

Comparison of Color Stability of Ceramic Brackets When Exposed To Potentially Staining Solutions

¹Dr. Jithesh Kumar, Professor and Head, Mahe Institute of dental Sciences and Hospital, Pondicherry

²Dr.Thomas Kutty Alex, Senior Lecturer, Mahe Institute of dental Sciences and Hospital, Pondicherry

³Dr.Aswin.A, Post Graduate student, Mahe Institute of Dental Sciences and Hospital, Pondicherry

⁴Dr. Suresh Babu, Professor, Mahe Institute of dental Sciences and Hospital, Pondicherry

⁴Dr. Panjami Marish, Reader, Mahe Institute of dental Sciences and Hospital, Pondicherry

⁵Dr.Divya Chandrasekaran, Post Graduate student, Mahe Institute of Dental Sciences and Hospital, Pondicherry

Corresponding Author: Dr.Aswin.A, Post Graduate student, Mahe Institute of Dental Sciences and Hospital, Pondicherry

Citation of this Article: Dr. Jithesh Kumar, Dr.Thomas Kutty Alex, Dr. Aswin.A, Dr. Suresh Babu, Dr. Panjami Marish, Dr.Divya Chandrasekaran,“ Comparison of Color Stability of Ceramic Brackets When Exposed To Potentially Staining Solutions”, IJDSIR- February - 2021, Vol. – 4, Issue - 1, P. No. 188 -200.

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Characteristics of an orthodontic appliance include good esthetics and optimal technical performance. There are intrinsic and extrinsic stains which is responsible for the color change of orthodontic ceramic bracket.

Aim and objectives: To evaluate the color stability of ceramic bracket exposed to various potentially staining solutions. To analyze the color stability of four brands of ceramic brackets exposed to various potentially staining solutions.

Materials and methods

- 160 ceramic brackets used, 40 AO, 40 3M, 40 ORMCO, 40 GAC
- Staining solution were used packed drinking water, turmeric solution, tea, coca cola. Each bracket

dipped in their respective solution and analyzed for color change during interval of 1 day (24 hrs), 3 days (72 hrs) and 6 days (144 hrs) respectively and the color the measurements are made using spectrophotometer.

Results: AO bracket was found to be most stable followed by ORMCO, 3M and GAC respectively.

Conclusion: From this present study it can be concluded that most potentially staining solution are turmeric solution, followed by Tea, then coke and the least is the packaged drinking water. While when comparing the color stability of ceramic bracket, the least color changes as occurred in American orthodontics ceramic brackets(E=3.78) followed ORMCO brackets(E=3.99),3M Unitek(E=4.31) GAC brackets showed the highest color changes (E=5.01).

Keywords: ORMCO, GAC, Color Stability

Introduction

Characteristic of an ideal orthodontic appliance include good esthetics and optimum technical performance. Since there is an increase in the number of adult orthodontic patients who are opting various esthetically superior appliances, ceramic brackets were introduced to orthodontic specialty in 1986 and since then have become a vital part of the orthodontists' armamentarium. The rate of acceptance by the patients, particularly adults, over the superior esthetics of ceramic brackets are greater when compared to the conventional stainless steel brackets¹. The two primary types of esthetic brackets are the ceramic and the plastic brackets. Since the damage to the enamel were higher with the use of ceramic brackets, the plastic brackets have become more popularized in early 1990s²

Other than the safer removal, the plastic bracket shows various disadvantages during clinical usage. These can be summarized in color changes, structural or hardness derangements and morphological disturbances. Some of these problems also concern ceramic brackets³.

Bracket staining is related to its time of immersion in various solutions. Any observable color change was detected and recorded⁵. The main concern for patients as well as clinicians was the color stability of these esthetic brackets. There are two types of stains internal (Endogenous) and external (Exogenous)⁶. The external discoloration is mainly due to color dyes such as food dyes, tea stains, coffee, Colored mouth rinses, etc. The extent of external discoloration depends on the structure of the material, filler content and the surface roughness⁷. Internal discoloration is nothing but the discoloration which is built into the material or inside⁸.

