

Comparing the color stability of different tooth coloured brackets

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Abstract

Introduction: As the number of adults seeking orthodontic treatment increased, the esthetic brackets were introduced. The colour stability of these esthetic brackets has remained the main concern for clinicians as well as patients. Though, the ceramic brackets had similar disadvantages of getting stained in the oral environment over a period of time, they were more resistant to various stresses and torquing forces. The purpose of this study was to take into consideration, the staining of the brackets due to individual diets and to evaluate the effect of commonly consumed liquids; turmeric solution, red wine, coffee and multi-vitamins upon colour stability of ceramic brackets.

Aim and objective: The aim of this study was to investigate and analyze the discolouring effect of certain food dyes and the effect of time on colour stability of ceramic brackets. To analyse the colour stability of ceramic brackets at the interval of 24 and 72 hours.

Material and method: Total number of sixty specimens of ceramic brackets of three different companies as American orthodontics, Ormco and Galaxy (Camay) were used. Four staining solutions, coffee, red wine, turmeric solution, and multivitamin syrup were used. Each subgroup has 5 ceramic brackets. Discoloration was recorded at T1 (after 24 hours) and T2 (after 72 hours). Spectrophotometric evaluation was performed

with use of Datacolour 550. 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: Turmeric stained the Galaxy (Camay) brackets more and American orthodontic brackets the least after 24 and 72 hours. Similarly, Coffee showed the highest staining with the Ormco (symetri clear) brackets and least with the Galaxy (Camay) brackets after both the time intervals. Red wine discolouration is seen the highest with Ormco (symetri clear) brackets and the least with Galaxy (Camay) after 24 hours but after 72 hours Galaxy (Camay) shows greater amount of stain uptake. With multi-vitamin syrup, Galaxy (Camay) gives the maximum staining whereas Ormco (symetri clear) gives the minimum staining after first time interval and also at the end of the study.

Conclusion: American orthodontics shows the least values, suggesting greater colour stability against the staining solutions. On the other hand, Galaxy (Camay) brackets show greater mean values which depicts otherwise.

Keywords: Ceramic Brackets, Invisible Braces, Color Stability, Staining of Brackets.

Introduction

The growing population of adult orthodontic patients not only wants an improved smile, but also better esthetics during the treatment. Over the years, the esthetic appearance of fixed orthodontic appliance has become a vital concern. As the number of adults seeking orthodontic treatment increased, the esthetic brackets were introduced. Three types of orthodontic bracket are currently available; metal, ceramic and plastic. The

metal brackets although provide good mechanical properties, esthetically they are not appreciated.¹

The first esthetic brackets appeared in the 70's and were made from polycarbonate, a plastic material. Although these brackets were reasonably esthetic, this material did not present suitable properties for clinical use. Several studies showed clinical problems such as deformation and structural weakness, poor adhesion and poor stain resistance during treatment.

In the mid-1980s, other types of material were tested to meet the esthetic needs of the orthodontic market. Although various modalities have been incorporated in orthodontics to improve esthetics during the treatment, but composite and ceramic brackets remain the most popular options preferred by the patients. Composite bracket are made up of polycarbonate which adsorbed water during orthodontic treatment. Ceramic brackets are mainly made from aluminium oxide and are available in two forms according to the manufacturing process: polycrystalline or monocrystalline.²

An increased strength is a major advantage of ceramic brackets over composite brackets. Nevertheless, the use of ceramic brackets may result in problems with excessive bond strength and damage the enamel during removal due to their brittle nature.¹

Polycrystalline or alumina polycrystalline brackets are made of aluminum oxide crystals fused at high temperatures (near 1950°C). Monocrystalline brackets are made of a single crystal produced from the combination of particles of aluminum oxide fused at a higher temperature (2100°C) and cooled slowly, thus enabling thorough control of crystallization.

Thus, the manufacturing process produces translucent and non translucent ceramic brackets. Monocrystalline brackets are included in the translucent brackets group

while polycrystalline brackets are non-translucent. The translucency of monocrystalline brackets is due to the structure of a single crystal that provides passage of light. Polycrystalline brackets are not translucent because their structure presents a lack of boundaries between the crystals and impurities incorporated during the manufacturing process, thereby hindering passage of light.

To have a good esthetic appearance, non-translucent brackets need to be similar in colour and fluorescence to the underlying tooth, whereas translucent brackets need to have sufficient translucency so as to allow the colour and fluorescence of the tooth to pass through them. However, it is essential that both have good colour stability.²

The colour stability of these esthetic brackets has remained the main concern for clinicians as well as patients. Though, the ceramic brackets had similar disadvantages of getting stained in the oral environment over a period of time, they were more resistant to various stresses and torquing forces.

There are two types of discolouration of esthetic brackets: Internal (endogenous) and external (exogenous). The external discolouration is chiefly due to colour dyes, such as food dyes, tea stains, coffee, coloured mouth rinses, etc. The material, structure, filler content and surface roughness play a decisive role in the extent of external discolouration.

The chief culprit for internal discolouration was found to be UV radiation and thermal energy. Two general methods can be used to analyse the colour of an object; visual and instrumental. Visual colour determination is based on visual comparisons of the object with standard colour and most frequently applied in dentistry. Visual colour assessments are a result of physiological and

psychological responses to radiant energy stimulation. Alteration in perception can occur as a result of uncontrolled factors, such as fatigue, aging, emotions, lighting conditions and metamerism. It is the most scientific and practical method to assess colour stability. Colourimetry is the branch of science concerned with numerically specifying the perceived colour of the object as well as differences in perceived colour between two objects judged to be different. Reflected colour is calculated according to Commission International de l'Eclairage (CIE) LAB colour scale by measuring the ratio of reflected light to incident light (spectral reflectance) under specified geometric conditions. One of the most important features of the CIELAB system is its arrangement as an approximately uniform three-dimensional colour space. The amount of colour change can be influenced by number of factors, including oral hygiene, water sorption, incomplete polymerization and surface roughness.¹

The purpose of this study was to take into consideration, the staining of the brackets due to individual diets and to evaluate the effect of commonly consumed liquids; turmeric solution, red wine, coffee and multi-vitamins upon colour stability of ceramic brackets.

Aim and Objectives

Aim: To investigate the discolouring effect of certain food dyes and the effect of time on colour stability of ceramic brackets.

Objectives

- To analyse the discolouring effects of turmeric solution, coffee, red wine and multi-vitamins on ceramic brackets.
- To analyse the colour stability of ceramic brackets at the interval of 24 and 72 hours.

Null Hypothesis

There is no colour difference in the ceramic brackets after immersion in different staining solution; Turmeric solution, coffee, red wine and multi-vitamins.

Material and Method

Sample: An in-vitro, study to determine the colour stability of various ceramic brackets in different solution, was carried out on 60 ceramic brackets manufactured by three different brands such as American orthodontics, Ormco and Galaxy (Camay). These brackets were immersed in four types of the solution- Turmeric, coffee, red wine, multivitamin syrup.

