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Original Research

Evaluation of color stability of orthodontic esthetic archwires

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ABSTRACT:
Background: To evaluate the color stability of orthodontic esthetic archwires. **Materials & methods:** In this study, 4 types of esthetic archwires were assessed. The brand, cross section size and composition were shown according to the manufacturers. Samples of each brand were prepared. A staining solution was prepared. To relate the amount of color change (ΔE*) to a clinical environment, the data were converted to National Bureau of Standards (NBS) units as follows: NBS units=ΔE*×0.92. **Results:** The definitions of color changes quantified by NBS units were used. Samples of 4 brands of wires was stained and color changes were measured accordingly on 7th days and after 21 days. All brands showed staining after 7 days, but at different intensities. Clinically apparent staining occurred in all brands after 21 days. The optis archwire presented the highest color alteration as according to NBS units measured on 7 days and after 21 days was 9.03 and changed to 11.06. **Conclusion:** All esthetic archwires assessed showed clinically noticeable color change after 21 days in staining solution.
Keywords: esthetic arch wires, color, orthodontic.

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INTRODUCTION

Appearance is one of patients' main concerns during orthodontic treatment. There is a growing demand for esthetic appliances, but most fixed orthodontic appliance components are metallic and silver in color. [1]

This problem has been partially solved by the introduction of esthetic brackets made of ceramic or composite, which are becoming more popular. [2] However, most archwires are still made of metal such as stainless steel and nickel-titanium. A number of alternatives have been explored to create an esthetic archwire that would allow efficient orthodontic treatment from the labial aspect. [3]

Orthodontic wires are widely used as part of orthodontic appliances throughout treatment. These wires are made from metal alloys such as stainless steel (SS), cobalt-chromium-nickel (Co-Cr-Ni), β-titanium (β-Ti), and nickel-titanium (Ni-Ti) alloys. [4,5] The main advantage of using these metal alloys in orthodontic wires is their superior mechanical properties compared to other materials such as polymers and ceramics. However, one disadvantage of these metallic wires is the metal's opaque appearance, which deters many patients from orthodontic treatment. [6] To address this issue, many types of esthetic brackets have been developed for orthodontic appliances. [7] These brackets have been made from alumina, zirconia, polycarbonates, and their composites. [8]

Due to good color stability and improved adhesion, esthetic brackets have become very popular in Orthodontics in recent decades. Moreover, the demand of adult patients for orthodontic treatment performed with esthetic orthodontic brackets has increased substantially. Furthermore, as regards elastomeric ligatures used to tie the bracket/wire combination, clinical orthodontists are concerned and would like to make sure the ligatures' characteristics remain unchanged. Color changes caused by staining resulting from food ingestion or contact with intraoral fluids are particularly undesirable. These changes are due to swelling and discoloration when elastomers are exposed to the intraoral environment, and it is caused by buccal fluids and bacteria that fill up the spaces in the rubber matrix. [9,10] In order to minimize the

influence of some types of food affecting the color of elastomeric ligatures and archwires, metallic pigments have been added during the manufacturing process; however, they reduce the level of force released, impairing their elastomeric properties. Hence, this study was conducted to evaluate the color stability of orthodontic esthetic archwires.

MATERIALS & METHODS

In this study, 4 types of esthetic archwires were assessed. The brand, cross section size and composition were shown according to the manufacturers. Samples of each brand were prepared. A staining solution was prepared.

To relate the amount of color change (ΔE*) to a clinical environment, the data were converted to National Bureau of Standards (NBS) units as follows: NBS units=ΔE*×0.92. Data was collected and results were analysed.

Table 1: Critical Marks of Color Change According to the National Bureau Standards

NBS unit	Definitions of Color differences	
0.0-0.5	Trace	Extremely slight change
0.5-1.5	Slight	Slight change
1.5-3.0	Noticeable	Perceivable change
3.0-6.0	Appreciable	Marked change
6.0-12.0	Much	Extremely marked change
12.0+	Very much	Change to other color

RESULTS

The definitions of color changes quantified by NBS units were used. Samples of 4 brands of wires was stained and color changes were measured accordingly on 7th days and after 21 days. All brands showed staining after 7 days, but at different intensities. Clinically apparent staining occurred in all brands after 21 days. The optis archwire presented the highest color alteration as according to NBS units measured on 7 days and after 21 days was 9.03 and changed to 11.06.

