

Original Article

Colour Stability of Various Types of Acrylic Teeth Exposed to Coffee, Tea and Cola

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Abstract

Statement of Problem: Acrylic teeth of dentures are prone to discoloration due to frequent exposure to different colouring solutions in the oral environment. Thus, in order to maintain their aesthetic appearance, they must possess high colour stability while exposed to colorant solutions.

Objectives: To compare the colour stability of three different brands of acrylic teeth following immersion in coffee, tea and cola.

Materials and Methods: This in vitro experimental study was conducted on 90 acrylic teeth in three groups (n = 30) of Ivoclar (Italy), PolyDent (Slovenia) and Apple (Iran). The teeth were immersed in coffee, cola and tea for one, three and six weeks (the teeth were not in contact with each other). Colour parameters were assessed before and after immersion using a spectrophotometer, and overall change in colour parameters was calculated. The overall colour change (ΔE) of the three groups at different time points was analyzed using one-way ANOVA. Pairwise comparisons were performed using Tukey's test.

Results: Coffee caused the greatest colour change in Apple acrylic teeth after six weeks (mean ΔE of 4.6 for coffee and 3.4 for tea and cola). Tea caused an almost equal colour change in the three groups. The greatest colour change in the Ivoclar teeth occurred in cola after six weeks (mean ΔE of 3.3, 3.4 and 2.8 for cola, tea and coffee, respectively). The greatest ΔE occurred at six weeks and was the highest in Apple, followed by PolyDent and then Ivoclar teeth in coffee (mean ΔE of 4.6, 3.4 and 3.3, respectively $p < 0.001$).

Conclusions: Despite the significant colour change in the three groups, ΔE in Ivoclar group was within the clinically acceptable range of ≤ 3.3 . A slight colour change was expected regarding the Apple and PolyDent acrylic teeth clinically.

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Introduction

Colour is among the most important factors for aesthetic appearance of prosthetic restorations. Aside from optimal chemo-mechanical properties of acrylic resins, their availability in different colour shades has increased their application in dentures. Denture materials must have optimal colour stability since they are constantly exposed to different foods and beverages in the oral environment [1,2]. Acrylic resins can pick up stains over time. Through the process of adsorption, liquid molecules adhere to resin materials depending on the environmental conditions and, consequently, possible discolorations may occur [3].

One major shortcoming of acrylic teeth is their gradual colour change over time. Colour change of acrylic resins may be due to internal or external factors. Internal or intrinsic factors are mainly related to chemical changes in the composition and formulation of materials while external factors mainly depend on the surface properties of the material and the environment in which the material is placed. It has been well documented that some beverages such as tea, coffee and fruit juice leave stains on dental materials. The magnitude of colour change also depends on the oral hygiene status and frequency of using cleaning agents by patients [4,5]. Extrinsic colouring agents include stains of foods, drinks or tobacco, which penetrate deep into the dental plaque and calculus and react with them [6].

Materials used for the fabrication of artificial teeth include porcelain, acrylic resin, reinforced acrylic resin and composite resins [7]. Reinforced acrylic and composite resin teeth were fabricated to overcome the problems due to the low wear resistance of acrylic resin teeth; however, some concerns exist regarding their colour stability when exposed to colouring materials [5,7].

This study aimed to compare the colour stability of three acrylic teeth (Ivoclar, PolyDent and Apple) exposed to coffee, tea and cola using a spectrophotometer.

The null hypothesis was that there is no difference between various brands of acrylic teeth in terms of color stability.

Materials and Methods

This in vitro experimental study assessed the colour change of three types of acrylic teeth of shade A1,

namely Ivoclar (Ivoclar Vivadent AG FL-9494, Schaan, Liechtenstein), Apple (Ideal Macou, Tehran, Iran), and PolyDent (Denal Products Industry Vilcja Draga 42 Pri Novi Gorici). We preferred to use acrylic artificial teeth because they have more advantages such as pleasant esthetic, chemically bonding to acrylic base and easily grounding and polishing. Thirty samples in each group were evaluated (a total of 90).

The tea solution was prepared by immersing 2 prefabricated doses (2 x 2 g) of tea (Yellow Label Tea; Lipton, Rize, Turkey) in 200mL of boiling water at 100°C for one minute. After removing the tea waste, the final volume of the solution reached 200mL. To make coffee solution, 6 g of ground coffee powder (Nescafe Classic, Nestle, Switzerland) was poured in coffee filter and 200mL of water at 100°C was added. The obtained solution was passed through another filter and the final volume reached 200mL. In cola group, specimens were stored in 37°C cola (Coca-Cola; Coca-Cola Co, Istanbul, Turkey).

Baseline colour measurements of samples were performed before immersing them in colouring solutions, using a spectrophotometer. To simulate laboratory heating, ninety teeth were mounted in a flask containing gypsum and subjected to acrylic resin heat polymerization process. Ten teeth were immersed in each solution in such a way that they were not in contact with each other. The teeth were immersed in the solutions for one, three and six weeks. To prevent sedimentation, the solutions were replaced every three days.

