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Colour Stability of Different Types of Aligner Material Expossed To Staining Agents

[1]Dr. Rahil Khandhar, Consultant Orthodontist, Jodhpurgam, Ahmedabad

[2]Dr. Aashka Doshi, Part III PG Student, Department of Orthodontics and dentofacial orthopedics, Ahmedabad Dental College and Hospital, Ahmedabad

[3]Dr. Sonali Mahadevia, Head of the Department, Department of Orthodontics and Dentofacial Orthopedics, Ahmedabad Dental College and Hospital, Ahmedabad

[4]Dr. Keyur Soni, Professor, Department of Orthodontics and Dentofacial Orthopedics, Ahmedabad Dental College and Hospital, Ahmedabad

Corresponding Author: Dr. Rahil Khandhar, Consultant Orthodontist, Jodhpurgam, Ahmedabad.

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Abstract

Introduction: Since patient's acceptance has increased for removable devices, clear thermoplastic retainers have been introduced as an aesthetically acceptable, comfortable, and inexpensive alternative to conventional removable retainers. Whereas fulltime wear of clear retainers immediately after the removal of fixed appliances is recommended, different opinions exist concerning the length of time and the wear regimen of these devices.

Aim and objective: The aim of this study was to compare the colour stabilities of different types of orthodontic aligner materials before and after exposure to staining agents. The objectives of the study were to evaluate colour stability of supraflex, orthospark and leone aligner material exposed to coffee, tea, red wine turmeric solution and mineral water.

Material and method: Total number of sixty flat specimens of thermoplastic sheets of three different companies orthospark®, leone® and supraflex® were used. Five staining solutions black coffee, tea, red wine, turmeric milk, and mineral water as control were used. A total 60 specimen: 20 specimen per company, n= 12 per staining solution, were fabricated for staining experiment. Spectrophotometric evaluation was performed with use of Datacolour 650. Colorimetry values were obtained using the spectrometer and changes in color (ΔE) were determined using the Commission Internationale de l'Eclairage (CIE) *L*a*b**. using the formula.

Results: Results showed that for turmeric milk, coffee, red wine, and mineral water results were statistically significant at 7days, 14days between group. For tea result was statistically significant at 14days between group and insignificant at 7days.

Conclusion: In the Leone brand, prominent staining was observed in red wine, tea, and turmeric milk solution. For the Orthospark brand, staining was observed in red wine, coffee, and tea solution. On the other hand, turmeric milk, coffee, and tea significantly changed the colour of the Supraflex brand.

Keywords: Aligners, Invisible Braces, Thermoplastic Sheets, Staining of Aligners

Introduction

The aesthetic considerations associated with social perceptions influence orthodontic treatment.[1] The increasing demand for more aesthetic orthodontic appliances has elicited an aesthetic revolution marked by the emergence of invisible appliances, such as aesthetic brackets, lingual appliances, and clear aligners.[2] Among these appliances, clear aligners are often preferred over brackets by not also adults but also teenagers, owing to aesthetic and comfort considerations.[3]

The clear aligner treatment process is based on the sequential use of aligners made of transparent thermoplastic materials.[4] Various thermoplastic materials are currently used for fabrication,[5] including polyvinyl chloride,[6] polyurethane (PU),[7] polyethylene terephthalate (PET) [8], and polyethylene terephthalate glycol (PETG).[9]

Many studies have been conducted on clear aligners, particularly focusing on the mechanical properties of the aligners[10] or the biomechanics of tooth movement during orthodontic treatment.[11] Researchers have also investigated new clear aligner materials to obtain desirable mechanical properties for orthodontic treatment.[12] However, although clear aligners are promising aesthetic orthodontic appliances, the aesthetic stability of clear aligner materials has scarcely been reported.

