



A Comparative Analysis of Staining Effects on Translucency in Two Transparent Retainers Exposed to Various Cleansers

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ABSTRACT

Objectives: Due to their aesthetic appeal and translucent properties, clear thermoplastic retainers have become increasingly popular. However, ensuring their proper maintenance and cleaning is a significant challenge. It is essential to prevent any negative impact of cleaning solutions on the translucency and color consistency of retainers. Therefore, this study aimed to assess the effect of different cleaning solutions on the light transmission (translucency) rate of two distinct types of clear thermoplastic sheets.

Materials and Methods: Two different clear thermoplastic sheets (Erkodent, Shodental), and five disinfectant solutions including chlorhexidine, Listerine, hydrogen peroxide, GUM whitening, and acid acetic served as the study materials and distilled water was used as control. The samples in each group (N=12) were immersed in the respective solutions for 15 minutes, twice a week and their light transmittance was measured using spectrophotometry after one and three months. Statistical analysis was conducted using two-way analysis of variance, with the significance level set at $P < 0.05$.

Results: Light transmittance decreased from baseline to 3 months for all study groups. After three months, the lowest translucency was related to retainers manufactured with Erkodent sheets, cleaned with GUM whitening ($74.11 \pm 10.72\%$). The highest translucency after this period was found in retainers prepared with Shodental sheets immersed in Listerine mouthwash ($88 \pm 1.55\%$). Only retainers treated with hydrogen peroxide showed significant difference between the thermoplastic sheets, which was higher in Erkodent ($P < 0.05$).

Conclusion: Our findings indicated that among the studied solutions, cleaning translucent retainers with Listerine mouthwash twice a week has the least effect on light transmission.

Keywords: Mouthwashes; Orthodontic Retainers; Orthodontic Appliances, Removable; Orthodontics; Translucency; Spectrophotometry

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INTRODUCTION

One of the most significant objectives after orthodontic therapy is to preserve the outcomes. Relapse is documented to occur in about 70% of orthodontic instances [1]. The periodontium, occlusion, soft tissue, and development are all variables that can trigger

a relapse [2]. To keep the final orthodontic outcome in place, a variety of removable and fixed retainer equipment is used.

Following efficient orthodontic therapy, various removable retainers have been employed to keep the teeth in their finished functional and aesthetic situation [3].

Removable retainers such as Hawley retainers (HRs) and vacuum-formed retainers (VFRs) are the most frequently administered in orthodontic intervention [4]. Clear thermoplastic retainers are becoming increasingly prominent because of their esthetic and translucent characteristics [5]. Patients and clinicians continue to place a high value on the translucency and color durability of clear retainers. Studies show that environmental conditions such as temperature, humidity, and pressure influence mechanical and physical behaviors, including resistance against fracture, resistance against abrasion, and discoloration of clear thermoplastic products [6,7].

Despite the fact that retainers are necessary to prevent orthodontic relapse, studies have shown that bacteria accumulate on clear appliances' surface micro cracks [8]; Consequently, a very effective cleaning technique is very important to facilitate the use of a retainer for a long period of time in order to avoid the accumulation of bacteria on their surfaces, since these devices can alter the ecosystem of the oral cavity and lead to oral-dental diseases [9]. Also, food and beverage coloring, organic and non-organic fluids, heat, moisture, long-term interaction with salivary enzymes, inhaled gases, ingesting masses, speaking, and bruxism are all factors that can affect the color of clear retainers; as a result of the near-invisible character of clear retainers, sustaining the translucency of the retainers is an important consideration for patients [10].

Cleaning and maintaining retainers will remain a top priority as their utilization grows in prominence following orthodontic therapy. There are many ways to clean retainers effectively, which can help them, last a long time and make them more likely to be employed; different chemical and mechanical cleaning strategies, including using a toothbrush, toothpaste, and various mouthwashes, are available to help keep the appearance characteristics of these clear plaques [10, 11].