Sample Grouping

Four main groups (Solutions) -

Group A: Turmeric solution

Group B: Coffee

Group C: Red wine

Group D: Multivitamin syrup

Three sub groups (brackets) -

Group I: American Orthodontics

Group II: Ormco (Symetri clear)

Group III: Galaxy (Camay)

Each subgroup contains 5 ceramic brackets.

Instrument

Datacolor 550 spectrophotometer



Figure 1: Spectrophotometer

Instrument specifications

Instrument Type: Dual beam integrating sphere with xenon flash lamp.

Illumination Source: Pulsed xenon, filtered to approximate D65.

Spectral Analyzer: Proprietary SP 2000 analyzer with dual 256-diode array and high-resolution holographic grating.

Wavelength Range: 360 – 700nm

Effective Bandwidth: 10nm

Aperture Configuration

Large Area View- 30mm illuminated/ 26mm viewed

Small Area View- 9mm illuminated/ 5mm viewed

Ultra-Small Area View- 6.5mm illuminated/ 2.5mm viewed

X-Ultra Small Area View-3mm illuminated/2.5mm viewed

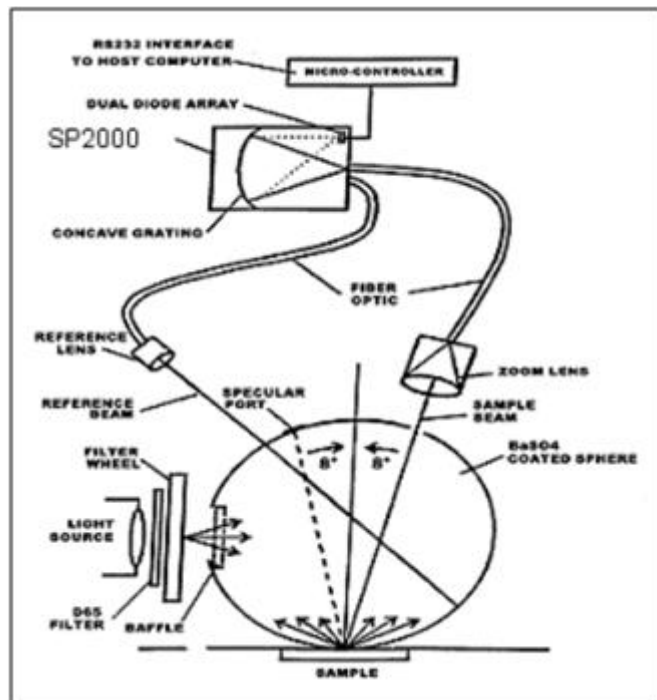


Figure 2: Schematic diagram of spectrophotometer

Material

1) Turmeric solution

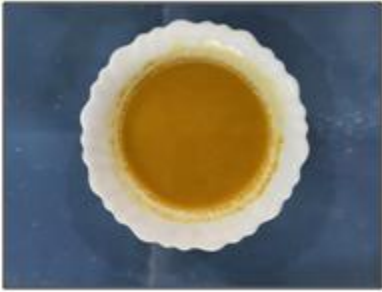


Figure 3: Turmeric solution made with water and turmeric

2) Coffee

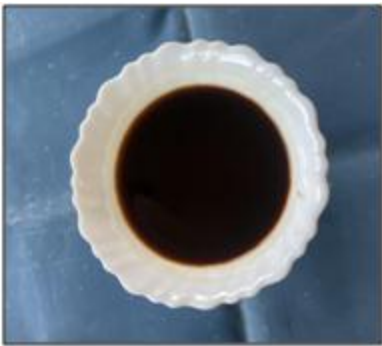


Figure 4: Coffee

3) Red wine



Figure 5: Red wine

4) Multivitamin syrup



Figure 6: Multivitamin Syrup

5) bracket kit manufactured by American Orthodontics



Figure 7: American Orthodontics bracket kit

6) Ormco Symetri clear bracket kit



Figure 8: Ormco (symetri clear) bracket kit

7) Galaxy (Camay) ceramic bracket kit



Figure 9: Galaxy (Camay) ceramic bracket kit

8) 12 well plates



Figure 10: 12 well petridish

9) Slides



Figure 11: Microscopic Slides

Method

The three orthodontic bracket manufacturing brands selected for this study include American orthodontics, Ormco (symetri clear) and Galaxy (Camay). Thereafter, 60 microscopic slides were taken & labelled with the chosen brand names and then bracket specimen were fixed accordingly using cyanoacrylate adhesive, as shown in Figure 12.



Figure 12: Labeled microscopic slides

Quantitative measurements of the light reflections for each specimen determining its colour, were made using Data color 550 Spectrophotometer, which is a dual beam Spectrophotometer that uses pulsed xenon illumination source. Small Area View (9mm illuminated/5mm viewed) aperture configuration was selected for the testing. The initial values at time T_0 were recorded. The brackets were then removed from the slides and were cleaned off any remaining debris.

Four solutions used to check for colour stability of the orthodontic brackets were turmeric, coffee, red wine and multi vitamin syrup. Of which 30 ml of red wine (Fratelli, 12.5% v/v) & Moktel immune multivitamin syrup were taken as provided by the manufacturer. The Turmeric and coffee solutions were made by mixing 30ml of water with 1 table spoon of turmeric & coffee powder respectively.

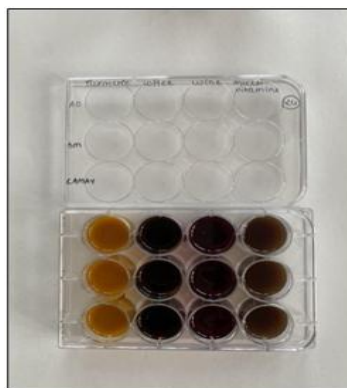


Figure 13: Labeled petri dish with solutions

A sterile 12 well petri dish was taken and labelled for the solutions as shown in Figure 13. Each column of the petri dish was suggestive of four main groups i.e. turmeric, coffee, red wine and multivitamins. The solutions are divided into three equal parts (10 ml each) and poured into the respective wells. Each row was allotted to the three subgroups i.e. American Orthodontics, Ormco (symetri clear) and Galaxy (Camay). Five brackets of each were immersed in all four solutions, and kept at room temperature for 24 hours.

Brackets were then taken out from the solutions carefully, washed with drinking mineral water for 10 minutes, and dried.

Microscopic slides are taken and labelled with the bracket brand and solution names. Dried brackets are then carefully secured on the labelled slides with cyanoacrylate adhesive. Discolouration of brackets were recorded at T1 using the same Spectrophotometer.

Following testing, the brackets were once more taken off the microscopic slides, and any leftover adhesive was wiped off. All the brackets were put back according to the brand names in the same solutions as before and was kept at the room temperature for 72 hours. After 72 hours, brackets were removed, cleaned for 10 minutes with mineral water, and dried. With the help of cyanoacrylate adhesive, brackets were attached to the previously labelled microscopic slides, and T2 final discolourations values were recorded using the same spectrophotometer.

