CHX] and 17% ethylenediaminetetraacetic acid (EDTA]. At the end of this period, the samples were taken out of the solutions and the color measurements were repeated.

Results: Among all the materials, the discoloration of distilled water group was found to be the lowest at statistically significant level. The highest level of discoloration of Biodentine was observed in CHX, whereas the highest discoloration of wMTA Angelus was found in NaOCl. The maximum discoloration of ES was found after the exposure to EDTA, followed by the discoloration of BIO MTA exposed to NaOCl.

Conclusion: Biodentine and wMTA Angelus may be used by clinicians as an alternative when the esthetic concerns play dominant role.

KEYWORDS

BIO MTA+, biodentine, color stability, EndoSequence root repair material, wMTA angelus

ÖZ

Farklı irrigasyın solüsyonlarının çeşitli kalsiyum silikat bazlı materyaller üzerindeli renk değişimine etkisinin incelenmesi

Amaç: Çalışmamızın amacı, wMTA Angelus, Biodentine, EndoSequence Root Repair Material (ES) ve BIO MTA+ kalsiyum silikat bazlı kök tamir materyallerinin farklı irrigasyon solüsyonlarına maruz bırakılması sonrası renk değişimlerinin karşılaştırılmasıdır.

Gereç-Yöntemler: Çalışmamız her bir grupta 4 örnekten oluşacak şekilde 4 gruptan oluşturuldu. Tüm materyaller homojen olacak şekilde karıştırılıp test kaplarına yerleştirildi. Sertleşme süresi sonrası tüm örnekler irrigasyon solüsyonuna maruz bırakılmadan once spektrofotometre yardımı ile materyallerin ilk renk değerleri ölçüldü. Her materyale ait birer örnek distile su, 5.25% NaOCl, 2% klorheksidin glukonat (CHX) ve 17% etilendiamintetraasetik asit (EDTA) solüsyonları içerisinde 24 saat süre ile bekletildi. Bu sürenin sonunda tüm örnekler solüsyon içerisinden çıkartılıp tekrar renk ölçümleri yapıldı.

Bulgular Tüm gruplar içerisinde materyallerin istatistiksel olarak anlamlı derecede en az renklenme gösterdiği irrigasyon solüsyonu distile su olarak tespit edildi. Biodentine' deki en yüksek orandaki renk değişimi CHX ile teması sonrası görülürken, wMTA' da NaOCL ile temas sonrası görüldü. ES' de en yüksek orandaki renk değişimi EDTA ile temas sonrası görülürken BIO MTA'da NaOCL le temas sonrası görüldü.

Sonuç: Biodentine ve wMTA Angelus klinisyenler tarafından estetik beklentilerin yüksek olduğu vakalarda tercih edilebilir.

ANAHTAR KELİMELER

BIO MTA+, biodentine, renk değişimi, EndoSequence, wMTA angelus

The mineral trioxide aggregate (MTA], which are the calcium silicate–based materials (CSM], were firstly produced in 1993 and introduced to the market as a root-end filling material, but they started to be used in various treatments including the vital pulp treatment, perforation restoration, apexification and revascularization.[1] Although MTA has many advantages such as bacteriostatic character, dimensional stability, radiopacity, biocompatibility, and impermeability, it has also certain disadvantages such as difficulty of application, high costs, and discoloration.[2]

The tooth discoloration, which is seen after the endodontic treatment because of the materials used, is an undesired condition for both clinician and patient. The penetration of materials, which were used, into the dental hard tissues through the dentine tubules and the discoloration seen on the materials in the course of time are considered among the factors leading to the post-treatment

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[α] Hatay Mustafa Kemal University, Faculty of Dentistry, Department of Endodontics, Hatay, Turkey

discoloration of teeth.[3] The new calcium silicate-based materials were developed specifically in order to minimize the negative outcomes of MTA such as the discoloration. White MTA (wMTA] was developed specifically for the use in esthetic zones and many studies on the discoloration seen after its clinical use were added into the literature.[4-6] wMTA Angelus (Angelus Solucoes Odontologicas, Londrina, Brazil] was developed for this purpose and the manufacturer recommends its use in esthetic zones under favor of its color stability.[7]

Although Biodentine (Septodont, Saint Maur des Fosses, France] was developed as CSM and it was actually introduced as a dentine restoration material, the manufacturer states that it can also be used in endodontic conditions similar to MTA. Available in powder and liquid forms, Biodentine includes tricalcium silicate, calcium carbonate, and zirconium oxide as the radiopacifier in its powder form and calcium chloride as reaction initiator agent in its liquid form.[8]

The studies on bio-ceramic materials having characteristics similar to MTA shed light to the development of EndoSequence Root Repair Material (ES, Brasseler USA, Savannah, GA] and the minimization of negative characteristics of MTA such as the difficulty of clinical use and the length of hardening duration. It includes calcium silicates, zirconium oxide, tantalum oxide, and calcium phosphate monobasic. The manufacturer introduced this product in two different forms to the market as moldable putty form and preloaded syringe form.[9]

