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Evaluation of the Effect of Orthodontic Treatment on Tooth Color Changes in Patients Referring to the Specialty Clinic of Zahedan Faculty of Dentistry

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ABSTRACT

Introduction: Orthodontic treatment interferes with oral hygiene and can discoloration. Therefore, given the importance of tooth discoloration for patients, the present study determined the effect of orthodontic treatment on tooth color changes.

Materials and Methods: Thirty-six patients under orthodontic treatment were evaluated. Photographs were taken before and after orthodontic treatment to evaluate color changes of the teeth. The photos were evaluated by experts and laypeople. The researcher completed a questionnaire consisting of each patient's demographic data and treatment information (the composite resin type, the bonding agent type, and the bracket and wire types). Then, the relationships between these variables and tooth discoloration were analyzed. McNermar test was used to compare tooth color distribution status before and after orthodontic treatment. Chi-squared or Fisher's tests were used to compare the tooth discoloration distribution status in terms of each variable studied. Spearman's correlation coefficient was used to determine the relationship between demographic variables and tooth discoloration. Statistical significance was set at $P<0.05$.

Results: Tooth colors were different before and after treatment. There were no significant relationships between tooth discoloration and the variables of composite resin type, bonding agent, bracket type, and gender. However, the relationship between age and tooth discoloration was significant.

Conclusion: Various factors affect tooth color changes after orthodontic treatment. Although the majority of the factors evaluated in the present study did not alone have a significant relationship with tooth discoloration, it can be claimed that tooth discoloration due to orthodontic treatment is a multifactorial finding with several confounding factors.

Keywords: Discoloration; Orthodontic treatment; Tooth color.

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Introduction

Dental esthetics is important for many individuals and concerns about tooth color have increased. Previous studies have shown that the appearance of teeth, in the absence of other information, can affect peoples' attitudes during social interactions [1-9]. Fixed orthodontic appliances make oral hygiene difficult and increase the plaque-retaining areas on tooth surfaces that are less susceptible to dental caries, causing tooth discoloration and creating white spots around brackets due to the accumulation of plaque [10,11]. Several studies have shown that fixed orthodontic treatment might affect tooth color. Although these problems are not always discernible clinically, teeth become darker after orthodontic treatment, shifting toward red, especially yellow [12-14]. Tooth enamel discoloration might be due to the direct absorption of food coloring agents and the corrosion products of orthodontic appliances, even after orthodontic treatment [15]. In addition, post-bonding procedures, including the removal of adhesive remnants with rotary and manual abrasive tools, might increase the enamel surface roughness, leading to tooth discoloration.

Tooth color results from the interaction between light and the surface of tooth enamel, which is perceptible by the human eye [14]. Two routine methods are available for in vivo analysis of tooth color: visual evaluation and measurement by a device. Visual evaluation is carried out by comparing the tooth colors with a shade guide, which is considered subjective and is the most commonly used method. However, different factors, including environmental light conditions, experience, age, human eye fatigue, and the inherent limitations of the currently used shade guides, might affect the visual shade selection and its characteristics.

Currently, different commercial systems, including 3D colorimetry, spectroradiometry, spectrophotometry, and digital color analysis, are used clinically and in research for determining shades and colors [12,14]. Color changes due to therapeutic procedures might depend on bonding agents and tooth type; however, evidence supporting this is not strong [16]. In this line, Kamber et al. (2018) conducted a systematic review and meta-analysis entitled "Does orthodontic treatment have a permanent effect on tooth color?" The aim was to evaluate the effect of orthodontic treatment with fixed appliances on patients' tooth color. The above research concluded that very low-quality evidence shows that orthodontic treatment might be associated with tooth color changes; however, these changes are not always clinically perceptible. Treatment-induced tooth discoloration might depend on bonding agents and tooth type; however, evidence supporting this is not strong [17]. In addition, Kaya et al. (2018) carried out a study entitled "The long-term follow-up of tooth enamel color change after treatment with fixed orthodontic appliances." The researchers above concluded that during the first three months, there was a significant increase in the brightness of teeth [18]. Karamozos et al. (2010) carried out a study entitled "The color evaluation after orthodontic treatment: A prospective clinical trial." The study aimed to prospectively evaluate the internal color changes of natural teeth due to fixed orthodontic treatment. The above researchers concluded that the color of natural teeth changes in different ways after fixed orthodontic treatment [12]. Therefore, considering a lack of certainty in previous studies and the importance of tooth color change for patients, the present study was undertaken to determine the effect of orthodontic treatment on tooth color changes.

Materials and Methods

This study was an analytical/cross-sectional study. Thirty-six patients referring to the Faculty for orthodontic treatment were included based on inclusion criteria.

Inclusion criteria: A need for comprehensive orthodontic treatment with fixed appliances in both arches, the presence of all permanent teeth, treatment without tooth extraction, no severe crowding (>4mm), no plaque accumulation and gingivitis before bracket bonding, no dental caries, no prosthetic appliances in the examined teeth, no smoking, and no excessive consumption of coffee and tea. A preoperative photograph was taken. In addition, a photograph was taken at the end of orthodontic treatment after debonding the fixed appliance, polishing the teeth using a #12 carbide bur, and brushing with a prophylactic paste.