Spectrophotometer assessment

CIE lab system was given by Commission Internationale de l'Eclairage in 1976. A colour graph consisting of L^* , a^* , and b^* co-ordinates can be made by means of mathematical calculations. Parameter L^* denotes the

degree of darkness and lightness and a^* and b^* values to chroma. DE^* between two colour positions in the three-dimensional $L^*a^*b^*$ colour space calculated as follows:

$$\Delta E^* = [(L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2]^{1/2}$$

$\Delta E1 = T1 - T0$ (Discolouration after 24 hours)

$\Delta E2 = T2 - T0$ (Discolouration after 72 hours)

Result

Table 1: Paired T sample test for Turmeric solution

	Mean	N	SD	Std. Error Mean	Mean Difference	P Value
Ao E1(T1-T0)	3.39	5	0.011	0.005	0.664	0.000
Ao E2(T2-T0)	4.05	5	0.007	0.003		
Ormco E1(T1-T0)	7.83	5	0.007	0.003	3.452	0.000
Ormco E2(T2-T0)	11.28	5	0.004	0.002		
Galaxy E1(T1-T0)	17.48	5	0.004	0.002	1.672	0.000
Galaxy E2(T2-T0)	19.15	5	0.009	0.004		

E1=colour changes after 24 hours and E2=Colour changes after 72 hours

Graph 1: Mean values for turmeric solution

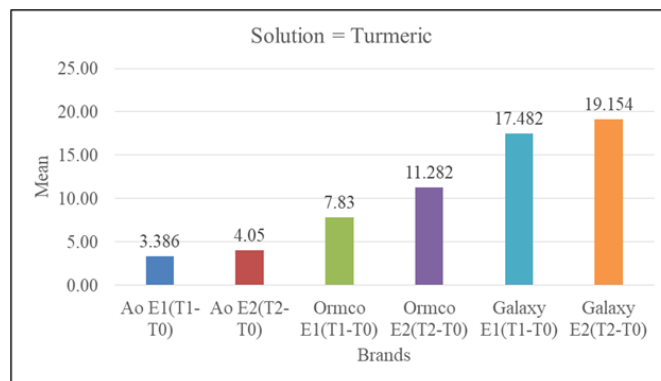
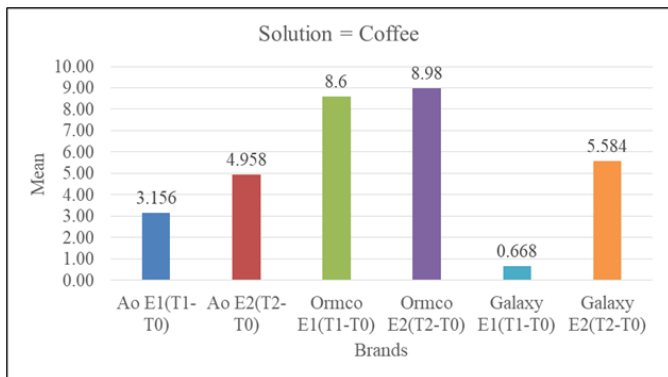


Table 2: Paired T sample test for Coffee solution

	Mean	N	SD	Std. Error Mean	Mean Difference	P Value
Ao E1(T1-T0)	3.16	5	0.005	0.002	1.802	0.000
Ao E2(T2-T0)	4.96	5	0.004	0.002		
Ormco E1(T1-T0)	8.60	5	0.071	0.032	0.380	0.000
Ormco E2(T2-T0)	8.98	5	0.000	0.000		
Galaxy E1(T1-T0)	0.67	5	0.004	0.002	4.916	0.000
Galaxy E2(T2-T0)	5.58	5	0.009	0.004		

E1=colour changes after 24 hours and E2=colourchanges after 72 hours

Graph 2: Mean values for coffee solution



E1=colour changes after 24 hours and E2=colour changes after 72 hours

Graph 4: Mean values for Multi-vitamin solution

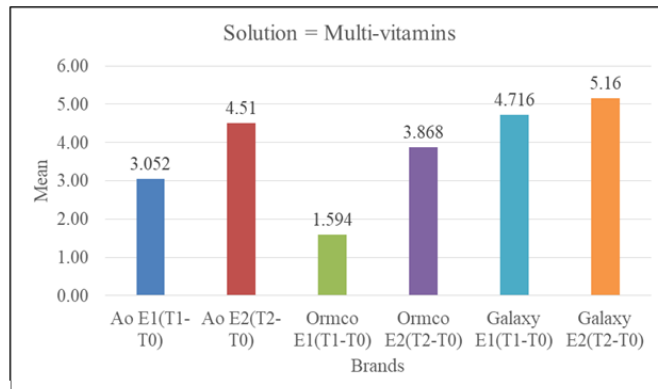


Table 3: Paired T sample test for Red wine solution

	Mean	N	SD	Std. Error Mean	Mean Difference	P Value
Ao E1(T1-T0)	3.05	5	0.004	0.002	1.458	0.000
Ao E2(T2-T0)	4.51	5	0.000	0.000		
Ormco E1(T1-T0)	1.59	5	0.009	0.004	2.274	0.000
Ormco E2(T2-T0)	3.87	5	0.004	0.002		
Galaxy E1(T1-T0)	4.72	5	0.005	0.002	0.444	0.000
Galaxy E2(T2-T0)	5.16	5	0.007	0.003		

E1=colour changes after 24 hours and E2=colour changes after 72 hours

Graph 3: Mean values for Red wine solution

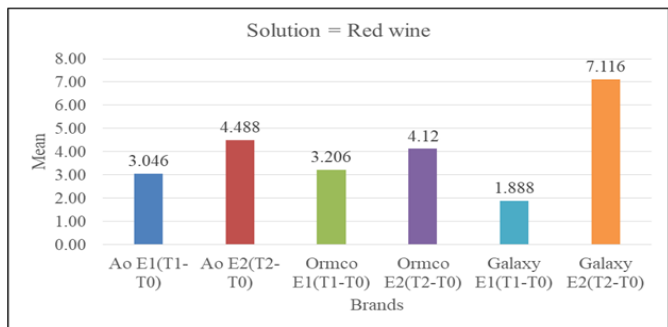


Table 4: Paired T sample test for Multi-vitamins solution

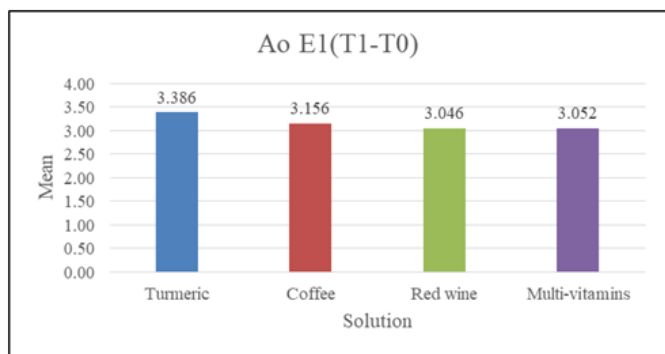
	Mean	N	SD	Std. Error Mean	Mean Difference	P Value
Ao E1(T1-T0)	3.05	5	0.005	0.002	1.442	0.000
Ao E2(T2-T0)	4.49	5	0.004	0.002		
Ormco E1(T1-T0)	3.21	5	0.005	0.002	0.914	0.000
Ormco E2(T2-T0)	4.12	5	0.000	0.000		
Galaxy E1(T1-T0)	1.89	5	0.004	0.002	5.228	0.000
Galaxy E2(T2-T0)	7.12	5	0.005	0.002		