It is possible that the optical properties of

retainers, such as color and appearance, may be affected by the application of various mouth rinses [12]; despite the increasing popularity of clear thermoplastic retainers, the research on this retainer has relatively limited efficient and cleaning techniques for such retainers are nowadays the subject of very few experiments. Therefore, this study aimed to evaluate the effect of several available cleaning methods on the light transmission (translucency) of two different types of clear thermoplastic sheets, namely Erkodent, and Shodental.

MATERIALS AND METHODS

Study design:

In this in vitro study, pre-prepared sheets of Erkodent and Shodental were immersed in five disinfectant solutions consisting of chlorhexidine, Listerine, hydrogen peroxide, GUM bleaching and acetic acid. Distilled water served as the control.

Sample size calculation:

The minimum sample size in each group (N=12) was calculated by one-way ANOVA, considering $\alpha=0.5$, $\beta=0.2$, standard deviation=2.5, and effect size=0.75.

Ethics statement:

All experiments were approved by the Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.DENTISTRY.REC.1400.007).

Preparing the samples:

Two types of thermoplastic sheets (Erkodent, Shodental) with the same thickness (1mm) were vacuumed by a forming press machine (Erkodent, Australia) and thermoformed on a flat surface, and sampled into 15×15mm² pieces by a bur.

Experimental design:

The samples were immersed in an artificial saliva solution in an incubator at 37°C during the experimental period and were subjected to disinfection with various solutions according to the manufacturers' instructions. The treatment time was 15 minutes twice a week for the study solutions and 3 minutes twice a week for the controls:

Group 1: Samples were immersed in 200ml chlorhexidine 0.2% (Vi-one, Lacer Health Company, Spain).

Group 2: Samples were treated with 200ml Listerine (Johnson & Johnson, Ireland).

Group 3: Samples were immersed in 200ml acetic acid 2.5% (Pejouhan Teb Farabi, Iran).

Group 4: Samples were treated with 200ml hydrogen peroxide 3% (Merk, Germany).

Group 5: Samples were immersed in 200ml GUM Whitening mouthwash (Grupo Boniquet Sparchim SA, Spain).

Control group: Samples were immersed in 200ml distilled water.

Light transmittance assay:

Using a technique previously suggested for monitoring translucency of dental ceramics, the light transmittance of the materials was ascertained [13]. This method quantifies the percent light transmittance through the retainer material into a spectrophotometer (Lambda 365, Perkinelmer, America) in the visible light spectrum (400-700 nm).

Light transmittance measurement time:

According to previous studies, the amount of discoloration of the retainers relates directly to time, and it was demonstrated that this amount of discoloration is obvious within the first three months of use; therefore, the time period chosen for this assessment is the first three months of use; In order to measure the amount of light that passes through each sample, spectrophotometry test Were performed at the end of the first and third months [8,14].

Conditions of the experiment:

All measurements were made in the same conditions and according to the spectrophotometry standard protocol by a person who was blinded to the groups in order to decrease measurement errors.

During the spectrophotometry test, all measurements were taken in the same room under standard lighting and the same spectrometer was used to measure each sample.

The machine was calibrated using white light spectrum before each measurement and for standardizing the position of the samples in the window detector of the spectrophotometer, each sample was placed in a unique situation.

Statistical analysis:

The statistical analysis was conducted using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). The data of quantitative variables were presented as the mean, standard deviation, standard error, and minimum and maximum values. Data were evaluated using two-way analysis of variance (ANOVA) and values $P < 0.05$ were considered statistically significant.

RESULTS

According to the results, the translucency of both retainers decreased in all cleaning method after three months. However, listerine mouthwash and acetic acid after three months (T2) caused a slight increase in translucency, compared to the beginning of the research (T0) in retainers constructed with Erkodent sheets.