To attain a good esthetic appearance, the color and fluorescence of the non translucent brackets need to be similar to the underlying tooth, whereas the translucency of the translucent brackets should be higher to allow the

color and fluorescence of the tooth to pass through them. However, it is essential that both have good color stability⁹. Even though the ceramic bracket shows superior esthetics when compared to the metal brackets, it is not color stable for long term. Some studies suggest that substances containing pigments which are commonly found in food and drinks in the oral environment alters the color of these brackets¹⁰.

In the present study the food articles, turmeric, tea and coffee were included to see their effect on the color of denture base material. There are related studies but unlike other food, turmeric powder being an essential ingredient commonly used as a coloring and flavoring agent in many Asian cuisines, especially for curries, as well as for dyeing. The curcumin in turmeric has proven, strong anti inflammatory and antioxidant properties. Its effect would be more relevant while studying the ceramic brackets used by most of the laboratories in India

Aim and Objectives

Aim: To evaluate the color stability of ceramic brackets exposed to various potentially staining solutions.

Objectives

1. To analyze the color stability of four brands of ceramic brackets exposed to various potentially staining solutions.
2. To compare the color stability of four brands of ceramic brackets exposed to various potentially staining solutions.

Materials and Methodology

A total 160 aesthetic brackets for central incisors had been used. MBT 0.022 slot type of different brands listed in the table have been utilized for this study. These brackets have been divided into four groups according to their manufacture name.

The ceramic brackets used in this study are monocrystalline in nature.

GROUP 1:40 ceramic brackets of AMERICAN ORTHODONTICS

GROUP 2:40 ceramic brackets of 3M UNITEK

GROUP 3:40 ceramic brackets of ORMCO

GROUP 4:40 ceramic brackets of GAC

Solutions: Four solutions have been used as they are most widely used in daily life,

1. Packaged drinking water as control
2. Tea (Brooke bond)
3. Cold drink (Coca Cola)
4. Turmeric solution

The staining solutions have been prepared in the following concentrations:

1. Tea (Brooke Bond, India)¹¹

To prepare the tea solution 2.8 g of tea was added to 150 ml of boiled distilled water.

2. Coca-Cola (Hindustan Coca-Cola, India)

3. Turmeric solution (Eastern condiments Ltd, India)

To prepare the turmeric solution 0.5g of turmeric has been added to 150 ml of distilled water.

4. Artificial saliva¹¹

The artificial saliva has been prepared in the laboratory from 0.4 g Sodium chloride (NaCl), 1.21 g Potassium chloride (KCl), 0.78 g Sodium dihydrogen phosphate dehydrate (NaH₂PO₄·2H₂O), 0.005 g Hydrated sodium sulphide (Na₂S·9H₂O), 1g Urea CO (NH₂)₂ and 1000ml of deionized water. 10N Sodium hydroxide has been added to this mixture until the pH value has been measured at 6.75±0.15. This mixture is sterilized by autoclave.

Total Samples = 160	Packaged Drinking Water (330 ml) Artificial Saliva (660ml) [10]	Tea (330 ml) Artificial Saliva (660ml) [10]	Coca-Cola (330 ml) Artificial Saliva (660ml) [10]	Turmeric Solution (330 ml) Artificial Saliva (660ml) [10]
Group 1: Ceramic Bracket AMERICAN RTHODONTICS[40]	1a	1b	1c	1d
Group 2: Ceramic Bracket 3M UNITEK [40]	2a	2b	2c	2d
Group 3: Ceramic Bracket ORMCO [40]	3a	3b	3c	3d
Group 4: Ceramic Bracket GAC [40]	4a	4b	4c	4d