To evaluate tooth color changes, the photographs were taken under consistent clinical lighting conditions using a Canon EOS 90D digital camera and submitted to observers using PowerPoint software. The observers consisted of three orthodontists and three laypersons. After obtaining the necessary permission from the authorities, simple sampling was adopted to select patients from the Specialty Dental Clinic of the Zahedan University of Medical Sciences. Patients referring to the Clinic for orthodontic treatment, who were willing to participate in the study, were included. The samples were selected in two months. After the patients

were provided with the necessary information on the research process, those willing to participate were included. All the patients signed informed consent forms and were reassured about the confidentiality of all their data. Then, the researcher completed a researcher-made questionnaire consisting of demographic data and therapeutic data (composite resin type, the bonding agent if the data were available, the bracket type, and the wire type). Then, the relationships between these variables and tooth color change were evaluated. To compare tooth color changes, the frontal view of each patient's occlusion and the right and left occlusion before and after treatment were coded to mask the patient's data and submitted to three orthodontists and three laypersons who compared the preoperative and postoperative photographs. After two weeks, the observers repeated the comparison, and their opinions were included in two groups by the researcher: changed and unchanged.

During orthodontic treatment, all the patients were instructed to use Oral-B mouthwash regularly. The orodental hygiene status was evaluated regularly, and future instructions were provided if necessary. The patients were instructed to carry out conventional toothbrushing three times daily, use interdental brushes three times daily, and use mouthwash and dental floss every night in addition to brushing. The data were analyzed with SPSS 25. Descriptive data were used, including means, standard deviations, frequencies, and percentages. McMemar's test was used to compare color change distribution status before and after orthodontic treatment. Chi-squared or Fisher's test was used to compare color change distribution statuses in each group of variables evaluated. Spearman's correlation coefficient was used to determine the correlation between demographic variables and tooth color changes. Statistical significance was set at $P<0.05$.

Results

In the present study, 36 patients aged 19-33 years and a mean age of 27.19 years were included before and after orthodontic treatment. Table 1 presents the general information of the included patients. The qualitative variables were reported with frequencies (percentages), and the quantitative variables were reported with means (standard deviations). Chi-squared test was used to determine and compare the frequency distribution of tooth colors before and after orthodontic treatment (Table 2). All the specialists and laypersons believed that the tooth colors were significantly different before and after orthodontic treatment ($P<0.05$). Spearman's correlation coefficient was used to determine the correlation between the composite resin type and tooth color changes at the end of orthodontic treatment. The results showed no significant correlation between the composite resin type and tooth color changes after orthodontic treatment ($P>0.05$). Given the correlation coefficient value (0.245), there was a weak position correlation between the composite resin type and tooth color changes. Spearman's correlation coefficient was used to determine the correlation between the bracket type and tooth color changes at the end of orthodontic treatment (Table 3).

There was no significant relationship between the bracket type and tooth color changes after treatment ($P>0.05$). Given the correlation coefficient value (0.250), there was a weak positive correlation between the bracket type and toot color changes. Spearman's correlation test was used to determine the relationship between wire type and tooth color changes after the end of orthodontic treatment. The relationship between wire type and tooth color was not significant ($P=0.15$). The correlation coefficient between wire type and tooth color was 0.245, indicating a positive, weak correlation. The relationship between gender and tooth color changes was not significant ($P=0.05$); however, the relationship between age and tooth discoloration was significant ($P=0.012$). The correlation coefficient between age and tooth discoloration was -0.413, indicating a moderate negative correlation. McNemar's test was used to compare the frequency distribution of tooth color frequencies based on the opinion of experts and laypeople after orthodontic treatment. There was a significant difference in the frequency of tooth discoloration based on the opinion of experts and laypeople after orthodontic treatment ($P<0.05$).

Table 1. The descriptive data of the included patients.

Variable	*Total*
Age	*27.19 (3.267)*
Gender	
Male	*13 (36.1)*
Female	*23 (63.9)*

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Variable	Total
Composite resin	
Ortho Technology Resilience	27 (75.0)
American Ortho	6 (16.7)
GC	3 (8.3)
Bonding agent	
Ortho Technology Resilience	27 (75.0)
American Ortho	6 (16.7)
GC	3 (8.3)
Bracket type	
Protect	30 (83.3)
American Ortho	6 (16.7)
Wire type	
Protect	30 (83.3)
American Ortho & Protect	6 (16.7)

Table 2. Chi-squared test and the distribution and comparison of toot color frequencies before and after orthodontic treatment based on the observers' opinions.

