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The Effect of Staining Solutions and a Cleanser Tablet on the Surface Roughness and Color Stability of Various Artificial Tooth Types: An In Vitro Study

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ABSTRACT

Aim: This study aimed to evaluate the effect of different solutions and a cleaning tablet on the color stability and surface roughness of different types of artificial teeth.
Materials and Methods: Conventional polymethylmethacrylate (PMMA), cross-linked isosite (CLI), and double cross-linked acrylic (DCA) teeth were allocated into 4 groups according to the immersion protocol to be applied as AS (artificial saliva immersion for 14 days), AS+C (artificial saliva immersion for 14 days and then applying Corega for 1 week, 8 hours a day), Co (immersion in coffee solution for 14 days), Co+C (immersion in coffee solution for 14 days and then applying Corega for 1 week, 8 hours a day). The specimens' color (L*, a* and b* values) and surface roughness variables were measured at the baseline and after immersion protocols. The color changes (ΔE) of the specimens were calculated using the CIEDE2000 formula. Data were evaluated by the Kruskall Wallis H and the ANOVA test. The Wilcoxon Sign and Bonferroni tests were used for comparisons (α=0.05).
Results: The lowest ΔE00 value was found in Group PMMA exposed to Corega suspension after immersion in artificial saliva [Group PMMA-AS+C: 2.33(1.72)]. According to the ΔE00 values, there was no statistically significant difference according to the materials of both the solution and the artificial teeth ($p>0.05$). None of the test groups showed significant difference in baseline surface roughness values ($p>0.05$). However the protocol Co+C increased the surface roughness of CLI teeth ($p<0.05$). Also, PMMA teeth showed higher surface roughness for protocols AS and AS+C.
Conclusion: According to the results of this in-vitro study, coloring solutions affected surface roughness to varying degrees. Clinicians should consider cost-effective aspects for aesthetic expectations when choosing artificial teeth.

Boyama Solüsyonlarının ve Temizleme Tabletinin Çeşitli Yapay Diş Tiplerinin Yüzey Pürüzlülüğü ve Renk Stabilitesi Üzerindeki Etkisi: İn Vitro Çalışma

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ÖZET

Amaç: Bu çalışmada farklı solüsyonların ve temizleme tabletinin farklı tipteki yapay dişlerin renk stabilitesi ve yüzey pürüzlülüğü üzerindeki etkisi değerlendirildi.
Gereç ve Yöntemler: Konvansiyonel polimetilmetakrilat (PMMA), çapraz bağlı izosit (CLI) ve çift çapraz bağlı akrilik (DCA) dişler uygulanacak immersiyon protokolüne göre AS (14 gün boyunca yapay tükürük immersiyonu), AS+C (14 gün boyunca yapay tükürük immersiyonu ve ardından 1 hafta boyunca günde 8 saat Corega uygulaması), Co (14 gün boyunca kahve solüsyonu immersiyonu), Co+C (14 gün boyunca kahve solüsyonu immersiyonu ve ardından 1 hafta boyunca günde 8 saat Corega uygulaması) olmak üzere 4 gruba ayrıldı. Numunelerin renk (L*, a* ve b* değerleri) ve yüzey pürüzlülüğü değişkenleri başlangıçta ve daldırma protokollerinden sonra ölçülmüştür. Numunelerin renk değişimleri (ΔE) CIEDE2000 formülü kullanılarak hesaplanmıştır. Veriler Kruskall Wallis H ve ANOVA testi ile değerlendirilmiştir. Karşılaştırmalar için Wilcoxon İşaret testi ve Bonferroni testleri kullanılmıştır (α=0.05).
Sonuçlar: En düşük ΔE00 değeri, yapay tükürüğe daldırıldıktan sonra Corega süspansiyonuna maruz bırakılan Grup PMMA'da bulunmuştur [Grup PMMA-AS+C: 2,33(1,72)]. ΔE00 değerlerine göre, hem solüsyon hem de yapay dişlerin materyallerine göre istatistiksel olarak anlamlı bir fark bulunmamıştır ($p>0.05$). Başlangıç yüzey pürüzlülüğü değerlerinde, test gruplarının hiçbiri anlamlı farklılık göstermemiştir ($p>0.05$). Ancak Co+C protokolü CLI dişlerin yüzey pürüzlülüğünü arttırmıştır ($p<0.05$). Ayrıca, PMMA dişler AS ve AS+C protokolleri için daha yüksek yüzey pürüzlülüğü göstermiştir.
Sonuç: Bu in-vitro çalışmanın sonuçlarına göre, renklendirme solüsyonları yüzey pürüzlülüğünü farklı derecelerde etkilemiştir. Klinisyenler yapay diş seçimi yaparken estetik beklentiler için maliyet-etkinlik yönlerini göz önünde bulundurmalıdır.

