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EVALUTION OF COLOR STABILITY OF FIBER REINFORCED POLYMER COMPOSITE WIRES AND COATED AESTHETIC ARCH WIRES

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ABSTRACT:-

Objectives: Aesthetics in orthodontics has become an essential goal, rather than the necessity. To alleviate the esthetic demand, coated metallic wires were introduced, however the color of coated arch wires degrades over time due to external stains.The aims of the study were to evaluate the color stability of and coated arch wires after exposure of staining solution fiber reinforced polymer composite wires for 7, 14 and 21 days.

Materials and methods: Fiber reinforced polymer composite wires(Biomers), Optiflex (Armco), Epoxy coated NiTi wire (G & H) and Rodhium coated NiTi wires (American orthodontics) with cross section dimensions of 0.018" were evaluated for color stability after exposure of staining solution for 7, 14 and 21 days.The colormeasurement of each sample was performed using a spectrophotometer.The data were converted to National Bureau of Standards (NBS) units, to relate the amount of color change (ΔE*) to a clinical environment. One-way ANOVA test was used to compare the ΔE* value (color change) amongthe different wire brands at different time period. Tukey's honestly significant difference test (HSD) was performed to test any statistically significant difference in ΔE* value (color change) between any two groups.

Results: While comparing the significance, all wires show statistical significance with other having more significant value towards epoxy coated NiTi wire.

Conclusion: Noticeable color changes are observed in all esthetic arch wires when in contact with a staining solution after 21 days. Among the four types of arch wires evaluated in the

study, Fiber reinforced polymer composite arch wire exhibited more color change and epoxy coated NiTi arch wire showed a mild color change.

Keywords: Fiber reinforced polymer composite wires, Epoxy coated archwires, Color stability, Spectrophotometer

1. INTRODUCTION:-

Aesthetics in orthodontics has become an essential goal, rather than the necessity. An alternate to metallic orthodontic appliances, were made of composite or ceramic brackets which materialize transparency for esthetics. Metallic arch wires compromised esthetics,as they were made of stainless steel, nickel titanium, or titanium molybdenum alloy. To alleviate the esthetic demand, coated metallic wires were introduced, to reinforce anchorage[1] and as fixed retainers.[2] The stripping of the coatings due to increased friction were the drawback of coated esthetic wires.[3] In order to trounce this, fiber reinforced polymer composite wires (FRPC) were established, which composed of continuous E-glass fibers and epoxy polymer matrix obtained by tube shrinkage technique through composite technology.[4] The FRPC archwire, being translucent in nature, allows tooth color transmission, thereby improving esthetics when compared to coated archwires. However, few authors have stated that the color of coated archwires degrades over time.[5] Discoloration of esthetic archwires are mainly due to external stains caused by colored mouth rinses, food dyes and beverages.The amount of color change can be influenced by a number of factors, including oral hygiene and water absorption.[6]The objective of this study was to evaluate the color stability of and coated arch wires after exposure of staining solution for 7, 14 and 21 days.

2. MATERIALS AND METHODS:-

In this experimental study, four esthetic arch wire were evaluated for color stability. (Biomers), Optiflex (Armco), Epoxy coated NiTi wire (G & H) and Rodhium coated NiTi wires (American orthodontics) with cross section dimensions of 0.018" were evaluated. Each sample wire was cut into 20 mm length with orthodontic wire cutter and washed in distilled water to remove the surface impurities, and blot dried.

The staining solution was prepared by dissolving 15 g coffee (Nescafé) in 500 mL of boiling distilled water. The solution is cooled to 37^0C, then filtered through filter paper and incubated at 37^0C throughout the experiment. The wires were immersed in staining solution for 24 hours (T_o) and the color of each sample was measured using spectrophotometer VITA Easyshade Compact (VITA Zahnfabrik, Bad Säckingen, Germany, Model DEASYC220).

The color measurements were repeated and recorded at 7 days (T_1), 14 days (T_2), and 21 days (T_3), after immersing the samples in the solution. Prior to each measurement, samples were rinsed with distilled water and blot dried. The spectrophotometer was calibrated according to the manufacturer instructions, preceding with the measurements. The average values were recorded from five measurement of each of the four samples. Since, the visual color assessment is subjective, the color changes were characterized using the Commission Internationale de I'Eclairage L*a*b* color space (CIE L*a*b*) to obtain an objective color measurement.[7]

The visual perception of color differences are quantitatively analyzed with these systems. The formula used to express The total color differences are calculated by the formula ΔE* 5 ([ΔL*]2 + [Δa*]2 +[Δb*]2)1/2, where ΔL*, Δa*, and Δb* are differences in L* (lightness with values from 0 (black) to 100 (white)), a* (color saturation from red to green on a scale of -60 to 60), and b* (color saturation from yellow to blue on a scale of 60 to 60, where positive values indicate varying intensities of yellow) values before (T0) and after immersion at each time interval (T1, T2, T3). The data were converted to National Bureau of Standards (NBS) units, to relate the amount of color change (ΔE*) to a clinical environment.[8] Koksal and Dikbas suggested the quantification of color change by NBS units = ΔE* X 0.92. [9]

Critical Marks of Color Change According to the National Bureau Standards are as follows:

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

The data obtained were entered into the computer database. The response of frequencies were calculated and analysed by using Statistical Software package of Social Sciences (SPSS) version 22.0 version. One-way ANOVA test was used to compare the ΔE* value (color change) among the different wire brands at different time period. Tukey's honestly significant difference test (HSD) was performed to test any statistically significant difference in ΔE* value (color change) between any two groups. In the statistical evaluation, the following levels of significance were used as follow: Non-significant $p>0.05$, Significant $0.05\geq p>0.01$ and highly significant $p\leq 0.01$.