Translucency at the beginning of the research:

At the beginning of the research, the lowest translucency (%) was related to the retainers constructed with Erkodent sheets and cleaned with acetic acid and retainers manufactured with Shodental sheets washed with GUM whitening (85.52 ± 2.91 and 87.22 ± 0.76 , respectively). However, the highest translucency for retainers constructed with Erkodent and Shodental sheets was the opposite; the highest translucency at the beginning of the research was related to retainers manufactured with Erkodent sheets in washing with GUM whitening and for retainers manufactured with Shodental sheets in cleanig with acetic acid (87.96 ± 0.7 and 88.81 ± 1.01 , respectively) (Tables 1 and 2). At the beginning of the research, the difference of translucency of retainers prepared by Erkodent and Shodental sheets was insignificant, with the exception of acetic acid and hydrogen peroxide ($P=0.026$, $P=0.006$, and $P<0.05$, respectively). Moreover, there was no significant difference between various cleaning methods at the beginning of the study in terms of change in translucency of thermoplastic sheets (Tables 1, 2).

Table 1. Translucency variations (Mean (%)±Standard deviation) of retainers composed of Erkodent and Shodental sheets using different disinfecting solutions at three time points

Solution	Time								
	T ₀			T ₁			T ₂		
	Erkodent	Shodental	P	Erkodent	Shodental	P	Erkodent	Shodental	P
Distilled water	86.52±0.58	87.57±1.33	0.107	84.23 ±0.88	87.28±1.05	0.817	83.24 ±4.54	83.66±5.88	0.082
Acetic acid 2.5%	85.52±2.91	88.81±1.01	0.026*	85.52 ±0.57	87.14±1.50	0.047*	86.69±1.55	86.14±1.21	0.505
Chlorhexidine 0.2%	88.43±0.96	88.57 ±1.02	0.817	81.87 ±8.90	85.14±0.84	0.007*	81.1±1.11	83.39±1.22	0.411
GUM whitening	87.96±0.70	87.22 ±0.76	0.112	85.23 ±2.62	87.49±0.98	0.159	74.11±10.72	81.93±6.55	0.093
Hydrogen peroxide 3%	86.02±1.06	88.32 ±1.22	0.006*	84.3 ±1.66	86.94±2.33	0.815	84.45±1.21	83.5±7.93	0.043*
Listerine	85.75±3.11	88.33 ±0.58	0.098	85.85±2.28	87.57±1.28	0.140	87.34±1.27	88±1.55	0.442

T0: baseline; T1: after one month; T2: after three months

* Significant

Table 2. Comparison of the impact of various disinfecting solutions on the translucency of Erkodent and Shodental retainers at three different time points

Sheet	Time	Solutions (Mean (%)±Standard deviation)							P
		Distilled water	Acetic acid 2.5%	Chlorhexidine 0.2%	GUM whitening	Hydrogen peroxide 3%	Listerine		
Erkodent	T ₀	86.52 ±0.58	85.52±2.91	88.43±0.96	87.96±0.70	86.02±1.06	85.75±3.11	0.317	
	T ₁	84.23 ±0.88	85.52 ±0.57	81.87 ±8.9	85.23 ±2.62	84.30±1.66	85.85±2.28	0.001*	
	T ₂	83.24 ±4.54	86.69±1.55	81.1±1.11	74.11±10.72	84.45±1.21	87.34±1.27	0.023*	
Shodental	T ₀	87.58±1.33	88.81±1.01	88.57±1.02	87.22±0.76	88.32±1.22	88.33±0.58	0.109	
	T ₁	86.28±1.05	87.14±1.50	85.14±0.84	87.49±0.98	86.94±2.33	87.57±1.28	0.020*	
	T ₂	83.66±5.88	86.14±1.21	83.39±1.22	81.93±6.55	83.5±7.93	88±1.55	0.271	

T0: baseline; T1: after one month; T2: after three months

* Significant

Translucency after one month:

After one month, the lowest translucency (%) was related to retainers manufactured with Erkodent and Shodental sheets in chlorhexidine mouthwash (81.87 ± 8.90 and 85.14 ± 0.84 , respectively). On the other hand, the highest translucency was related to retainers prepared with Erkodent and Shodental sheets in Listerine mouthwash (85.85 ± 2.28 and 87.57 ± 1.28 , respectively) (table 1,2). The difference in the translucency of retainers manufactured with Erkodent and Shodental sheets after a month was insignificant in all washers, except for acetic acid and chlorhexidine mouthwash ($P=0.047$, $P=0.007$, and $P<0.05$, respectively). Nonetheless, the difference between the different washing methods was significant in both thermoplastic Erkodent and Shodental sheets ($P=0.001$, $P=0.020$, and $P<0.05$, respectively) (Tables 1 and 2).

Translucency after three months:

After three months, the lowest translucency (%) was related to retainers manufactured with Erkodent and Shodental sheets in cleaning with GUM whitening (74.11 ± 10.72 and 81.93 ± 6.55 , respectively). The highest translucency after three months was related to retainers prepared with Erkodent and Shodental sheets in Listerine mouthwash (87.34 ± 1.27 and 88 ± 1.55 , respectively). The translucency of samples cleaned with acetic acid was ranked second after Listerine (86.69 ± 1.55 and 86.14 ± 1.21 for retainers prepared with Erkodent and Shodental sheets, respectively) (table 1,2). The translucency difference of the retainers made with Erkodent and Shodental sheets was not significant after three months, with the exception of hydrogen peroxide ($P=0.043$ and $P<0.05$, respectively). Different cleaning methods of translucency of Erkodent and Shodental thermoplastic sheets were significant and insignificant, respectively ($P=0.023$, $P=0.271$ and $P<0.05$, respectively) (table 1, 2).

Tables 1 to 2 show translucency change of retainers manufactured with of two different types of clear thermoplastic sheets (Erkodent, Shodental).

DISCUSSION

Due to lack of being visible, application of the clear retainers is more acceptable and increasing among the patients after orthodontic treatment [15]; nevertheless, making them clean is still a challengeable issue. Numerous studies have reported that various factors can cause a change in color and aging phenomenon in clear retainers that include heat, humidity, enzymes of the saliva, and food [16]. At the moment, few studies have been conducted in terms of presenting an effective way for how to clean these retainers. Zafeiriadis et al. carried out a research to examine the appearance of the clear retainers within three months; they cleaned the retainers twice a day via toothbrush and water (without using any disinfectant) and investigated color change on the first day of examining, 15 and 30 days thereafter using a spectrophotometer. The used retainers showed the color change as time passed and there was a positive relationship between passing time and color change. Of course, the researchers pointed out that the reluctant color difference was less than 3.7 that was acceptable from the clinical point of view [8]; but the most important factor in using the retainers are the patients' acceptance and their cooperation and in addition to the examined color change by the spectrophotometer, the patients' opinion is important as well. According to Moslemzadeh et al. the patients notice more discoloration in the first month; in other words, the patients noticed more color change in the clear retainers within the first month and less color change within the following months (follow up 3 and 6 months) [14]. Regarding the importance of the first days after finishing orthodontic treatment and the cooperation of the patients in retainer's application to avoid relapse, it is better to use mouthwash and other ways of cleaning so that their appearance will change less in this time using disinfectant [17]. In this vein, due to lack of enough studies in this field, the current research aims to examine the short-term (one month) and the long-term effect (three months) of different

cleaning method on clarity and translucency of made retainers with two plates of erkodent and shodental so the researchers can present an appropriate method to clean the retainers. In the present study, washing samples using GUM whitening twice a week, resulted in a small reduction in the samples translucency in the first month, and at the end of the first month, samples washed with chlorohexidine had the lowest translucency. However, at the end of the third month, samples cleaned using GUM whitening had a bigger reduction in comparison to the others. Cleaning samples using chlorohexidine twice a week resulted in the reduction of transparency and light transmission of over time retainers; chlorohexidine action mechanism may result in some reversible side effects such as food taste alteration, mucosal stimulation, and brownish yellow pigmentation on teeth, tongue, and composite repairs, which the translucency decreasing could be its consequence [18-20].