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INTRODUCTION

Removable dentures have been used for a long time to restore the impaired functions of edentulous and partially edentulous patients. [1] Artificial teeth, essential structural components of removable prostheses, are frequently used for both fixed and removable restorations on implants in today's prosthetic dental treatment.[2] Artificial teeth should have adequate mechanical properties to withstand the forces of chewing during everyday use, such as being resistant to abrasion, fracture, and pH changes.[3] They should also offer optimum aesthetic properties to fulfill the demands of patients.[3,4]

Color stability is one of the most clinically important aesthetic features of artificial teeth. Because color change indicates ageing or deterioration of the prosthesis.[5] Discoloration or staining may occur due to intrinsic or extrinsic factors.[1,3] Extrinsic staining is caused by plaque accumulation on artificial tooth surfaces or stains caused by coloring substances such as coffee, tea, and tobacco. The effect of these factors may increase by poor oral hygiene or inappropriate and low-frequency application of cleaning agents. On the other hand, intrinsic factors depend on the physical and chemical characteristics of the artificial teeth material. They may increase the artificial tooth's reaction with the coloring agents or the absorption of coloring solutions.[6,7]

Another factor related to staining is the surface properties of the material. Micro-cracks, micro-gaps, and pores on the surface prepare a suitable environment for the penetration of solutions that cause staining.[8] The process of cleaning easier and prevent accumulation of plaque and bacterial colonization, artificial teeth should have a smooth surface.[9] Denture cleanser immersion and daily brushing are examples of artificial cleaning techniques.[9,10] Effervescent tablet forms of denture cleaners are generally used to remove calculus effectively and debris from denture surfaces.[11] However, daily use of such denture cleaners may affect artificial teeth' physical and surface properties by increasing surface roughness, which may result in discoloration.[12,13] Therefore, it is of importance to know the surface characteristics and color stability of different artificial teeth and their reactions to different cleaners.[1,2,6]

The most used materials in the production of artificial teeth include methacrylate resin, reinforced methacrylate resin, and composite resin.[1] Artificial teeth materials have also diversified significantly with the developing dental industry, including new-generation acrylic teeth with highly cross-linked isosite material, acrylic resin teeth with interpenetrating polymer network, and composite resin teeth with different filling sizes.[2] Given the wide variety of artificial teeth on the market, evaluation of surface roughness and color stability will guide clinicians and laboratory technicians when selecting artificial teeth.

Previous studies have examined the color stability of artificial teeth with different properties in different staining solutions but failed to obtain a consistent result. [1,7,14] Moreover, the evaluation of new-generation artificial teeth is scarce in the literature. Therefore, the aim of this study was to evaluate the color stability and surface roughness of artificial teeth with three different compositions after exposure to coffee and a commonly used cleansing tablet. The null hypothesis of this study was that there would be no difference in color change and surface roughness regardless of artificial tooth type and immersion protocol.