Figure 1: Brackets in Coca Cola

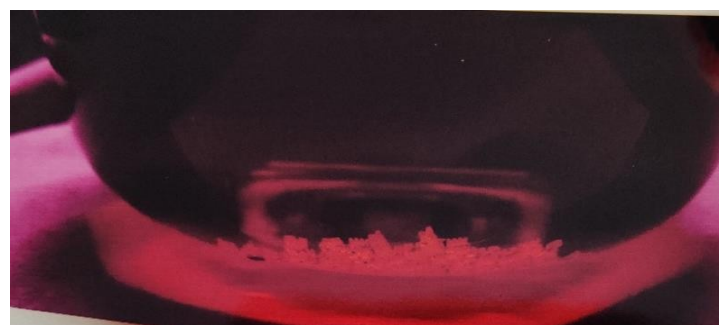


Figure 2: Brackets in Tea



Figure 3: Brackets in Drinking Water



Figure 4: Brackets in Turmeric Solution



Figure 5: Porcelain Stand

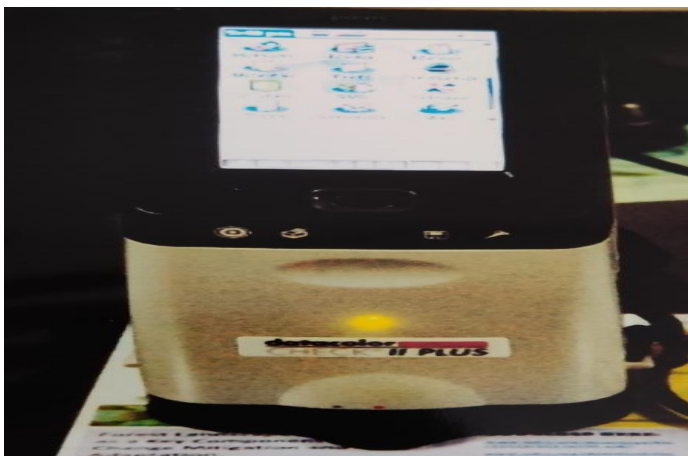


Figure 6: Spectrophotomete

For the control or base value, each bracket group has been analyzed for its original color value at 0-day interval, before it has been immersed into the solution. The values are recorded and standard values are taken for the further comparison with the experimental group.

Four customized porcelain stand with desired slot size of each bracket type has been utilized to fit the brackets in them. This also has served the purpose of no external light gets interfered during analysis and reading. Each bracket has been dipped in their respective solutions and analyzed for the color changes during the time interval of 1 day (24 hrs), 3 days (72 hrs) and 6 days(144hrs) respectively.¹²

For analyzing the samples at the determined time interval, the brackets from each subgroup has been taken out of the solution and rinsed for 20 minutes with deionized water to remove the excessive stains followed by grabbing it in filter paper to dry them. This procedure is carried out in each subgroup in the study. The color measurements are made using spectrophotometer.

Color measurements of ceramic brackets obtained from the spectrophotometer are subjected to statistical analysis, to find the significant difference in color stability between various groups and to correlate the clinical significance.

Results

All the ceramic brackets immersed in Packaged drinking water, Tea, cola, Turmeric solution with artificial saliva showed color changes. Mean, standard deviation and test of significance of mean values of color change between different subgroups for Group I (AMERICAN ORTHODONTICS), Group II (3M UNITEK), Group III (ORMCO) and Group IV (GAC) are shown in [Tables 2–5] respectively. Analysis of variance is used to generate the test for significance (p) value which is < 0.001 .

American Orthodontics Ceramic Bracket was found to be the most color stable followed by ORMCO, 3M Unitek and GAC. All the ceramic brackets showed clinically

acceptable color change with all staining solutions over 144 hours of period. The staining solution with maximum staining potential was turmeric solution with artificial saliva followed by tea diluted with artificial saliva and cola diluted with artificial saliva and the least stain is packed drinking water diluted with artificial saliva at all time intervals.

The highest color change occurred with turmeric solution (d group) in all the brands at the end of 144 hours. The mean value with least change in turmeric solution is American orthodontic bracket with E=3.78, second least is ORMCO bracket E=3.99 followed by 3M Unitek of E=4.31 and the highest change was recorded by GAC bracket with E=5.01. The second most common stain solution was in tea (b group) in end of 144 hours. The

highest E=4.76 value which is recorded under GAC brackets which is highly susceptible to stain. The least was recorded by American orthodontic bracket with E=2.47, followed by ORMCO E=2.89 and 3M Unitek E=3.01