From an aesthetic perspective, the colour stability and transparency of orthodontic clear aligners should be stable during the 2-week orthodontic treatment periods.[13] However, the colour stability of dental materials is often influenced by various factors, such as ultraviolet irradiation, staining beverages, and mouthwashes.[14`] Studies have reported that PU-based elastomeric ligatures are vulnerable to pigment adsorption from food and drink in the oral cavity.[15] During usage, it is recommended that aligners be removed before eating and drinking. However, studies have reported that patient compliance regarding removable orthodontic appliances is insufficient,[16] and this often is a matter of concern for orthodontists.

The exposure of the aligner to staining agents in the oral cavity is inevitable, especially when users drink without taking the aligners out of their mouths because of time constraints during work. For patients who do not follow the instructions, the pigments in staining agents might accumulate and lead to colour changes in the aligner materials. Thus, clear aligners might become less aesthetically appealing even during the 2-week treatments,[17] and this is a clinical concern. Therefore, there is a need to investigate the colour stabilities of commonly used aligners to provide evidence for both patients and orthodontists regarding clinical aesthetic considerations and instructions.

The aim of this study was to compare the colour stabilities of different types of orthodontic aligner materials before and after exposure to staining agents. The objectives of the study was to evaluate colour stability of supraflex,

orthospark and leone aligner material exposed to coffee, tea, red wine turmeric solution and mineral water.

Materials And Method

The study was conducted after the ethical approval. Total number of sixty flat specimen of thermoplastic sheets were used. Thermoplastic sheets of three different companies orthospark®, leone® and supraflex® were used from which aligners are manufactured. Five staining solutions black coffee, tea, red wine, turmeric milk and mineral water as control were used in present study.

At baseline (T0) when samples had not yet been subjected to staining solutions, testing were performed after 7 days (T1) and after 14 days (T2) with use of spectrophotometer. Flat specimen was thermoformed over square block made up of dental stone of random size. Specimen were thermoformed using the Biostar®. Each specimen was heated for 60 seconds and cooled for 40 second. A total 60 specimen: 20 specimen per company, n= 12 per staining solution, were fabricated for staining experiment.

The staining solutions used were black coffee, tea, red wine, turmeric milk and mineral water. The coffee solution was prepared with a ratio of 10g of instant coffee powder (Nescafe® classic) per 400 ml of distilled water. Tea solution was prepared using 9g concentrated tea powder per 600ml of milk. Red wine (Fratelli Carbernet Sauvignon) was used. Turmeric solution was prepared with ratio of 10g of turmeric powder per 600 ml of milk. Mineral water was used as acontrol solution. Staining solutions were filled into different containers in which specimen were immersed (figure 1).

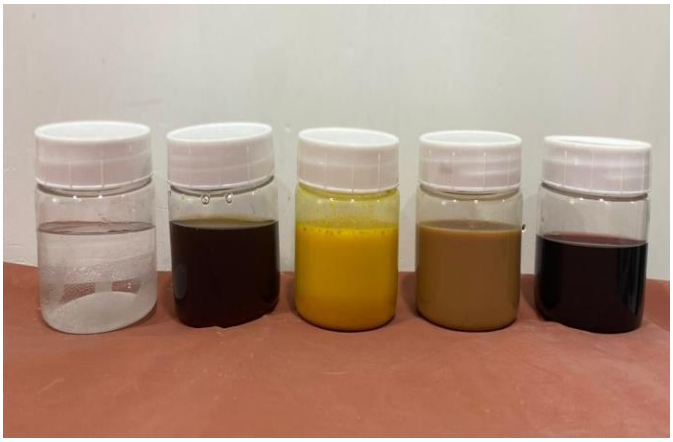

Figure 1: Staining Solutions

Through the staining portion of the experiment the specimens were kept in staining solution and when being transported were placed in a container labelled accordingly and measurements were taken, then specimens were returned later in the day and new staining solutions were filled in the container. Immersed specimens were kept in the containers. After 7days and 14days of immersion specimen were taken for colour testing. Staining solutions from container were replaced by freshly prepared solutions daily. All specimens were removed from liquid solution, air dried and measurements were obtained.