MATERIALS AND METHODS

This study investigated the effect of Corega cleanser tablet application on the surface roughness and color stability of 3 different artificial teeth (conventional polymethylmethacrylate, cross-linked isosite, and double cross-linked acrylic) after exposure

to a coloring beverage. The minimum specimen size for this study was calculated as n = 8 per group (N = 128) with 81% power, 0.63 effect size, and error level α = 0.05. The materials used in the study and their contents are shown in Table 1, and the properties and preparation procedures of the solutions used are shown in Table 2.

Table 1: Content details of denture teeth evaluated

Artificial teeth material	Group abbreviations	Trade name	Manufacturer
Conventional polymethylmethacrylate	PMMA	Ivostar, Gnathostar	Ivoclar Vivodent AG, Italy
Cross-linked isosite	CLI	SR Orthosit PE	Ivoclar Vivodent AG, Italy
Double cross-linked acrylic	DCA	SR Vivodent DCL	Ivoclar Vivodent AG, Italy

Table 2: The properties of the materials used and preparation procedures of the solutions

Immersion solution	Manufacturer	Chemical composition	Preparation procedure	pH
Artificial saliva	Custom made	KCl (0.4 g L−1) NaCl (0.4gL−1) $CaCl_2(H_2O)$ (0.795 g L−1) $NaH_2PO_4(H_2O)$ (0.69 g L−1) Na_2S (0.005 g L−1) Urea (1 g L−1)	To create 1 L of artificial saliva, all of the ingredients were mixed. The desired pH of the saliva was then determined by adding 15 ml of 0.1 M NaOH.	6.5
Coffee (without sugar)	Nescafe Classic, Nestle, Bursa, Turkey	Grinded coffee Dipotasium phosphate Sodium poliphophate Trisodium sitrate, milk protein Diasetil tartaric acid Silicone dioxide, sucrose	2 g coffee granules were placed in 200 ml boiled distilled water for 7 min and allowed to cool at room temperature.	5
Corega Tablets	Corega Tablet Block Drug Company, Inc., NJ, USA	Sodium bicarbonate Potassium monopersulfate Sodium perborate monohydrate Sodium laurly sulfoacetate	The effervescent denture tablet was prepared by adding one tablet to 200 mL of 40°C warm water.	8.4

(NaCl: Sodium chloride, KCl: Potassium chloride, $CaCl_2(H_2O)$: Calcium chloride hydrate, $NaH_2PO_4(H_2O)$: Sodium dihydrogen phosphate monohydrate, Na_2S: Sodium sulfide, NaOH: Sodium hydroxide)

Thirty-two maxillary central artificial teeth (shade: A2) of each brand (PMMA, CLI, and DCA) were randomly allocated into four subgroups (n = 8) and immersed in 4 different solutions as follows: 1. Protocol AS: Specimens were kept in artificial saliva for 14 days 2. Protocol AS+C: Specimens were kept in artificial saliva for 14 days and then exposed to a Corega solution for 1 week, 8 hours a day 3. Protocol Co: Specimens were kept in coffee solution for 14 days 4. Protocol Co+C: Specimens were kept in a coffee solution for 14 days and then exposed to a Corega solution for 1 week, 8 hours a day.

Immersion in all solutions was monitored in an incubator (FN 500, Nüve, Turkey) by refreshing the solutions every 24 hours. After the soaking period, each specimen was cleaned with distilled water and dried with tissue paper before measurements. Surface roughness and color measurements were performed on all specimens at baseline and after immersion in the solutions.