Table 5: One way ANOVA for American Orthodontics

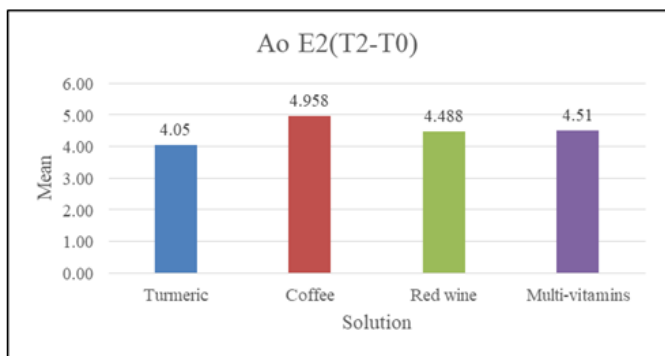
		N	Mean	SD	SE	95% Confidence Interval for Mean			
						Lower Bound	Upper Bound	Min	Maxi
Ao E1(T1-T0)	Turmeric	5	3.39	0.01	0.01	3.37	3.40	3.37	3.40
	Coffee	5	3.16	0.01	0.00	3.15	3.16	3.15	3.16
	Red wine	5	3.05	0.01	0.00	3.04	3.05	3.04	3.05
	Multi-vitamins	5	3.05	0.00	0.00	3.05	3.06	3.05	3.06
	Total	20	3.16	0.14	0.03	3.09	3.23	3.04	3.40
Ao E2(T2-T0)	Turmeric	5	4.05	0.01	0.00	4.04	4.06	4.04	4.06
	Coffee	5	4.96	0.00	0.00	4.95	4.96	4.95	4.96
	Red wine	5	4.49	0.00	0.00	4.48	4.49	4.48	4.49
	Multi-vitamins	5	4.51	0.00	0.00	4.51	4.51	4.51	4.51
	Total	20	4.50	0.33	0.07	4.35	4.66	4.04	4.96
Ao DIFF	Turmeric	5	0.66	0.01	0.01	0.65	0.68	0.65	0.68
	Coffee	5	1.80	0.00	0.00	1.80	1.81	1.80	1.81
	Red wine	5	1.44	0.00	0.00	1.44	1.45	1.44	1.45
	Multi-vitamins	5	1.46	0.00	0.00	1.45	1.46	1.45	1.46
	Total	20	1.34	0.43	0.10	1.14	1.54	0.65	1.81

E1=colour changes after 24 hours and E2=colour changes after 72 hours

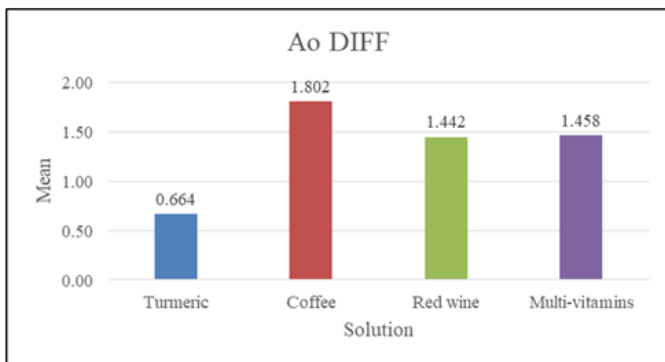
Graph 5: One way ANOVA for E1 for American Orthodontics



Graph 6: One way ANOVA for E2 for American Orthodontics



Graph 7: One way ANOVA for DIFF for American Orthodontics



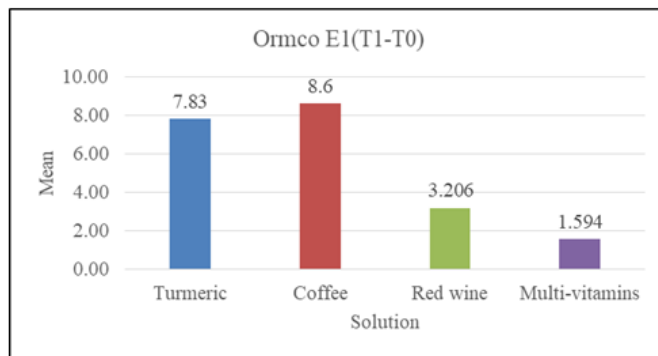
E1=Colour changes after 24 hours and E2=Colour change after 72 hours

Table 6: One way ANOVA for Ormco (symetri clear)

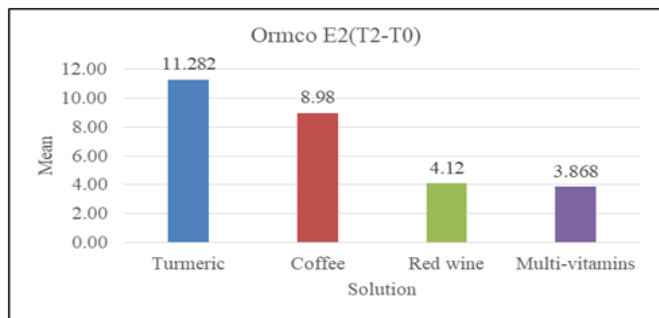
	N	Mean	SD	SE	95% Confidence Interval for Mean			
					Lower Bound	Upper Bound	Min	Maxi
Turmeric	5	7.83	0.01	0.00	7.82	7.84	7.82	7.84
Coffee	5	8.60	0.07	0.03	8.51	8.69	8.50	8.70
Red wine	5	3.21	0.01	0.00	3.20	3.21	3.20	3.21
Multi-vitamins	5	1.59	0.01	0.00	1.58	1.61	1.59	1.61
Total	20	5.31	3.05	0.68	3.88	6.74	1.59	8.70
Turmeric	5	11.28	0.00	0.00	11.28	11.29	11.28	11.29
Coffee	5	8.98	0.00	0.00	8.98	8.98	8.98	8.98
Red wine	5	4.12	0.00	0.00	4.12	4.12	4.12	4.12
Multi-vitamins	5	3.87	0.00	0.00	3.86	3.87	3.86	3.87
Total	20	7.06	3.26	0.73	5.54	8.59	3.86	11.29
Turmeric	5	3.45	0.01	0.00	3.44	3.46	3.44	3.46
Coffee	5	0.38	0.07	0.03	0.29	0.47	0.28	0.48
Red wine	5	0.91	0.01	0.00	0.91	0.92	0.91	0.92
Multi-vitamins	5	2.27	0.01	0.00	2.26	2.29	2.26	2.28
Total	20	1.76	1.23	0.28	1.18	2.33	0.28	3.46