Spectrophotometric evaluation was performed with use of Datacolour 650(figure 2). Colorimetry values were obtained using the spectrometer and changes in color (ΔE) were determined using the Commission Internationale de l'Eclairage (CIE) *L*a*b** . Using the formula below ΔE can be calculated:

$\Delta E = ((\Delta L^*)2 + (\Delta a^*)2 + (\Delta b^*)2)1/2$

ΔE values are obtained from difference in values from data time point. All Δ values were calculated using timepoint 0, T1-T0, T2-T0. Specimens were inserted into custom slot on spectrophotometry machine ensuring readings were taken. Change in color is analyzed using ΔE.

Figure 2: Spectrophotometer (Datacolour 650)

Statistical Analysis and Results

For statistical analysis, paired T test, ANOVA, post hoc turkey test was done. Data compilation was done in an excel sheet format. The results showed that determination of mean values of (turmeric milk, coffee, tea, red wine,) for supraflex, orthospark and leone brands respectively shows that turmeric milk shows highest value followed by coffee, red wine, and tea. In individual group, comparison of mean values of group-turmeric milk between three brands (supraflex, orthospark, leone) suggested that orthospark brand showed highest value followed by leone and supraflex at 7 days. At 14 days orthospark show highest mean value followed by supraflex and leone.

While on the other hand, comparison of mean values of group-coffee between three brands (supraflex, orthospark, leone) suggested that orthospark brand shows highest value followed by leone and supraflex at 7 days. At 14 days orthospark shows highest mean value followed by supraflex and leone.

In similar way, comparison of mean values of one group-tea between three brands (supraflex, orthospark, leone) suggested that orthospark brand shows highest mean value followed by leone and supraflex at 7days. At 14 days supraflex shows highest mean value followed by orthospark and leone. For group-wine comparison of mean values between three brands (supraflex, orthospark, leone) suggested that orthospark brand shows highest mean value followed by leone and supraflex at 7 days and 14 days. For mineral water group, comparison of mean values of one group (mineral water) between three brands (supraflex, orthospark, leone) suggested that supraflex brand shows highest mean value of followed by orthospark and leone.

As shown in the table 1- ANOVA test was done and the results showed that for turmeric milk, coffee, red wine, and mineral water results were statistically significant at 7days, 14days between group. For tea result was statistically significant at 14days between group and insignificant at 7days.

Table 1: ANOVA Test

ANOVA						
		Sum of Squares	df	Mean Square	F	ANOVA P Value
Turmeric Milk 7days	Between Groups	0.010	2	0.005	8.069	0.010
	Within Groups	0.006	9	0.001		
	Total	0.016	11			
Turmeric Milk 14days	Between Groups	0.187	2	0.093	8.333	0.009
	Within Groups	0.101	9	0.011		
	Total	0.287	11			
Turmeric Milk Diff	Between Groups	0.125	2	0.063	4.651	0.041
	Within Groups	0.121	9	0.013		
	Total	0.246	11			
Coffee 7days	Between Groups	0.035	2	0.018	36.273	0.000
	Within Groups	0.004	9	0.000		
	Total	0.040	11			
Coffee 14days	Between Groups	0.024	2	0.012	60.667	0.000
	Within Groups	0.002	9	0.000		
	Total	0.026	11			
Coffee Diff	Between Groups	0.010	2	0.005	10.286	0.005
	Within Groups	0.004	9	0.000		
	Total	0.014	11			
Tea 7days	Between Groups	0.002	2	0.001	3.000	0.100
	Within Groups	0.003	9	0.000		
	Total	0.005	11			
Tea 14days	Between Groups	0.007	2	0.004	4.941	0.036
	Within Groups	0.007	9	0.001		
	Total	0.014	11			
Tea Diff	Between Groups	0.013	2	0.007	3.341	0.082
	Within Groups	0.018	9	0.002		
	Total	0.031	11			
Red Wine 7days	Between Groups	0.048	2	0.024	77.571	0.000
	Within Groups	0.003	9	0.000		
	Total	0.051	11			
Red Wine 14days	Between Groups	0.020	2	0.010	50.667	0.000
	Within Groups	0.002	9	0.000		
	Total	0.022	11			