Color measurements of the specimens were made from the middle third of the labial surface using a spectrophotometer (VITA Easyshade V; Vita Zahnfabrik, Germany) against a neutral grey background[15] in a light-controlled box[16] under standard D65 illumination.[17]

The color measurements of the specimens were calculated using the CIE2000 formula as

$$\Delta E_{00} = [\Delta L'/k_L \times S_L^2 + \Delta C'/k_C \times S_C^2 + \Delta H'/k_H \times S_H^2 + R_T \times \Delta C'/k_C \times S_C \times \Delta H'/k_H \times S_H]^{1/2}$$

The coefficient-K, also known as the parametric factor, expresses the effect of influencing the judgement of color difference. The S coefficient explains the visual homogeneity efficiency. In addition, a rotational factor (RT) was added to correct the deficiency in the blue-violet region in which L′, C′, and H′ are the transformed forms of LCH and KLSL is lighting weighting function, KCSC is chroma weighting function, KHSH is hue weighting function and RT is a rotational factor. In the present study, the parametric factors of the ΔE00 color difference formula were set to 1.[3]

The surface roughness of each specimen was measured from the labial surface using a contact profilometer (Perthometer; Mahr Gmbh, Ingolstadt, Germany). The measurement length was set to 1.75 mm, the cutoff 0.25 mm, and the instrument was calibrated before each group. Three distinct measurements in micrometers (μm) were taken for every specimen, and the average of these measurements was computed. Statistical analysis was conducted using the average Ra values.

Statistical Analysis

The data obtained in this study were analyzed using the SPSS 22 package program (IBM SPSS Inc., Chicago, USA). Compliance with normal distribution was evaluated by the Shapiro-Wilk test. ANOVA was utilized to compare three or more independent groups with normal distribution, and the Kruskal-Wallis test was employed when there was no normal distribution. The Wilcoxon and Bonferroni tests were used for comparisons (α=0.05).

RESULTS

Descriptive statistics for ΔE values of the test groups are given in Table 3. The lowest ΔE00 value was found in Group PMMA exposed to Corega suspension after immersion in artificial saliva [Group PMMA-AS+C: 2.33(1.72)]. The highest ΔE00 value was found in Group DCA immersed in coffee solution [Group DCA-Co: 9.55(4.46)]. According to the ΔE00 values, there was no statistically significant difference for comparisons between the groups according to both the type of immersion solution and the materials of the artificial teeth (p>0.05).

Table 3: Descriptive statistics and statistical significance evaluation for ΔE values obtained from the test groups

Test Group	Immersion protocol				
	AS	**AS+C**	**Co**	**Co+C**	***p***
PMMA	3.91(2.45)[a] 6.84 ± 3.28	2.33(1.72)[a] 5.26 ± 3.8	2.61(1.84)[a] 9.24 ± 3.19	2.67(2.03)[a] 7.52 ± 7.44	0.651†
CLI	4.31(3.59)[a] 3.77 ± 2.33	4.37(2.12)[a] 2.63 ± 1.39	5.52(4.7)[a] 5.07 ± 4.23	4.88(4.07)[a] 3.55 ± 2.29	0.646**
DCA	2.98(10.65)[a] 4.72 ± 2.41	4.5(5.79)[a] 4.59 ± 2.41	9.55(4.46)[a] 6.12 ± 3.68	7.67(4.03)[a] 6.0 ± 3.06	0.204†
p	0.092**	0.067**	0.080†	0.245†	

(PMMA: conventional polymetylmethacrylate, CLI: cross-linked isosite, DCa: double cross-linked acrylic, AS: artificial saliva, AS+C: artificial saliva + Corega, Co: coffee, Co+C: coffee + Corega)

** ANOVA test. † Kruskal-Wallis test. The data were presented as the median(IQR) and mean ± SD. The statistically significant p value is in bold. There is a statistically significant difference between groups with different superscripts (p<0,05).

Descriptive statistics of Ra values obtained from the test groups are shown in Table 4. At baseline, none of the test groups showed significant differences (p>0.05). Considering intragroup comparisons after immersion protocols, Group PMMA and DCA showed no significant difference in Ra values (p>0.05). However, Group CLI showed a higher Ra value after being immersed in Corega following coffee (p<0.05) compared to other immersion protocols for which similar results were obtained (p>0.05). Intergroup comparisons after immersion protocols showed similar results for Co and Co+C protocols irrespective of the test group (p>0.05). On the other hand, PMMA teeth showed significantly lower Ra values than other artificial teeth groups for immersion protocols AS and AS+C (p>0.05). The differences between other test groups were insignificant (p>0.05).