Change in colour parameters was calculated using a spectrophotometer and reported. Colour parameters were measured at baseline and at one, three and six weeks after immersion. Spectrophotometer was calibrated prior to the onset of the study. Changes in CIE L*a*b* colour parameters were calculated and reported. Total colour change was also calculated using the formula below:

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

The data were analyzed using SPSS, version 21.0. The mean and standard deviation of colour change in the acrylic teeth after immersion in coffee, tea and cola were calculated and reported at one, three and six weeks. Comparison of colour change of the acrylic teeth was done using one-way two ANOVA. Pairwise comparisons of acrylic teeth and solutions were made using Tukey's HSD test. ($\alpha = 0.05$)

Results

The mean and standard deviation of colour change of Apple, Ivoclar and PolyDent acrylic teeth following immersion in tea, coffee and cola solutions are presented in Table 1, respectively.

The results showed that all three types of acrylic teeth experienced some degrees of colour change after immersion in the colouring solutions. The colour change was smaller in the first week but increased by prolongation of immersion time. The greatest colour change occurred at six weeks and was the highest in Apple followed by PolyDent and Ivoclar acrylic teeth in coffee (mean ΔE of 4.6, 3.4 and 3.3 respectively).

Discussion

Several studies have assessed the effect of different solutions on the colour of dental materials. Jafari *et al.* evaluated the effect of different mouthwashes on the colour of porcelain [8]. Studies on stainability of the acrylic teeth following immersion in different colouring solutions have all shown variable degrees of colour change [9-11]. However, variations in the staining of acrylic teeth following immersion in colouring solutions have been documented. Colour change due to exposure to colouring agents often occurs due to extrinsic accumulation of stains on the surface or in the subsurface of restorations. Overall, stain adsorption due to exposure to colouring solutions

Table 1: The mean and standard deviation of colour change of the acrylic teeth in tea, cola and coffee solutions at one, three and six weeks

Solutions	Time	Type of tooth	Mean \pm SD	p-value	
Tea	One week	Apple	3.1 \pm 0.9	0.400	
		Ivoclar	3.4 \pm 0.02		
		PolyDent	3.4 \pm 0.07		
	Three weeks	Apple	3.4 \pm 0.05		0.001
		Ivoclar	3.4 \pm 0.01		
		PolyDent	3.4 \pm 0.01		
	Six weeks	Apple	3.4 \pm 0.07		0.140
		Ivoclar	3.4 \pm 0.01		
		PolyDent	3.5 \pm 0.01		
Cola	One week	Apple	2.65 \pm 0.01	0.007	
		Ivoclar	2.4 \pm 0.3		
		PolyDent	2.6 \pm 0.1		
	Three weeks	Apple	2.7 \pm 0.3		0.001
		Ivoclar	3.4 \pm 0.4		
		PolyDent	2.7 \pm 0.3		
	Six weeks	Apple	3.4 \pm 0.01		0.001
		Ivoclar	3.6 \pm 0.08		
		PolyDent	3.4 \pm 0.02		
Coffee	One week	Apple	2.5 \pm 0.2	0.001	
		Ivoclar	2.3 \pm 0.01		
		PolyDent	2.7 \pm 0.01		
	Three weeks	Apple	4.8 \pm 0.01		0.001
		Ivoclar	2.7 \pm 0.03		
		PolyDent	3.4 \pm 0.01		
	Six weeks	Apple	4.6 \pm 0.04		0.001
		Ivoclar	2.8 \pm 0.02		
		PolyDent	3.5 \pm 0.01		

SD: Standard Deviation

has been more commonly reported in the acrylic teeth of dentures, and dental composites and porcelain rank next. Based on the results, colour change following immersion of the acrylic teeth in colouring agents was significant [12,13].

Variable thresholds have been set for the perception of colour change by a normal observer. Raecke *et al.* reported that colour change was detectable in values of $\Delta E \geq 4$ [14]. Seghi *et al.* and the National Bureau of Standards reported $\Delta E = 1.5$ to be visually detectable [15]. However, a consensus has been reached by most studies on $\Delta E \leq 3.3$ to be clinically acceptable [16,17]. This threshold is often used to assess the efficacy and suitability of dental materials for restorative treatments.

Considering the above mentioned values, it appears that colour change following immersion of the Ivoclar acrylic teeth in colouring solutions, slightly more than acceptable value which is 3.2. However, some concerns exist regarding the colour change of Apple and PolyDent. The difference in colour change values and the standard threshold was close in all the three groups. However, ΔE of samples in colouring solutions would be lower considering the in vitro design of the study and frequent refreshing of solutions.

Mutlu-Sagesen *et al.* assessed the colour change of porcelain, reinforced acrylic and conventional acrylic teeth following immersion in coffee, tea and cola and reported results similar to ours [10]. Koksal and Dikbas reported a significant colour change in the porcelain and acrylic teeth after immersion in coffee, cola and tea for one and two weeks and one month [5]. However, the colour change in the acrylic teeth was higher in the current study.