Discussion

In modern times there is increasing demand for esthetic orthodontic appliances. Aligners has grabbed people's attention because it fulfills their esthetic demand and comfort. Limited information is available regarding thermoplastic retainer colour change associated with staining agents and/or patient oral application. Substantial changes in retainer morphology have been reported, caused by speech, swallowing and bruxism, which alters the surface and structural characteristics of polyurethane material. External discolouration could be a function of time, temperature, and pH while retainers are kept in mouth during the drinking of acidic soft drinks, wine, coffee, tea, fruit juices or other liquids. Also, adsorption of proteinaceous material and regional calcification of stagnation points, which have been shown to occur in the retainer's surface, could be factors influencing retainer colour.

The stability of optical properties such as absorption, reflection, refraction and the scattering of light may be influenced by a number of factors existing in the oral cavity, including the continuous exposure to saliva, crevicular fluid and the other organic and inorganic oral fluids, while transparency loss of the retainer material has been shown to occur in vivo within a two-week wearing time. It is also likely that internal discolouration could be caused by thermal energy and/or UV irradiation, which may induce physicochemical reactions in the retainer polymer. However, there are no supportive studies available.

When a patient eats or drink without taking the aligners out of their mouths there are chances of staining and that might become less esthetically appealing during 2 weeks of treatment. Thus, the purpose of this study was to assess the colour stabilities of commonly used aligner materials for patients and orthodontists regarding esthetic consideration and instructions.

In the present study we compared the colour stabilities of 3 different types of orthodontic aligner materials before and after exposure to staining agents. Samples of three companies were immersed into 5 different staining agents. Colour stability was assessed with use of spectrophotometer after 7 and 14 days respectively.

In the present study we found that various solutions gave significant results in different time durations. On the other hand, three different aligner companies also showed different staining properties with different solutions.

Zafeiriadis AA et al., 2014[21] found that coffee, tea, and red wine had marked color changes to the ViveraR retainer material after exposure for 12 hours and 7 days. This study observed the change in color from calculating the ΔE showed that coffee had the greatest change followed by tea and with minimal changes from red wine.

Liu CL et al., 2016[25] the findings were consistent in displaying those thermoplastic materials showed significant change in color after being subjected to pigmented solutions for 7 days. The study showed that color change was greater for the Invisalign material when stained with coffee

Bernard G, Rompré P, Tavares and Montpetit A (2020)[27] found that after specimens were subjected to staining solutions for 12 hours and 7 days there were significant changes in color for the Invisalign® material after being stained with coffee and wine compared to the ClearCorrect® or Minor Tooth Movement® material. For its part, black tea caused marked extrinsic stains on the surface of the three different brands of aligners.

Conclusion

Ending up with a take away note, we can conclude from the present study that for the Leone brand, prominent

staining was observed in red wine, tea, and turmeric milk solution. For the Orthospark brand, staining was observed in red wine, coffee, and tea solution. On the other hand, turmeric milk, coffee, and tea significantly changed the colour of the Supraflex brand.

Knowledge of the effects of the staining potential on the retainer's surface could guide clinicians regarding the instructions provided to patients upon retainer insertion, so that better long-term retainer maintenance and colour stability are preserved. The present findings suggest that it is important for patients to avoid drinking staining beverages, such as coffee and tea, while keeping the retainers in the mouth.

Further studies would be necessary to enhance the physical and optical properties of thermoplastic material when retainers are subjected to the hostile conditions of the oral cavity.

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