BIO MTA+ (Cerkamed, Pawłowski, Poland] was introduced to the market as CSM and the manufacturer claims that it is the MTA with the highest biocompatibility under favor of its high hydroxyapatite content. Its powder form contains calcium oxide, hydroxyapatite, silicon, iron, aluminum, sodium, potassium, and bismuth, whereas liquid form of this product includes purified water and calcium catalyst.[10]

Since the calcium silicate–based materials, which are widely used in endodontics, are most likely contact the endodontic irrigation solutions, the color stability of these materials in the clinical use plays an important role in the material selection. In a comprehensive literature research performed by the authors of present study, no study on the color stability of ES and BIO MTA+ in case of exposure to different endodontic irrigation solutions could be found. The aim of present study is to compare the color stabilities of 4 different calcium silicate–based materials in response to the exposure to different irrigation solutions. The null hypothesis of the present study is that the contact with irrigation solutions would cause no alteration in color in any group tested here.

MATERIALS AND METHODS

Statistical analysis

The data were evaluated with 2-way analysis of variance by using SPSS software (PASW Statistics 20; SPSS Inc, Chicago, IL]. The significant effects and interactions were further investigated with the post hoc Bonferroni test. The level of statistical significance was set at $P < .05$.

RESULTS

The digital images of materials, which were involved in the present study, before and after the exposure to irrigation solutions are shown in Figure 1. The mean values of changes in the color of materials are shown in Figure 2. Among all the materials, the discoloration of distilled water group was found to be the lowest at statistically significant level and the values were at clinically acceptable levels. The discoloration when exposed to Biodentine and wMTA Angelus irrigation solutions was at clinically acceptable level when compared to ES and BIO MTA+. The highest level of discoloration of Biodentine was observed in CHX, whereas the highest discoloration of wMTA Angelus was found in NaOCl. The maximum discoloration of ES was found after the exposure to EDTA, followed by the discoloration of BIO MTA exposed to NaOCl.

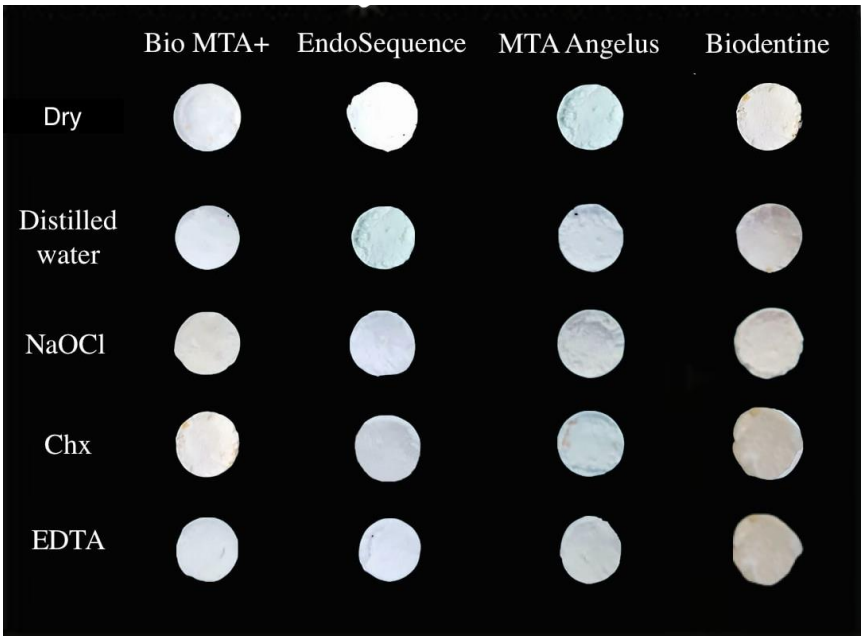

Figure 1.

The digital images of materials of before and after the exposure to irrigation solutions

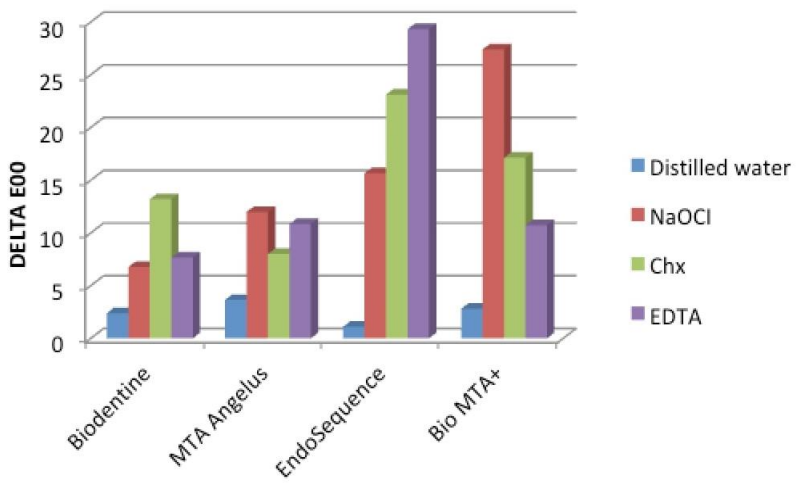

Figure 2.