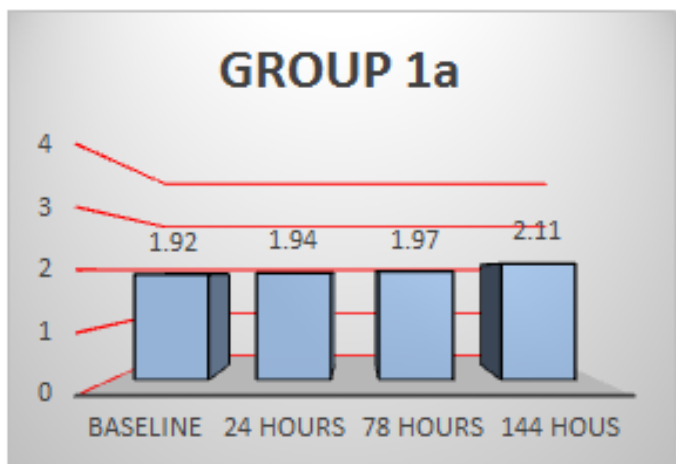
The third common stain solution was Coco-Cola (in C group) in end of 144 hours. The highest E=3.45 value was recorded in GAC brackets. The least was recorded by American orthodontic bracket with E=2.31, while the 3M Unitek E=2.89 and ORMCO E=2.81 values respectively.

The fourth solution was packed water (A group) in the end of 144 hours. As the hours increases the base value also drastically increased the highest value was recorded by GAC with E=2.95 value. The least was recorded by American orthodontic bracket E=2.01, followed by ORMCO with E=2.30 and 3M Unitek E=2.91

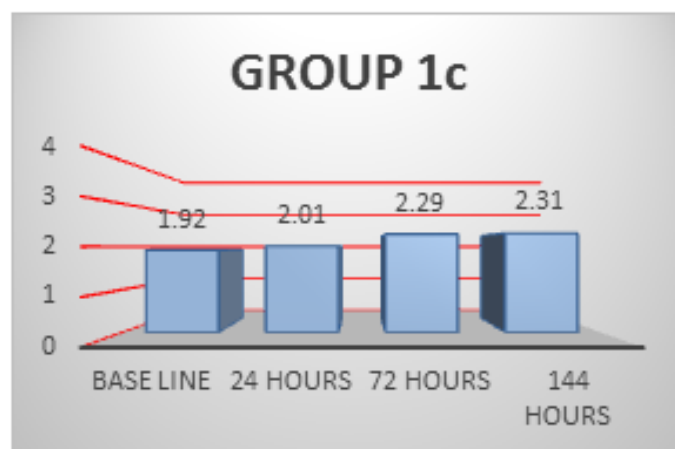
Table 2: Group 1 Ceramic Bracket AMERICAN ORTHODONTICS Intra-Group Comparison

Group 1	Time Period		N	Mean	Standard Deviation	p-value
Group 1		Baseline	10	1.92	0.96	–
Group 1a	Baseline	24 Hours	10	1.94	0.31	0.672
		72 Hours	10	1.97	0.23	0.765
		144 Hours	10	2.11	0.61	0.981
Group 1b	Baseline	24 Hours	10	2.31	0.22	0.040*
		72 Hours	10	2.33	0.47	0.022*
		144 Hours	10	2.47	0.29	0.011*
Group 1c	Baseline	24 Hours	10	2.01	0.27	0.023*
		72 Hours	10	2.29	0.19	< 0.001*
		144 Hours	10	2.31	0.21	< 0.001*
Group 1d	Baseline	24 Hours	10	3.31	0.18	0.001*
		72 Hours	10	3.57	0.29	0.002*
		144 Hours	10	3.78	0.37	< 0.001*

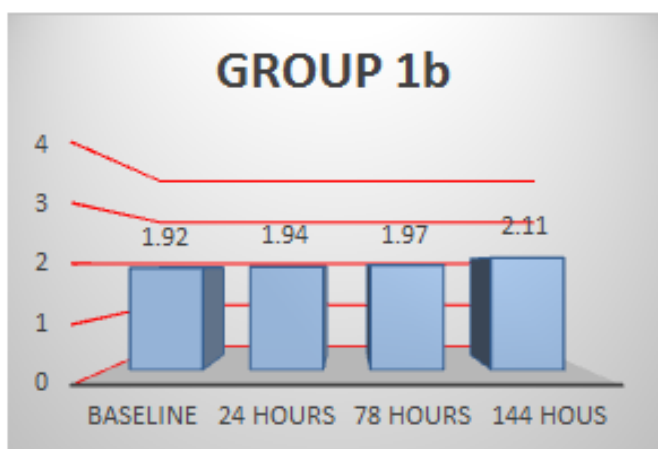
p-value based on ANOVA (Analysis of Variance) after adjusted for multiple comparisons using Bonferonni Correction (Post-hoc analysis) * = Statistically Significant (p < 0.05)