Aestheic NiTi wire and esthetic flexy super elastic on 7days and after 21 days were showing color change from noticeable and appreciable to both appreciable. In coated wire NiTi, color changes from 7day to 21 day as slight to noticeable.

Table 2: Color Change of Archwires Converted to NBS Units and Remark of Color Difference

Group	7 day		21 day	
	NBS units	Color change	NBS unit	Color change
Optis	9.03	Much	11.06	Much
Coated wire NiTi	0.8	Slight	2.1	Noticeable
Aesthetic NiTi wire	2.6	Noticeable	5.03	Appreciable
Esthetic flexy super elastic	3.8	Appreciable	5.02	Appreciable

DISCUSSION

Ideally, the color of esthetic archwires should match that of natural teeth and esthetic brackets. However, the colors of natural teeth vary according to the color measurement protocols used and also by race, gender, and age. [11,12]

Generally, values in the range of one unit are considered exact color matches because they cannot be identified by independent observers. [13] Since instrumental measurements eliminate the subjective interpretation of visual color comparison, spectrophotometers are used instead of visual evaluation.

Patients' concerns about facial esthetics and properly aligned teeth have been combined with increased life expectancy and quality of life to boost the demand for orthodontic treatment in adult patients; and with it, the demand for esthetic orthodontic appliances. Despite great improvement in the quality and stability of bracket color, esthetic appliances are faced with the challenge of changes that occur in the color of esthetic orthodontic ligatures when exposed to the intraoral environment. Thus, patients' complaints are frequent, given that the whole bracket/ligature combination becomes less esthetic, as elastomers undergo undesirable staining. Analyses of color changes in orthodontic ligatures are usually performed in vitro, which does not reflect reality. [14,15] In this study, the definitions of color changes quantified by NBS units were used. Samples of 4 brands of wires was stained and color changes were measured accordingly on 7th days and after 21 days. All brands showed staining after 7 days, but at different intensities. Clinically apparent staining occurred in all brands after 21 days. The optis archwire presented the highest color alteration as according to NBS units measured on 7 days and after 21 days was 9.03 and changed to 11.06.

A study by da silva DL et al, samples were evaluated after 7, 14, and 21 days of immersion in staining solution. Color measurements were performed by means of a spectrophotometer according to the Commission Internationale de I'Eclairage L*a*b* system, and color changes (ΔE*) and National Bureau of Standards units were computed. All brands showed

statistically significant color change after 21 days (ΔE* from 1.88 to 12.06). The Optis archwire (fiber-reinforced composite) presented the highest color alteration, although staining was observed only near its ends. The Trianeiro archwire (coated nickel-titanium) and the Ortho Organizers archwire (coated stainless steel) presented with less color change. [16] In this study, aestheic NiTi wire and esthetic flexy super elastic on 7days and after 21 days were showing color change from noticeable and appreciable to both appreciable. In coated wire NiTi, color changes from 7day to 21 day as slight to noticeable.

Another study by Kawabata E et al, four widely used commercial brands of elastomeric ligatures were selected and used in 20 adult patients in a split-mouth design. The ligatures were evaluated by orthodontists and patients in a double-blind manner on the day the ligatures were placed (T0) and 30 days after intraoral exposure (T1) by means of a system of staining scores. Groups were compared by Friedman test with $p < 0.05$. Orthodontists and patients reported similar staining scores ($p > 0.05$). Results showed that all brands underwent significant staining when exposed to the intraoral environment. A large individual variability in the degree of staining was also found for all brands. All four brands of esthetic ligatures showed significant staining, which appeared to be more pronounced for the MorelliTM brand. Changes in color of the elastomeric ligatures were perceived similarly by patients and orthodontists. The industry needs to improve the color stability of esthetic ligatures. [17]

CONCLUSION

All esthetic archwires assessed showed clinically noticeable color change after 21 days in staining solution.

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