The mean values of changes in the color of materials

DISCUSSION

The discoloration of materials is a clinical parameter that can be both visually perceived and quantified by using the devices making specific measurements. The spectrophotometric measurement method is a reproducible and objective method, which can detect even the smallest discoloration, widely used in dentistry.[12] CIE has been traditionally involved in colorimetry for dental materials. CIELAB color space (*L**: value axis; *a**: red-green axis; *b**: yellow-blue axis] has been classically the standard parameter for total color difference between two objects.[13,14] In recent years, it is recommended to use CIEDE2000, which is a much more sensitive formula, in determining the perceptual discoloration.[15] CIELAB discoloration formula was widely used in similar studies in the literature [12,16,17], and the discoloration ratios of samples were determined using CIEDE2000 color-difference formula and ΔL, Δa, and Δb values found at the end of measurements performed in the present study.

The results obtained in the present study showed that distilled water, NaOCl, CHX, and EDTA used for irrigation purposes in endodontic treatments caused discoloration in all of calcium silicate–based materials tested here. Thus, the null hypothesis of present study was rejected. The discolorations observed in Biodentine and wMTA Angelus were found to be at lower levels for all of the irrigation solutions, whereas the discoloration of ES and BIO MTA+ was found to be high and clinically unacceptable.

It was reported that the solution, which is used in irrigating the canals during the final irrigation phase of root canal treatment, remains in dentine tubules and canal walls and causes discoloration in materials.[18] NaOCl is the irrigation solution that is the most widely used endodontic treatments. In a previous study, it was reported that, as a result of exposure to NaOCl solution, white MTA may turn into dark brown-black color after interaction between NaOCl and bismuth oxide, which MTA material contains and which is used in order to ensure the radiopacity of material.[17] For this reason, instead of bismuth oxide, the researchers recommend the use of zirconium oxide or calcium tungstate for the radiopacity of materials in order to prevent the discoloration.[19] In the present study, the material having high level of discoloration when exposed to NaOCl was found to be BIO MTA+, whereas the Biodentine showed low level of discoloration that is close to the clinically acceptable level. It is thought that this is because Biodentine does not contain bismuth oxide and thus it might have interacted with NaOCl at low level.

In literature, there are few studies carried out on the discoloration of calcium silicate–based materials that might be because of CHX used as final irrigation solution in order to benefit from its high antimicrobial activity. However, Keskin et al (2016] tested ProRoot white MTA (Dentsply Tulsa Dental, Johnson City, TN], white MTA Angelus, Biodentine, and BioAggregate (Innovative Bioceramix, Vancouver, BC, Canada] as the calcium silicate–based materials. In the present study, a similar method was used and the materials were exposed to 5% NaOCl, 2% CHX, and distilled water for 24 hours. Similar to the results obtained in present study, the lowest level of discoloration was found in Biodentine in response to NaOCl and in White MTA Angelus in response to CHX. Considering the clinical esthetic concerns, the researchers recommend the use of BioAggregate and Biodentine, which contain no bismuth, as an alternative for the clinicians. In the present study, similar to NaOCl, the highest level of discoloration in response to CHX was observed in ES and BIO MTA+. In literature, there is no consensus on the CHX-caused discoloration of materials and the mechanism of this reaction. However, there are studies reporting that the micro-surface porosities of calcium silicate–based materials may play role in this process.[12,16]

In literature, there is no study, to which the effects of EDTA irrigation solution tested here on the discoloration can be compared. According to the present

results, the highest level of discoloration among the tested groups was observed as a result of the interaction between ES and EDTA. The level of discoloration was found to be much lower for the other materials. It was reported that EDTA, which is used in order to remove the smear layer from the root canal walls under favor of inorganic dissolvent effect during the final irrigation, might remain active in tubules for long time by penetrating deeply into the root canal walls.[20] This process provides the time necessary for the contact of materials, which were place in the root canal, with EDTA solution. Akbari et al. (2012] brought forward the idea that the discoloration of calcium silicate–based materials can be prevented by applying two layers of bonding agent on the dentine in order to occlude the dentine tubules in inlet cavity before placing the materials in the root canal. In order to understand the mechanism of this interaction causing the discoloration of materials seen in response to the contact of calcium silicate–based materials with EDTA, the further laboratory studies are needed.

In the present study, the materials were kept at 37°C and 100% moisture in order to complete the setting time before the exposure to irrigation solution and to achieve the optimum physical characteristics. However, this is not possible under the clinical conditions and the materials immediately interact with the solutions once they were placed into the canal. For this reason, the results obtained in the present study may differ from the outcomes to be achieved under clinical conditions.

CONCLUSION

The solutions, which are used for the irrigation purposes in root canal treatments, may cause various levels of discoloration in calcium silicate–based materials. According to the results obtained here, Biodentine and wMTA Angelus may be used by clinicians as an alternative when the esthetic concerns play dominant role.

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Corresponding Author:

Koray YILMAZ
Hatay Mustafa Kemal University
Faculty of Dentistry
Department of Endodontics
Hatay, Turkey
E-mail : koray1903@hotmail.com