Table 4: Surface roughness (Ra) values of artificial teeth at baseline and after immersion protocols

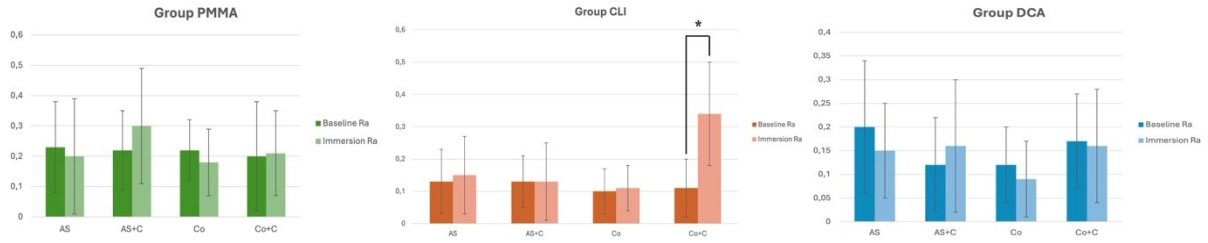
Surface roughness evaluation	Test groups			Median(IQR)		Total
Baseline	**PMMA**	0.23(0.15)	0.22(0.13)	0.22(0.1)	0.2(0.18)	0,14(0.12)^{A}
	CLI	0.13(0.1)	0.13(0.08)	0.1(0.07)	0.11(0.09)	0,14(0.10)^{A}
	DCA	0.20(0.14)	0.12(0.1)	0.12(0.08)	0.17(0.1)	0,22(0.17)^{A}
	p					0.050
		Immersion protocol				
		AS	**AS+C**	**Co**	**Co+C**	***p***
After immersion	**PMMA**	0.2(0.19)^{aA}	0.3(0.19)^{aA}	0.18(0.11)^{aA}	0.21(0.14)^{aA}	0.215
	CLI	0.15(0.12)^{aB}	0.13(0.12)^{aB}	0.11(0.07)^{aA}	0.34(0.16)^{bA}	**0.018**
	DCA	0.15(0.1)^{aB}	0.16(0.14)^{aB}	0.09(0.08)^{aA}	0.16(0.12)^{aA}	0.072
	p	**0.048**	**0.008**	0.344	0.131	

(PMMA: conventional polymetylmethacrylate, CLI: cross-linked isosite, DCa: double cross-linked acrylic, AS: artificial saliva, AS+C: artificial saliva + Corega, Co: coffee, Co+C: coffee + Corega)

The data were presented as the median(IQR). The statistically significant p value is in bold. A statistically significant difference exists between groups with different superscript lowercase letters within the same line ($p<0.05$). A statistically significant difference exists between groups with different superscript uppercase letters within the same column ($p<0.05$).

Comparisons of before and after surface roughness values for each group are shown in Figure 1. There was a significant difference in surface roughness values between baseline and after-immersion protocols only for Group CLI. The surface roughness of Group CLI increased after being subjected to Corega following immersion in coffee solution (Co+C) compared to baseline ($p<0.05$).

Fig. 1: Comparison of in-group surface roughness values of the test groups



(PMMA: conventional polymetylmethacrylate, CLI: cross-linked isosite, DCa: double cross-linked acrylic, AS: artificial saliva, AS+C: artificial saliva + Corega, Co: coffee, Co+C: coffee + Corega)
Median and The Interquartile Range of surface roughness values. (*$p<0.05$ indicate statistical differences between groups.)