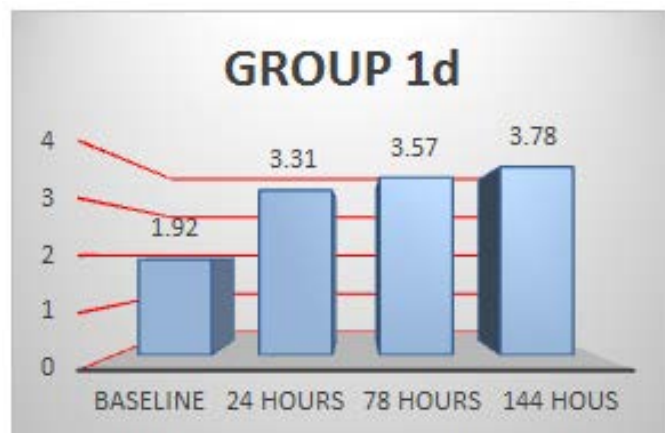
Graph 1: Comparison of colour stability of AMERICAN ORTHODONTIC brackets when placed in packed drinking water in respective hours.



Graph 3: Comparison of colour stability of AMERICAN ORTHODONTIC brackets when placed in Cola in respective hours.



Graph 2: Comparison of colour stability of AMERICAN ORTHODONTIC brackets when placed in tea in respective hours.



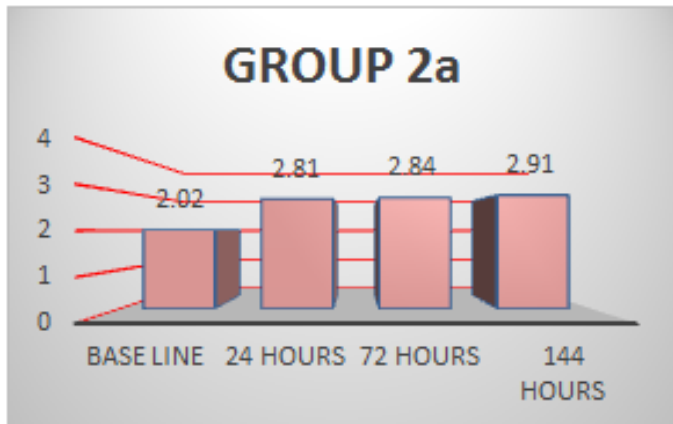
Graph 4: Comparison of colour stability of AMERICAN ORTHODONTIC brackets when placed in turmeric solution in respective hours.

Table 3: Group 2 Ceramic Bracket 3M UNITEK Intra-Group Comparison

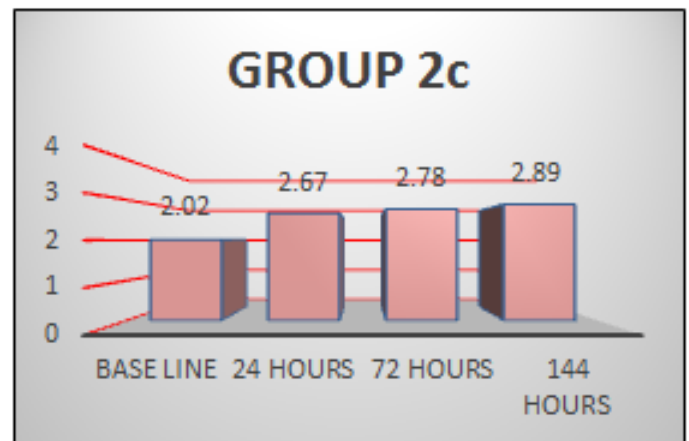
Group 2	Time Period	N	Mean	Standard Deviation	p-value	
Group 2	Baseline	10	2.02	0.73	–	
Group 2a	Baseline	24 Hours	10	2.81	0.79	0.117
		72 Hours	10	2.84	0.80	0.287
		144 Hours	10	2.91	0.99	0.197
Group 2b	Baseline	24 Hours	10	2.56	0.56	< 0.001*
		72 Hours	10	2.73	0.87	< 0.001*
		144 Hours	10	2.89	0.88	< 0.001*
		24 Hours	10	2.67	0.66	< 0.001*