3. RESULTS:-

Table 1. Total Color Difference (DE*) and Intragroup (Between Time Periods) and Intergroup (in Each Time Period) Comparison Using Tukey Post Hoc Test

Group of wires	T_0		T_1		T_2		T_3	
	Color difference	Intergroup comparision	Color difference	Intergroup comparison	Color difference	Intergroup comparison	Color difference	Intergroup comparison
Fiber reinforced composite wires	3.14 (4.23)[a]	A	8.94 (78.2)[b]	A	12.14 (53.2)[c]	A	15.98 (39.6)[d]	A

Optiflex	3.86(62.)[a]	B	5.92 (63.28)[b]	B	7.24 (49.42)[c]	B	11.24 (28.53)[d]	B
Epoxy coated NiTi wire	1.25(33.2)[a]	C	2.15 (72.35)[b]	C	5.23 (81.3)[c]	B	6.22 (18.20)[d]	C
Rodhium coated NiTi wires	1.98 (63.4)[a]	D	4.01 (23.6)[b]	D	6.78 (63.93)[c]	D	7.16 (36.29)[d]	D

a,b,c Different letters indicate a statistically significant difference (P , .05) between different time periods in each group (same line).

A,B,C,D,E Different letters indicate a statistically significant difference (P , .05) between groups in each time (same column).

Table (1) shows the total color difference (DE*) of the esthetic arch wires after24 hours, 7 days, 14 days, and 21 days of immersion in the staining solution and intragroup and intergroup comparisons according to Tukey's post hoc test. All wires show color change after 7 days of immersing in staining solution. Fiber reinforced composite wire shows more color change and epoxy coated NiTi wire shows mild color change. It shows that epoxy coated NiTi wire were the most color stable wire while comparing other wires. Intergroup comparison is done between two groups of wire at different time period and denoted by capital letter. Intragroup comparison is done within a brand of wire at different time period and denoted by small letter. On the whole Epoxy coated NiTi wire was considered as best wire than others because it shows light color change than other wires. While comparing the significance all wires show statistical significance with other having more significant value towards epoxy coated NiTi wire.

Table2. Color Change of Arch wires Converted to NBS Units and Remark of Color Difference

Group of wires	T_0		T_1		T_2		T_3	
	NBS Units	Color change	NBS Units	Color change	NBS Units	Color change	NBS Units	Color change
	3.02	Appreciable	8.09	Much	11.36	Much	15.20	Very much
Optiflex	3.70	Appreciable	5.29	Appreciable	7.22	Much	11.34	Much
Epoxy coated NiTi wire	1.6	Noticeab	2.8	Noticeab	5.37	Apprecia	6.07	Muc

	2	le	8	le		ble		h
Rodhium coated NiTi wires	1.83	Noticeable	4.90	Appreciable	6.47	Much	7.29	Much

Table (2) shows color change according to NBS units. Color changes (Δ E* < l, trace and slight color change) were not appreciable through naked eyes, While clinically acceptable color changes which appreciable by skillful operator (3.3 > Δ E* > l, slight and noticeable color change). But clinically unacceptable color changes which is appreciable by non-skilled persons (Δ E* > 3.3, appreciable color change).Epoxy coated NiTi wire were most color stable than others. Fiber reinforced composite wire show drastic amount of color change at different time intervals than Epoxy coated NiTi wires which shows least change over different time intervals. Although all wires shows some sort of color changes among different time intervals these are not much appreciable by human eyes, these changes are only expressed according to ΔE* values and NBS unit.

4. DISCUSSION:-

In orthodontic treatment, the color stability of coated esthetic arch wires plays a major role in esthetics to prove the clinical relevance. The color of natural teeth differs according to race, gender, age, irrespective of the color of coated esthetic arch wires, ligatures and brackets compromising esthetics.[10-12]

The ideal subjective method for identifying color changes is visual color comparison. For reducing the variance of subjectivity, a spectrophotometer was used with distinguished color scale in this study to achieve congruous results.[13-15]

According to the CIE *L*a*b** (or CIELAB) parameters, the color measurement system determines the small color differences.[7]The color differences quantified in previous studies, showed varying interpretations of ΔE*.[9,14,15] Therefore, in this present study, the NBS rating system is used to hamper the differences from previous studies. According to the study of da Silva et al,[16]DE* values can be converted to definitions with clinical significance in NBS rating system.

Previous studies [9,13,15,16,19] have stated that coffee was the most chromogenic agent in comparison with other staining dietary media like, cola and tea. Therefore, in this study the effect of staining was evaluated by using a coffee solution.

Epoxy coated NiTi arch wire showed mild color change, these findings were supported by the studies of Alsanea and Al Shehri.[18] Fiber reinforced composite wire showed noticeable color change after immersion in staining solution for 21 days. This is in concordance with the findings of the previous studies by Inami et al,[12] da Silva et al,[16]Mujawar et al,[17] and Rego, Lau, Araújo et al.[20]

Arthur et al,[21] stated thatthe color changes seen clinically are due to the optical properties within a polymer, were the oxidation of unreacted double bonds in the matrix of the polymerand the

subsequent formation of degradation products from water diffusion or the oxidation of the polymer, exhibiting the staining behavior of polymer coated arch wires.

The limitation of the present study was not able to reveal the optical properties of esthetic arch wires and not able to compare the results due to lack of similar studies. Hence, in future more studies have to be conducted comparing the color stability with various esthetic wires.

5. CONCLUSION:-

Noticeable color changes are observed in all esthetic arch wires when in contact with a staining solution after 21 days. Among the four types of arch wires evaluated in the study, Fiber reinforced polymer composite arch wire exhibited more color change and epoxy coated NiTi arch wire showed a mild color change.

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