E1=colour changes after 24 hours and E2=colourchanges after 72 hours

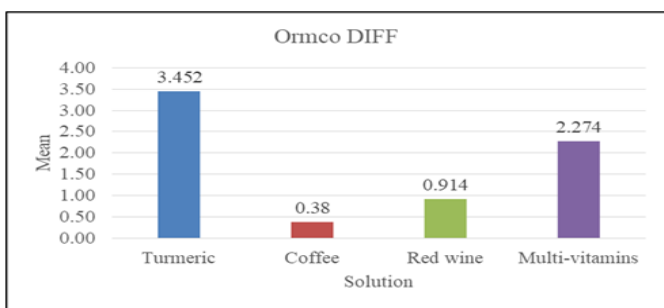
Graph 8: One way ANOVA for E1 for Ormco (symetri clear)



Graph 9: One way ANOVA for E2 for Ormco (symetri clear)



Graph 10: One way ANOVA for DIFF for Ormco (symetri clear)



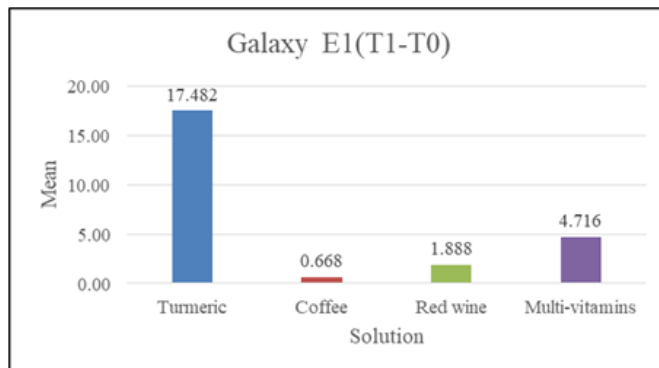
E1=colour changes after 24 hours and E2=colour changes after 72 hours

Table 7: One way ANOVA for Galaxy (Camay)

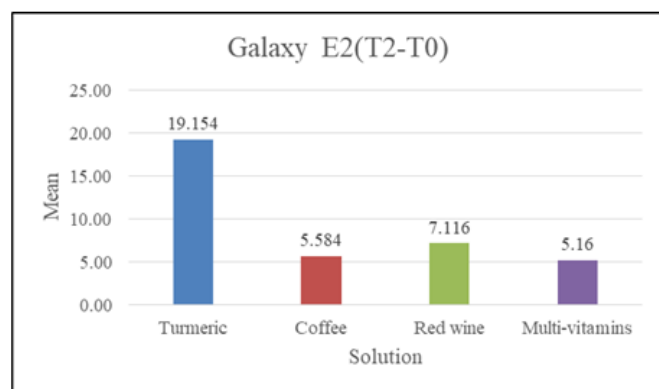
		N	Mean	SD	SE	95% Confidence Interval for Mean			
						Lower Bound	Upper Bound	Min	Maxi
Galaxy E1(T1-T0)	Turmeric	5	17.48	0.00	0.00	17.48	17.49	17.48	17.49
	Coffee	5	0.67	0.00	0.00	0.66	0.67	0.66	0.67
	Red wine	5	1.89	0.00	0.00	1.88	1.89	1.88	1.89
	Multi-vitamins	5	4.72	0.01	0.00	4.71	4.72	4.71	4.72
	Total	20	6.19	6.86	1.53	2.98	9.40	0.66	17.49
Galaxy E2(T2-T0)	Turmeric	5	19.15	0.01	0.00	19.14	19.17	19.14	19.16
	Coffee	5	5.58	0.01	0.00	5.57	5.60	5.58	5.60
	Red wine	5	7.12	0.01	0.00	7.11	7.12	7.11	7.12
	Multi-vitamins	5	5.16	0.01	0.00	5.15	5.17	5.15	5.17
	Total	20	9.25	5.91	1.32	6.49	12.02	5.15	19.16
Galaxy DIFF	Turmeric	5	1.67	0.01	0.00	1.66	1.68	1.66	1.68
	Coffee	5	4.92	0.01	0.00	4.90	4.93	4.91	4.93
	Red wine	5	5.23	0.00	0.00	5.22	5.23	5.22	5.23
	Multi-vitamins	5	0.44	0.01	0.00	0.44	0.45	0.44	0.45
	Total	20	3.07	2.11	0.47	2.08	4.05	0.44	5.23

E1=colour changes after 24 hours and E2=colour changes after 72 hours

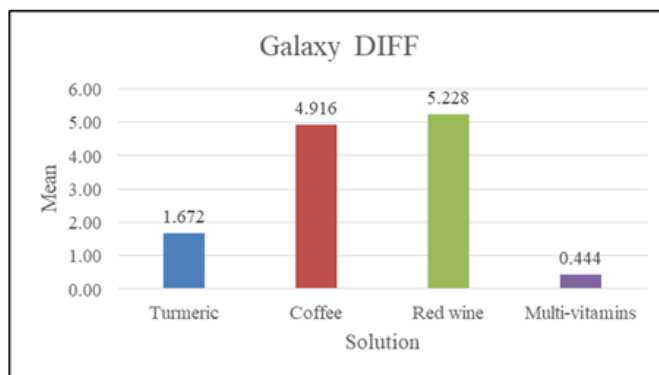
Graph 11: One way ANOVA for E1 for Galaxy (Camay)



Graph 12: One way ANOVA for E2 for Galaxy (Camay)



Graph 13: One way ANOVA for DIFF for Galaxy (Camay)



E1=colour changes after 24 hours and E2=colour changes after 72 hours

Table 8: ANOVA between groups and within groups for American Orthodontics

		Sum of Squares	df	Mean Square	F	Anova P Value
T0)	Between Groups	0.379	3	0.126	2404.825	0.000
	Within Groups	0.001	16	0.000		
	Total	0.380	19			
T0)	Between Groups	2.062	3	0.687	30555.481	0.000
	Within Groups	0.000	16	0.000		
	Total	2.063	19			
T0)	Between Groups	3.474	3	1.158	24376.807	0.000
	Within Groups	0.001	16	0.000		
	Total	3.474	19			

Table 9: ANOVA between groups and within groups for Ormco (Symetri clear)

		Sum of Squares	df	Mean Square	F	Anova P Value
T0)	Between Groups	177.050	3	59.017	45749.286	0.000
	Within Groups	0.021	16	0.001		
	Total	177.070	19			
T0)	Between Groups	201.721	3	67.240	6724020.500	0.000
	Within Groups	0.000	16	0.000		
	Total	201.721	19			
T0)	Between Groups	28.735	3	9.578	7396.494	0.000
	Within Groups	0.021	16	0.001		
	Total	28.756	19			

Table 10: ANOVA between groups and within groups for Galaxy (Camay)

		Sum of Squares	df	Mean Square	F	Anova P Value
T0)	Between Groups	893.408	3	297.803	13235675.481	0.000
	Within Groups	0.000	16	0.000		
	Total	893.408	19			
T0)	Between Groups	664.054	3	221.351	3689188.306	0.000
	Within Groups	0.001	16	0.000		
	Total	664.055	19			
T0)	Between Groups	84.574	3	28.191	563828.667	0.000
	Within Groups	0.001	16	0.000		
	Total	84.575	19			