DISCUSSION

This study investigated the effect of immersion in coffee and cleaning tablets on surface roughness and color stability of artificial teeth with different compositions. The null hypothesis of this study was partially rejected as no significant differences were found in the colour stability of different types of artificial teeth according to the immersion protocols, whereas significant differences were found in the surface roughness evaluations.

The color change of materials used in dentistry can be evaluated by visual observation or color measurement devices.[18] Color measurements performed by digital devices are much more reliable than visual evaluation since objective, rapid, and reproducible data can be obtained.[19,20] Digital color measurement devices include colorimeters, spectroradiometers, spectrophotometers, digital cameras, and image-analyzing systems.[21] In the dental field, color assessment by spectrophotometer was stated as the most preferred and reliable method.[18,20] Based on these considerations, color measurements were performed using a spectrophotometer device in the present study.

The Commission Internationale de l'Eclairage - CIE L* a* b* color system is used for the numerical expression of color change.[22,23] L* a* b* values are known as "chromaticity coordinates" in this three-dimensional color system. Evaluating the L*, a*, b* values individually is challenging and may be misleading. Therefore, the color change is evaluated by the mean color difference values (ΔE), which can detect even minor color differences.[24] ΔE is a numerical value indicating the amount of color difference perceived between two objects.[22,25,26]

ΔE can be calculated using CIELAB (ΔELab) or CIEDE2000 formulas (ΔE00). These two formulas can be used interchangeably when assessing the color differences of dental materials.[6] Recent studies have shown that the CIEDE2000 color difference formula can provide more accurate results in the assessment of color differences.[6,11] Since the parameters in this formula include weighing and scaling factors, color differences correlate better with the differences perceived by the human eye and are more clinically effective.[6]

Previous studies determined that the ΔE value for the CIEDE2000 system, the perceptibility threshold (PT) was accepted as 1.72 and the acceptability threshold (AT) as 4.08.[5,9] In our study, the lowest ΔE00 value was found in conventional PMMA artificial teeth subjected to cleaning tablet after immersion in artificial saliva [2.33(1.72)]. According to the CIEDE2000 system, there were no test groups that reached the perceptibility colour threshold, while all solution immersion groups of PMMA artificial teeth and artificial saliva immersion groups of double cross-linked acrylic artificial teeth remained below the acceptability colour threshold. The other ΔE00 values found in this study are above this AT values, meaning that they show a visible colour change when exposed to artificial saliva and coffee. These results may be due to the different chemical compositions of artificial teeth, degrees of polymerisation, crosslink density, molar mass distribution and oxidation properties of the polymer matrix structure.[27] Acrylic resins with linear structure or without sufficient crosslinking can absorb colourants when exposed to an aqueous environment. Due to the loosening of linkages along the polymeric network, this process causes plasticisation and subsurface modification of polymeric materials such as artificial teeth.[8]

Fraunhofer and Rogers[28] evaluated the erosive effects of different staining solutions on enamel specimens. They assumed an average of 700 g beverage intake with 20 seconds of intraoral duration daily, which equals the intraoral exposure time to these beverages as 25 hours per year. Based on this, they determined the 14-day test period would simulate approximately 13 years of beverage intake in a lifetime.[28] In previous studies, coffee was the standardized coloring solution with the determined immersion time.[9,29] Because of its yellow-brown color, tannic acid in coffee has been identified as the main staining agent.[30] In the present study, coffee and artificial saliva were used as the staining solutions with a predetermined immersion time of 14 days. Although insignificant, immersion in coffee solution increased ΔE values higher than other solutions in all artificial teeth groups. Also, using Corega cleaner tablets after immersion in coffee and artificial saliva solutions relatively reduced the staining caused by the solutions, yet this result was not statistically significant. Conversely, according to Peracini et al. [28] effervescent denture cleansers should be used with caution because they cause discolouration when submerged in Corega tablets. Sodium perborate or sodium bicarbonate are typically found in cleaning solutions in effervescent tablets.[31] The structure's sodium perborate decomposes to create an alkaline peroxide solution when these tablets dissolve in water,