Observer	Tooth color change (First stage)	Second stage		Chi-squared	P-value
		Yes	No		
Specialist A	Yes	8.1 (57%)	6.9 (42%)	5.844	0.016
	No	4.2 (18%)	18.8 (81%)		
Specialist B	Yes	5.6 (55%)	4.4 (44%)	7.714	0.005
	No	3.1 (11%)	24.9 (88%)		
Specialist C	Yes	11.6 (78%)	17.3 (77%)	8.691	0.003
	No	5.7 (22%)	4.7 (26%)		
Layperson E	Yes	12 (100%)	0	18.000	0.000
	No	6 (25%)	18 (75%)		
Layperson F	Yes	11.8 (68%)	5.3 (31%)	13.298	0.000
	No	2 (10%)	18 (90%)		

Table 3. The correlation between the bracket type and tooth color after treatment.

Dependent variable	Correlation coefficient	P-value
Tooth color	0.250	0.141

Discussion

Orthodontic treatment in the past mainly focused on improving occlusal functions, but now aesthetic concerns are very important. Color is one factor contributing to the acceptable beauty of teeth [19]. Many studies have shown that orthodontics can have adverse effects on tooth enamel. Most studies have shown that orthodontic treatment can change the color of tooth enamel [20]. According to the present study, the change in tooth color before and after orthodontic treatment was significant. In other words, the color of teeth was different before and after the treatment. The relationship between composite resin type and tooth color changes after orthodontic treatment of patients was not significant. Also, the relationship between bonding type, bracket type, wire type, and gender with changes in tooth color after orthodontic treatment of patients was not significant. However, the relationship between age and tooth color change was significant. In the current study, there was a significant relationship between fixed orthodontic treatment and tooth discoloration, consistent with studies by Juftis et al. [21] and Kamber et al. [17]. Huang et al. [22] also stated that insufficient data were available on the incidence of tooth discoloration during orthodontic treatment. The study by ÇÖREKÇİ

et al. showed no significant difference in the color change of tooth enamel after orthodontic treatment between the studied groups, which is different from the present study [23]. The current study showed that different types of brackets did not lead to significant differences in tooth discoloration, consistent with a study by Tunçer et al. [24]. Emad et al. [25] showed that the teeth became discolored after orthodontic treatment. In 80% of the patients, there was at least one tooth with an abnormal color, and this discoloration was higher in men than women, which is different from the current study. In addition, in our study, gender did not affect the change in tooth color. This study also showed that the color change in teenagers was more than in other age groups, and it was consistent with our study in that there was a significant difference between different age groups. Given the negative correlation between age and the probability of tooth discoloration after orthodontic treatment, with increasing age, the probability of tooth discoloration decreased among our studied population, i.e., the probability of discoloration in teenagers was higher than in adults.

In the present study, the type of bonding system did not affect the discoloration of the teeth; however, in the study by Pandian et al. [26], it was concluded that self-etch primers caused less discoloration than conventional etching systems and resin-modified glass ionomers (RMGI) caused the least color change compared to light-cured and self-cured systems [27]. Coskuner et al. [28] concluded in their study that despite using different polishing and etching methods, the color of the teeth would change after orthodontic treatment, consistent with the findings of the present study on tooth discoloration. Polishing will decrease the amount of discoloration but not eliminate it. Different etching times did not affect the color change of the teeth [29].

Maia et al. [30] investigated the effect of corrosion products of brackets and wires on tooth discoloration after orthodontic treatment. They concluded that the nickel and chromium resulting from corrosion change the color of tooth enamel. In the present study, the types of wires and brackets were investigated because different wires and brackets have different amounts of corrosion. The compositions of wires and bracket types did not significantly affect the discoloration of the teeth; however, this finding does not necessarily indicate the lack of the effects of wires and brackets on tooth discoloration. Corrosion of wires and brackets may occur in all types and affect the overall color change of the teeth. Haghighi et al. [31] investigated the effect of using light-cured and self-cured composite resins for bonding brackets on the discoloration of teeth after orthodontic treatment. They concluded that bonding and debonding brackets affect the color change of tooth enamel. Light-cured and self-cured composite resins had the same effect on tooth discoloration, consistent with the present study. In another study, ÇÖREKÇİ et al. [23] investigated the effects of four different orthodontic composite resins on tooth discoloration. They concluded that the composite resin type did not impact color changes, consistent with the present study. Pandian et al. [26] reported that polishing the tooth surface after removing the remnants of the composite resin reduces enamel discoloration. Unlike the study above, in the present study, different cleaning methods and tools did not result in significant differences in the color changes of teeth. The summary of studies shows that various factors affect the color changes of teeth at the end of orthodontic treatment.

In the present study, an attempt was made to compare the views of experts and laypeople, which is a very important point to show the differences between the priorities of experts and laypeople. Using photography with the same camera and lighting settings will help the reviewers make better judgments. For future research, to resolve the limitations of the current study, it is suggested to consider larger sample sizes and use spectrophotometry methods to determine the amount of color change. Also, the effect of using mouthwash during orthodontic treatment versus not using it can be assessed regarding tooth color changes.

Conclusion

Although most of the factors examined in this study did not have a significant relationship with tooth discoloration alone, it can be claimed that tooth discoloration due to orthodontic treatment is a multifactorial finding with several confounding factors, and the total sum of all factors provided a final judgment of laypeople and experts about tooth color changes after debonding.

Conflict of Interest

There is no conflict of interest to declare.

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