E1=Colour changes after 24 hours and E2=Colour changes after 72 hours

Table 11: Post Hoc analysis for American Orthodontics at E1

Dependent Variable	(I-J)	Std. Error	Sig.	95% Confidence Interval			
				Lower Bound	Upper Bound		
Ao	Turmeric	Coffee	.23000*	0.00458	0.000	0.2169	0.2431
	E1	Red wine	.34000*	0.00458	0.000	0.3269	0.3531
		Multi-vitamins	.33400*	0.00458	0.000	0.3209	0.3471
Coffee	Turmeric	Red wine	-.23000*	0.00458	0.000	-0.2431	-0.2169
	E1	Red wine	.11000*	0.00458	0.000	0.0969	0.1231
		Multi-vitamins	.10400*	0.00458	0.000	0.0909	0.1171
Red wine	Turmeric	Coffee	-.34000*	0.00458	0.000	-0.3531	-0.3269
	E1	Red wine	-.11000*	0.00458	0.000	-0.1231	-0.0969
		Multi-vitamins	-0.00600	0.00458	0.570	-0.0191	0.0071
Multi-vitamins	Turmeric	Coffee	-.33400*	0.00458	0.000	-0.3471	-0.3209
	E1	Red wine	-.10400*	0.00458	0.000	-0.1171	-0.0909
		Red wine	0.00600	0.00458	0.570	-0.0071	0.0191

Mean Difference = I-J

E1=Colour changes after 24 hours and E2=Colour change after 72 hours

Table 12: PostHoc analysis for American Orthodontics at E2

Dependent Variable	(I-J)	Std. Error	Sig.	95% Confidence Interval			
				Lower Bound	Upper Bound		
Ao	Turmeric	Coffee	-.90800*	0.00300	0.000	-0.9166	-0.8994
	E2	Red wine	-.43800*	0.00300	0.000	-0.4466	-0.4294
		Multi-vitamins	-.46000*	0.00300	0.000	-0.4686	-0.4514
Coffee	Turmeric	Red wine	.90800*	0.00300	0.000	0.8994	0.9166
	E2	Red wine	.47000*	0.00300	0.000	0.4614	0.4786
		Multi-vitamins	.44800*	0.00300	0.000	0.4394	0.4566
Red wine	Turmeric	Coffee	-.43800*	0.00300	0.000	-0.4294	-0.4466
	E2	Red wine	-.47000*	0.00300	0.000	-0.4786	-0.4614
		Multi-vitamins	-.02200*	0.00300	0.000	-0.0306	-0.0134
Multi-vitamins	Turmeric	Coffee	.46000*	0.00300	0.000	0.4514	0.4686
	E2	Red wine	-.44800*	0.00300	0.000	-0.4566	-0.4394
		Red wine	.02200*	0.00300	0.000	0.0134	0.0306

Mean Difference = I-J

E1=colour changes after 24 hours and E2=colour changes after 72 hours

Table 13: PostHoc analysis for American Orthodontics DIFF

Dependent Variable	(I-J)	Std. Error	Sig.	95% Confidence Interval			
				Lower Bound	Upper Bound		
Ao	Turmeric	Coffee	-1.13800*	0.00436	0.000	-1.1255	-1.1255
	DIFF	Red wine	-.77800*	0.00436	0.000	-0.7905	-0.7655
		Multi-vitamins	-.79400*	0.00436	0.000	-0.8065	-0.7815
Coffee	Turmeric	Red wine	1.13800*	0.00436	0.000	1.1255	1.1505
	E1	Red wine	.36000*	0.00436	0.000	0.3475	0.3725
		Multi-vitamins	.34400*	0.00436	0.000	0.3315	0.3565
Red wine	Turmeric	Coffee	.77800*	0.00436	0.000	0.7655	0.7905
	E1	Red wine	-.36000*	0.00436	0.000	-0.3725	-0.3475
		Multi-vitamins	-.01600*	0.00436	0.010	-0.0285	-0.0035
Multi-vitamins	Turmeric	Coffee	.79400*	0.00436	0.000	0.7815	0.8065
	E1	Red wine	-.34400*	0.00436	0.000	-0.3565	-0.3315
		Red wine	.01600*	0.00436	0.010	0.0035	0.0285

Mean Difference = I-J

E1=Colour changes after 24 hours and E2=Colour change after 72 hours

Table 14: Post Hoc analysis for Ormco (symetri clear) at E1

Dependent Variable	(I-J)	Std. Error	Sig.	95% Confidence Interval			
				Lower Bound	Upper Bound		
Ormco	Turmeric	Coffee	-.77000*	0.02272	0.000	-0.8350	-0.7050
	E1	Red wine	4.62400*	0.02272	0.000	4.5590	4.6890
		Multi-vitamins	6.23600*	0.02272	0.000	6.1710	6.3010
Coffee	Turmeric	Red wine	.77000*	0.02272	0.000	0.7050	0.8350
	E1	Red wine	5.39400*	0.02272	0.000	5.3290	5.4590
		Multi-vitamins	7.00600*	0.02272	0.000	6.9410	7.0710
Red wine	Turmeric	Coffee	-4.62400*	0.02272	0.000	-4.6890	-4.5590
	E1	Red wine	-5.39400*	0.02272	0.000	-5.4590	-5.3290
		Multi-vitamins	1.61200*	0.02272	0.000	1.5470	1.6770
Multi-vitamins	Turmeric	Coffee	-6.23600*	0.02272	0.000	-6.3010	-6.1710
	E1	Red wine	-7.00600*	0.02272	0.000	-7.0710	-6.9410
		Red wine	-1.61200*	0.02272	0.000	-1.6770	-1.5470

Mean Difference = I-JE1=Colour changes after 24 hours and E2=Colour changes after 72 hours

Table 15: Post Hoc analysis for Ormco (symetri clear) at E2

Dependent Variable			(I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Ormco E2(T2-T0)	Turmeric	Coffee	2.30200*	0.00200	0.000	2.2963	2.3077
		Red wine	7.16200*	0.00200	0.000	7.1563	7.1677
		Multi-vitamins	7.41400*	0.00200	0.000	7.4083	7.4197
Coffee	Turmeric	-2.30200*	0.00200	0.000	-2.3077	-2.2963	
	Red wine	4.86000*	0.00200	0.000	4.8543	4.8657	
	Multi-vitamins	5.11200*	0.00200	0.000	5.1063	5.1177	
Red wine	Turmeric	-7.16200*	0.00200	0.000	-7.1677	-7.1563	
	Coffee	-4.86000*	0.00200	0.000	-4.8657	-4.8543	
	Multi-vitamins	-2.52000*	0.00200	0.000	0.2463	0.2577	
Multi-vitamins	Turmeric	-7.41400*	0.00200	0.000	-7.4197	-7.4083	
	Coffee	-5.11200*	0.00200	0.000	-5.1177	-5.1063	
	Red wine	-2.52000*	0.00200	0.000	-0.2577	-0.2463	