In this study, we measured colour changes after the acrylic denture processing was done according to the manufacturer's instructions. We used Iranian brands to compare with foreign ones to be able to answer the patients' questions about Iranian artificial teeth qualities.

In the present study, colour change of the acrylic teeth at one and three weeks was greater but between three and six weeks it was lower in value. This finding is probably related to the absorption properties of acrylic resins, which experience severe colour change immediately after immersion in colouring solutions, but after a while they become saturated in terms of the presence of pigments and experience no further colour change [18].

Keskin *et al.* evaluated the colour stability of

polymer-based dentures and showed a reduction in colour parameters after an initial increase in the values [19]. This finding may also be attributed to the removal of sediments of solution accumulated on the surface of restorations because tea and coffee accumulate on the surface of the samples to reach a certain thickness and after that they are dissolved back into the solution.

In the current study, coffee caused the greatest colour change in the Apple acrylic teeth after six weeks of immersion (mean ΔE of 4.6 for coffee and 3.4 for tea and cola) while tea caused almost an equal colour change in all acrylic teeth. The greatest colour change in the Ivoclar acrylic teeth occurred after six weeks of immersion in cola solution (mean ΔE of 3.6 for cola, 3.4 for tea and 2.8 for coffee).

Tea, coffee and cola colouring solutions were selected due to their frequent use by the Iranian population. These drinks have also been used for evaluation of colour change of the acrylic, composite and porcelain teeth in previous studies [8,20-22].

It has been reported that colour change due to exposure to tea is very superficial and can be easily removed by tooth brushing [23]. With regard to coffee, colour change occurs due to the superficial and deep absorption of stains and, thus, cleaning is more difficult. However, only a small number of polar coffee stains penetrate deep into the restorative material [9]. Since tea is a highly popular drink, especially in the Middle Eastern countries, dentists must inform the patients regarding the colour change of the acrylic teeth due to exposure to tea. It has been recommended that patients should brush their teeth immediately after drinking tea.

In the current study, cola caused a relatively small change in the colour of the acrylic teeth and only the Ivoclar acrylic teeth experienced a significant colour change following immersion in cola. Insignificant colour change due to immersion in cola has been attributed to its relatively low pH [23] (about 2 according to the manufacturer). Cola takes its colour from the caramel colour additive, which is prepared by heating sugar or glucose in the presence of a mineral or alkalic acid. Its colour is in the range of light yellow to dark brown [24].

Tannin is a common constituent of colouring solutions such as tea and coffee, which is highly chromogenic [25]. Other factors affecting colour change following immersion in coffee include addition of sugar and its processing procedures such as filtering

[26]. Colour change due to immersion in coffee also occurs due to the superficial and deep absorption of colouring agents mediated by the compatibility of the polymer phase with the yellow coffee stains. Moreover, there is a possibility that polymers in the structure of acrylic resins absorb water molecules in this beverage. It has been documented that both tea and coffee are capable of causing a significant change in the aesthetic appearance of acrylic resins [4], which was also noted in the current study.

Mutlu-Sagesen *et al.* reported that coffee caused the greatest colour change in porcelain, resin reinforced acrylic and acrylic denture base materials used in removable dentures [10]. This finding has also been discussed by some other studies such as the study by Oguz *et al.* [5,27].

Tea leaves have considerable amounts of flavonoids, which are responsible for taste as well as staining caused by tea. Caffeine and caffeic acid in the formulation of coffee are related to the colour change of polymer materials [19]. Another study reported that tea, compared to coffee, caused more considerable colour change in resin-based materials [11].

Imirzalioglu *et al.* demonstrated an almost equal colour change in denture base acrylic resins caused by coffee and tea [9]. Due to the colouring effects of coffee, cola and tea on the acrylic teeth, limiting their consumption can have advantages in terms of colour stability of denture materials for patients [9].

One, three and six-week time points were chosen in this study since four weeks and longer periods of time have been evaluated in previous studies to determine the effect of immersion in colouring agents on different restorations [5,10,13,18,21]. Guller *et al.* reported that the mean time of drinking a cup of coffee was 15 minutes and people often drank 3.2 cups of tea or coffee per day. Thus, one-week storage in coffee or tea corresponds to seven months of their daily consumption. Three weeks of storage corresponds to 21 months and six weeks of storage corresponds to 42 months of consumption [28].

A limitation of this study was that the impact of saliva and similar temperature condition in the oral environment was not considered.

Conclusions

Considering the $\Delta E \leq 3.3$ as the clinically acceptable colour change, it appears that despite the considerable colour change in all the three groups these changes

in the Ivoclar acrylic teeth were in the clinically acceptable range. A slight colour change was expected regarding the Apple and PolyDent acrylic teeth clinically.

Conflict of Interest: None declared.

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