Group 2c	Baseline	72 Hours	10	2.78	0.57	< 0.001*
		144 Hours	10	2.89	0.78	< 0.001*
Group 2d	Baseline	24 Hours	10	3.49	0.45	< 0.001*
		72 Hours	10	3.81	0.66	< 0.001*
		144 Hours	10	4.31	0.36	< 0.001*

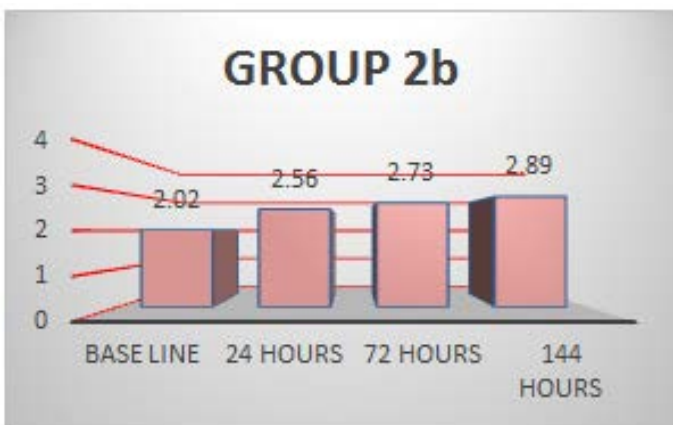
p-value based on ANOVA (Analysis of Variance) after adjusted for multiple comparisons using Bonferonni Correction (Post-hoc analysis) * = Statistically Significant (p < 0.05)



Graph 5: Comparison of colour stability of 3M UNITEKbrackets when placed in Packed drinking water in respective hours.



Graph 7: Comparison of colour stability of 3M UNITEK brackets when placed in Cola in respective hours.



Graph 6: Comparison of colour stability of 3M UNITEKbrackets when placed in Tea in respective hours.

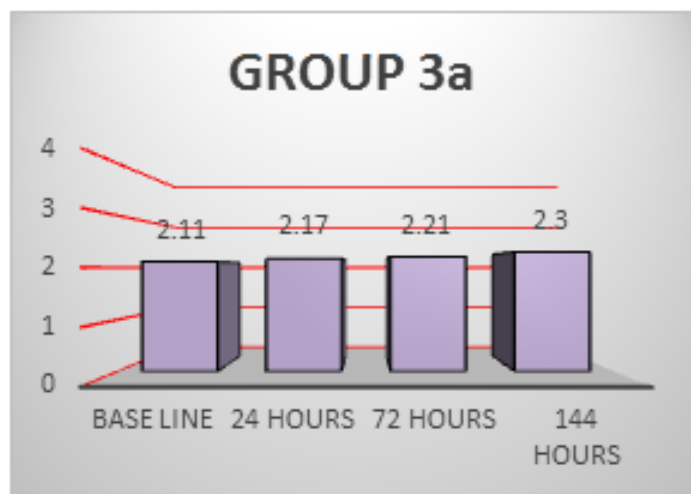


Graph 8: Comparison of colour stability of 3M UNITEKbrackets when placed in turmeric solution in respective hours.