Mean Difference = I-J

E1=colour changes after 24 hours and E2=colour changes after 72 hours

Table 16: Post Hoc analysis for Ormco (symetri clear) DIFF

Dependent Variable			(I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Ormco DIFF	Turmeric	Coffee	3.07200*	0.02276	0.000	3.0069	3.1371
		Red wine	2.53800*	0.02276	0.000	2.4729	2.6031
		Multi-vitamins	1.17800*	0.02276	0.000	1.1129	1.2431
Coffee	Turmeric	-3.07200*	0.02276	0.000	-3.1371	-3.0069	
	Red wine	-.53400*	0.02276	0.000	-0.5991	-0.4689	
	Multi-vitamins	-1.89400*	0.02276	0.000	-1.9591	-1.8289	
Red wine	Turmeric	-2.53800*	0.02276	0.000	-2.6031	-2.4729	
	Coffee	.53400*	0.02276	0.000	0.4689	0.5991	
	Multi-vitamins	-1.36000*	0.02276	0.000	-1.4251	-1.2949	
Multi-vitamins	Turmeric	-1.17800*	0.02276	0.000	-1.2431	-1.1129	
	Coffee	1.89400*	0.02276	0.000	1.8289	1.9591	
	Red wine	1.36000*	0.02276	0.000	1.2949	1.4251	

Mean Difference = I-J

E1=colour changes after 24 hours and E2=colourchanges after 72 hours.

Table 17: Post Hoc analysis for Galaxy (Camay) at E1

Dependent Variable			(I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Galaxy E	Turmeric	Coffee	16.81400*	0.00300	0.000	16.8054	16.8226
		Red wine	15.59400*	0.00300	0.000	15.5854	15.6026
		Multi-vitamins	12.76600*	0.00300	0.000	12.7574	12.7746
Coffee	Turmeric	-16.81400*	0.00300	0.000	-16.8226	-16.8054	
	Red wine	-1.22000*	0.00300	0.000	-1.2286	-1.2114	
	Multi-vitamins	-4.04800*	0.00300	0.000	-4.0566	-4.0394	
Red wine	Turmeric	-15.59400*	0.00300	0.000	-15.6026	-15.5854	
	Coffee	1.22000*	0.00300	0.000	1.2114	1.2286	
	Multi-vitamins	-2.82800*	0.00300	0.000	-2.8366	-2.8194	
Multi-vitamins	Turmeric	-12.76600*	0.00300	0.000	-12.7746	-12.7574	
	Coffee	4.04800*	0.00300	0.000	4.0394	4.0566	
	Red wine	2.82800*	0.00300	0.000	2.8194	2.8366	

Mean Difference = I-J

E1=colour changes after 24 hours and E2=colourchanges after 72 hours

Table 18: PostHoc analysis for Galaxy (Camay) at E2

Dependent Variable			(I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Galaxy E2	Turmeric	Coffee	13.57000*	0.00490	0.000	13.5560	13.5840
		Red wine	12.03800*	0.00490	0.000	12.0240	12.0520
		Multi-vitamins	13.99400*	0.00490	0.000	13.9800	14.0080
Coffee	Turmeric	-13.57000*	0.00490	0.000	-13.5840	-13.5560	
	Red wine	-1.53200*	0.00490	0.000	-1.5460	-1.5180	
	Multi-vitamins	.42400*	0.00490	0.000	0.4100	0.4380	
Red wine	Turmeric	-12.03800*	0.00490	0.000	-12.0520	-12.0240	
	Coffee	1.53200*	0.00490	0.000	1.5180	1.5460	
	Multi-vitamins	1.95600*	0.00490	0.000	1.9420	1.9700	
Multi-vitamins	Turmeric	-13.99400*	0.00490	0.000	-14.0080	-13.9800	
	Coffee	-.42400*	0.00490	0.000	-0.4380	-0.4100	
	Red wine	-1.95600*	0.00490	0.000	-1.9700	-1.9420	

Mean Difference = I-J

E1=colour changes after 24 hours and E2=colourchanges after 72 hours

Table 19: Post Hoc analysis for Galaxy (Camay) DIFF

Dependent Variable			(I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Galaxy DIFF	Turmeric	Coffee	-3.24400*	0.00447	0.000	-3.2568	-3.2312
		Red wine	-3.55600*	0.00447	0.000	-3.5688	-3.5432
		Multi-vitamins	1.22800*	0.00447	0.000	1.2152	1.2408
Coffee	Turmeric	3.24400*	0.00447	0.000	3.2312	3.2568	
	Red wine	-.31200*	0.00447	0.000	-0.3248	-0.2992	
	Multi-vitamins	4.47200*	0.00447	0.000	4.4592	4.4848	
Red wine	Turmeric	3.55600*	0.00447	0.000	3.5432	3.5688	
	Coffee	.31200*	0.00447	0.000	0.2992	0.3248	
	Multi-vitamins	4.78400*	0.00447	0.000	4.7712	4.7968	
Multi-vitamins	Turmeric	-1.22800*	0.00447	0.000	-1.2408	-1.2152	
	Coffee	-4.47200*	0.00447	0.000	-4.4848	-4.4592	
	Red wine	-4.78400*	0.00447	0.000	-4.7968	-4.7712	

Mean Difference = I-J E1=Colour changes after 24 hours and E2=Colour change after 72 hours.

Discussion

The need for a beautiful appearance after and during treatment with fixed orthodontic appliances has significantly increased. This led to the development of various esthetically superior appliances. Tooth coloured brackets includes plastic, composite, ceramic, zirconium, polycarbonates etc.¹² The superior esthetics of ceramic brackets compared to conventional stainless steel brackets is well accepted by the patient, particularly adults. Even though the ceramic brackets satisfied the esthetic needs of the patient, there was a drawback that these ceramic brackets undergo staining over a period of time. According to Axante et al. 9 and Faltermier et al. 3, external discolouration of the ceramic brackets is caused by food solutions and mouth rinses. The composition, structure, and water absorption of the ceramic brackets are among internal elements that can cause discolouration. Faltermier et al. and Arthur et al. discovered that a variety of factors, including the type of staining solution, the structure and makeup of the brackets, oral hygiene, and water absorption, can affect how much the colour of the aesthetic brackets changes. The purpose of the present in vitro study was to check the colour stability of ceramic brackets of different brands namely American Orthodontics, Ormco (symetri clear) and Galaxy (Camay) in different solutions. To evaluate the colour changes of ceramic brackets many authors have used different solutions. Yadav et al 1 Filho et al⁷ and Kannan et al¹⁰ used common beverages like black tea, coffee and coke. Wried et al⁴ used orange juice, red wine and curry. Tangjit et al ¹³ took yellow curry and green curry for testing. Since turmeric is more frequently used in Indian

cuisine, it is used in the present in vitro study. Red wine and multivitamin syrup were used as an immersion medium as more adults seek orthodontic treatment. Duration for the study was three days and colour changes were recorded after two time intervals that is 24 hours and 72 hours. Olivera et al² immersed the brackets for 21 days in the staining solutions. Faltermier et al³ investigated the colour stability after the immersing the brackets for about 72 hours. Wried et al⁴ checked the colour changes after 5 days and Kannan et al¹⁰ immersed the brackets for about 6 days. For the assessment of the colour changes different methods can be used such as Colorimeter, Spectrophotometer, digital analysis, visual assessments etc. Yadav et al¹, Olivera et al², Faltermier et al³, lee et al⁶ and Kannan et al¹⁰ used CIELAB scale colorimeter to evaluate colour changes. Akyalcin et al ⁹ analysed the staining of the brackets using digital analysis. Johnston¹⁶ by using the clinical colorimetry and visual assessment evaluated the colour of the restorations. Mancuso et al¹⁷ used the visual assessment to determine the colour stability. Lee et al¹⁸ evaluated esthetic brackets with spectroradiometer. As CIELAB method is widely used and reliable, Data color 550 Spectrophotometer is used in this study to check the colour changes occurring after one day and three days. The collected data was analyzed by using SPSS software Version 20. Paired T sample test for all the four solutions was done. Overall comparisons between three different groups were established using ANOVA (one-way analysis of variance) with a P value of less than 0.05. Further analysis was done using Tukey's posthoc test to compare between individual groups. The results demonstrated that there was statistically significant difference.