Cleaning of transparent retainers in listerinet mouthwash twice a week for 1 to 3 months, resulted in a higher translucency in comparison to the other cleaning methods. Agarwal et al. showed in their study that among seven studied cleaning methods, Invisalign, Polident, and listerinet cleaning crystals had the lowest alteration in the light transmission rate for polyurethane samples during 6 months that is in concordance with our results [21]. However, in the study performed by Emily Wible et al. showed that light transmission rate through samples had significantly decreased in all cleaning methods during 6 months from starting the study, and listerinet washed group showed the worst translucency. It also resulted in harshness on the thermoplastic sheet surface that is thinner than 0.5 micron and is clinically negligible [11]. Differences in the test results could be due to the study condition, thermoplastic sheet thickness, and brand of these sheets. In the study performed by Emily Wible et al., the light transmission rate through 3% hydrogen peroxide washed samples after 6 months was more than other methods [11]. In the present study, 3%

hydrogen peroxide mouthwash had the highest translucency after Listerine and acetic acid, and after 3 months. However, they claimed that hydrogen peroxide is an oxidative agent and produces oxygen free radicals that oxidizes polymers. This chemical reaction result is aging in polymers such as poly ethylene or poly propylene; so that, their study showed the flexural reduction for 3% hydrogen peroxide washed samples during a long time (after 6 months).

In contrast to the current research findings, research done by Brehove [22] found that Listerine mouthwash had the greatest incidence of discoloration, which may be attributable to variations in the methods used in the experiments. For example, thermoplastic sheet retainers were put in Listerine twice a week (15 minutes at a time) in the current research. In contrast, thermoplastic sheet retainers were inserted in Listerine four times a week during the investigation conducted by Brehove [22] (15 minutes at a time). Additionally, there were many discrepancies in the size of the thermoplastic sheets, the brand of the sheets, and the mouthwash producer.

The translucency of both thermoplastic sheets decreased over time; Except, the translucency of the Shodental thermoplastic sheet was significantly higher than the translucency of the Erkodent thermoplastic sheet in the hydrogen peroxide mouthwash and acetic acid at the beginning of the study and in the chlorhexidine mouthwash and acetic acid after one month. Also the translucency of the Erkodent thermoplastic sheet was significantly higher than the translucency of the Shodental thermoplastic sheet in hydrogen peroxide mouthwash after three months. In other conditions, no significant difference was observed between the two different sheets (table 1). Examination of Biopryl and Invisacryl thermoplastic sheets in a study conducted by Brehove [22] demonstrated that besides Listerine, which stimulates severe discoloration in Biocryl thermoplastic sheets, other techniques (Fresh Guard, Retainer Brite, and EverSmile Whitefoam) did not

apply negative effect; In fact, it can be said that in terms of translucency and color alteration, no significantly different was observed between both brands. Their findings, nevertheless, illustrated that Biocryl thermoplastic sheet was incredibly stiff and Invisacryl thermoplastic surface was highly rough in terms of physical properties such as flexural modulus and surface roughness [22]. Throughout the current research, the sole impact of mouthwashes on the translucency of two thermoplastic sheets, Erkodent and Shodental, has been evaluated.

There are some limitations in this research as with other laboratory studies, as follows:

1. Transparent retainers in the clinic are shaped like teeth, but in this study they were flat and had the same thickness.
2. Moisture, temperature change, food coloring, abrasion, microbial flora in the mouth, etc. could not be regenerated in laboratory conditions and can affect the transparency of retainers.

CONCLUSION

After washing the samples with different washing methods for three months, the results were indicative of a decrease in light passage through thermoplastic sheets over time. According to the results, washing the samples with Listerine mouthwash twice a week caused the lowest change in the level of light passage, whereas chlorhexidine mouthwash and gum bleach led to the highest translucency reduction.

CONFLICT OF INTEREST STATEMENT

None declared.

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