releasing oxygen and micromechanically removing debris from the surface.[31,32] This effect may cause discoloration, especially in the polymer structure of resin-based materials. [9] Additionally, studies revealed that resin-based materials are damaged by high peroxide and oxygenation concentrations found in alkaline solutions.[9,28] Surface irregularities caused by these cleaners may enhance the discoloration effect. Manufacturers recommend leaving the prostheses in chemical cleaners for 15 minutes for routine cleaning. However, in extreme staining, it is recommended to keep the dentures in the solution overnight to clean them, corresponding to approximately 8 hours.[26] In this study, we used the maximum recommended time to evaluate the effect of chemical denture cleaners. However, the results did not show any effect of Corega solutions. As the material type used affects the impact of cleaning effect, these controversial results may have derived from the difference in the material used.[28]

Kurtulmus-Yilmaz and Deniz[33] evaluated the staining susceptibility of various types of resin artificial teeth and the stain removal efficiency of denture cleaners. They showed that cross-linked acrylic and nanocomposite resin teeth were more sensitive to staining. Similarly, Ansari et al[34] evaluated the color stability of composite resin and acrylic resin teeth in tea and coffee and found that acrylic teeth performed better. On the contrary, Kundu et al[35] found that hybrid and nanofilled composite prosthetic teeth were better than conventional composite and acrylic resin teeth in terms of surface smoothness and staining resistance. Koksal and Dikbas[36] examined the color change of acrylic and porcelain artificial teeth in staining solutions and reported superior results for porcelain teeth. In this study, no statistically significant difference was found between the groups compared, regardless of the type of artificial tooth and the type of solution immersed ($p>0.05$). The discrepancy in the results of all these studies can be explained by differences in prosthetic tooth brands and different types of media and immersion times.[3,5] When tooth types are compared, the different color changes of resin teeth can be attributed to the manufacturing processes and factors such as the degree of polymer conversion and the amount of unreacted monomer remaining and initiators such as dibenzoyl peroxide.[5,9]

Surface roughness is an essential property that affects a material's polishing capacity and wear rate, along with the optical properties and microbial adhesion, by facilitating the mechanical retention of pigments and biofilm by increasing surface area.[37-39] The critical surface roughness value for dental materials has been determined as Ra=0.2 μm in previous studies, above which a rapid increase in plaque accumulation occurs.[40,41] In our study, all Ra values except for conventional PMMA teeth subjected to Corega after artificial saliva and isosite teeth subjected to Corega after coffee immersion were below this threshold value. The increased surface roughness may be caused by the high peroxide content of the Corega cleaning solution and the damaging effect of the oxygenation level caused by the mechanical effect of free radicals released during the cleaning process in a strong alkaline solution.[42] Durkan et al.[42] and Ayaz et al.[40] reported an increase in the surface roughness of acrylic materials after cleaning solutions similar to the present results. The difference in color and surface roughness values differed according to artificial teeth type may be due to the different chemical compositions of artificial teeth and differences in polymer matrix structure.

This study's limitations include the lack of evaluation of different cleaning procedures and the re-polishing effect of colored artificial teeth. The impact of various polishing techniques on the surface roughness and color stability of artificial teeth should be an object of future research.

CONCLUSION

According to the results of this in vitro study, coloring solutions affected surface roughness to varying degrees. Patients should be informed about the long-term effects of denture cleaning tablets, which may increase the surface roughness of conventional PMMA and isosite teeth with prolonged use. Clinicians should consider cost-effective aspects for aesthetic expectations when choosing artificial teeth.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics committee approval was not obtained.

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The authors declare that this study received no financial support.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: NEO, EIO, Data collection and processing: NEO, Analysis and interpretation: NEO, EIO, Literature review: NEO, EIO, Writing: NEO, EIO.

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