Table 1 shows mean difference among all three brands between E1 and E2 in turmeric solution. P value (<0.05) shows statistically significant difference. Graph 1 is a bar diagram of mean values for three brands showing the highest staining in Galaxy (Camay) brackets after 24 hours and 72 hours. Ormco (symetri clear) and American Orthodontic brackets shows lesser staining respectively.

Similarly, Table 2 and Graph 2 shows mean values for coffee solution. P value is showing significant difference and Ormco (symetri clear) brackets shows highest staining when immersed in coffee after both the time intervals. American Orthodontics exhibits more staining than Galaxy (Camay) after 24 hours (E1), while after 72 hours, Galaxy (Camay) exhibits greater discolouration.

Mean values for Red wine is demonstrated in Table 3 and Graph 3 and it is showing the highest staining in Galaxy (Camay) brackets at E2. In first 24 hours staining was more with Ormco (symetri clear) brackets compared to American Orthodontics brackets but in later hours American orthodontics brackets shows more discolourations.

For multivitamin syrup, the P value indicates statistically significant difference. As indicated in Table 4 and Graph 4, the Galaxy (Camay) brackets at E2, had the maximum discolouration, followed by American Orthodontics brackets and Ormco (symetri clear) brackets. After 24 hours, Ormco (Symetri Clear) Brackets show the least discolouration.

Table 5, 6 and 7 shows One way ANOVA for American Orthodontics, Ormco (symetri clear) and Galaxy (Camay).

According to Graph 5 American orthodontics brackets are stained the most by turmeric solution at E1 and red wine and multi-vitamins staining is equal and the least.

Whereas after 72 hours coffee staining is the highest which is seen Graph 6.

With coffee, Ormco (symetri clear) brackets get more discolouration after 24 hours and in later hours brackets are stained more with turmeric. This is represented by Graph 8 and 9 respectively.

Galaxy (Camay) brackets exhibit the greatest degree of discolouration with turmeric solution after the two time periods, as indicated in graphs 11 and 12. Interestingly, out of all the solutions and brands, coffee exhibits the least discolouration with Galaxy (Camay) brackets after 24 hours.

Table 8,9 and 10 demonstrates ANOVA within the groups and between the groups for American Orthodontics, Ormco (symetri clear) and Galaxy (Camay) respectively showing the P value 0.00 which is statistically significant.

Table 11–13 illustrates the comparison between the groups for American orthodontics using post hoc analysis. Post hoc analysis was performed for Ormco (Symetri Clear) and Galaxy (Camay), as shown in tables 14–16 and 17–19, respectively.

Olivera et al² and Hussain et al¹² showed that monocryalline ceramic brackets produced least staining whereas Guignone et al¹¹ showed that monocryalline ceramic brackets showed more staining. Yadav et al¹, Hussian et al¹² compared the brackets made of different materials such as plastic, composite, monocryalline, polycryalline, polycarbonate and zirconium. The results of the study showed that monocryalline type of ceramic brackets showed least staining which explains that the material of the bracket do influence the stain uptake. Olivera et al², Faltermier et al³, Wried et al⁴, lee et al⁶, Kannan et al¹⁰ concluded that there was gradual increase in the stain uptake with increase in the time of

immersion which is in accordance with the present study. This explains how the duration of immersion affects the degree of staining.

Olivera et al², Faltermier et al³, Wried et al⁴, Lee et al⁶, Kannan et al¹⁰ and Tangjit et al¹³ concluded that coffee as the staining solution produced greater degree of discolouration which is similar to present study. Red wine was identified by Faltermier et al.³ as a potential staining agent, which is consistent with the current results. Two additional solutions - turmeric solution and multivitamin - that have never been compared before have been added to the present study. Among all the other solutions, turmeric caused the most discolouration. Three brands—American Orthodontics, Ormco (Symetri Clear) and Galaxy (Camay)—have been compared in the current study. After three days, Galaxy (Camay), one of the three brands, displayed the most discolouration in all the solutions. Even though turmeric is the most potent staining solution, American Orthodontics brackets showed the least amount of discolouration when exposed to it.

Conclusion

An in-vitro study was done using ceramic brackets of three various manufacturer (i.e. American Orthodontics, Ormco (symetri clear) and Galaxy (Camay)) and immersing them into four different potentially staining solutions such as turmeric, coffee, red wine and multi-vitamin syrup to evaluate the colour stability of the brackets with the Spectrophotometer. The results were obtained using the Datacolor 550 spectrophotometer after 24 hours and 72 hours. The results showed that the brackets take up greater degree of staining when immersed and there is a gradual increase in the discolouration as the time progresses.

The Spectrophotometer result showed the greater

amount of discolouration after 72 hours (E2) than 24 hours (E1).

Turmeric stained the Galaxy (Camay) brackets more and American orthodontic brackets the least after 24 and 72 hours.

Similarly, Coffee showed the highest staining with the Ormco (symetri clear) brackets and least with the Galaxy (Camay) brackets after both the time intervals.

Red wine discolouration is seen the highest with Ormco (symetri clear) brackets and the least with Galaxy (Camay) after 24 hours but after 72 hours Galaxy (Camay) shows greater amount of stain uptake.

With multi-vitamin syrup, Galaxy (Camay) gives the maximum staining whereas Ormco (symetri clear) gives the minimum staining after first time interval and also at the end of the study.

According to the results, maximum increase in the mean values is seen in the turmeric solution and mean value are minimum for the multi-vitamin syrup. Concluding that the turmeric is the most potent staining solution and multi-vitamin is the least.

After 24 hours, American Orthodontic brackets show greater discolouration with turmeric but at the end of 72 hours coffee shows the highest staining. In contrast, coffee shows greater staining in first 24 hours with Ormco (symetri clear) but in the later hours staining is more with turmeric solution. Galaxy (Camay) brackets are stained the most by turmeric solution.

According to the mean values stated with the help of Spectrophotometer, American orthodontics shows the least values suggesting greater colour stability against the staining solutions. On the other hand, Galaxy (Camay) brackets shows greater mean values which depicts otherwise.

However, other in-vitro studies are recommended and also more in-vivo studies should be carried out to find the colour stability of ceramic brackets in the optimum oral environment.

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