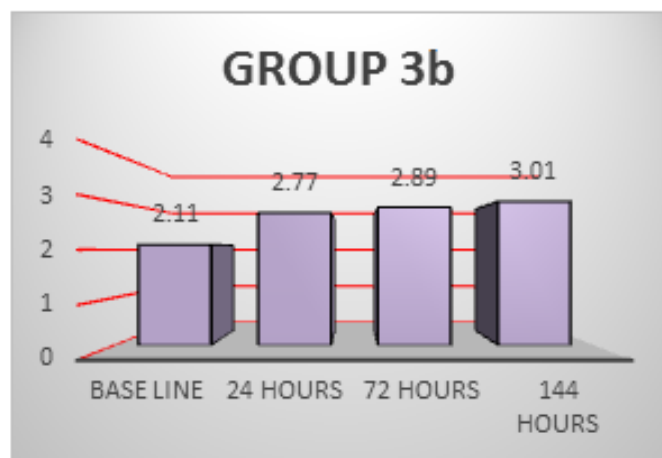
Table 4: Group 3 Ceramic Bracket ORMCO Intra-Group Comparison

Group 3	Time Period	N	Mean	Standard Deviation	p-value	
Group 3	Baseline	10	2.11	0.88	–	
Group 3a	Baseline	24 Hours	10	2.17	0.23	0.111
		72 Hours	10	2.21	0.54	0.120
		144 Hours	10	2.30	0.29	0.119
Group 3b	Baseline	24 Hours	10	2.77	0.65	0.011*
		72 Hours	10	2.89	0.87	0.019*
		144 Hours	10	3.01	0.19	0.020*
Group 3c	Baseline	24 Hours	10	2.67	0.92	0.047*
		72 Hours	10	2.71	0.37	0.032*
		144 Hours	10	2.81	0.29	0.041*
Group 3d	Baseline	24 Hours	10	3.41	0.76	< 0.001*
		72 Hours	10	3.67	0.91	< 0.001*
		144 Hours	10	3.99	0.86	< 0.001*

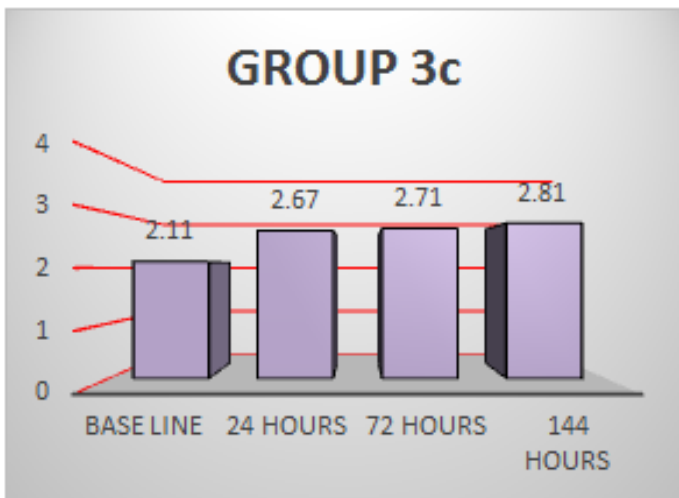
p-value based on ANOVA (Analysis of Variance) after adjusted for multiple comparisons using Bonferonni Correction (Post-hoc analysis) * = Statistically Significant (p < 0.05)



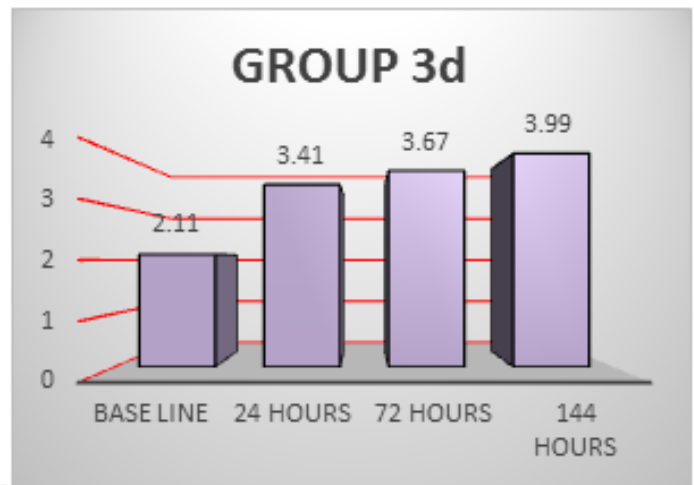
Graph 9: Comparison of colour stability of ORMCO brackets when placed in Packed drinking water in respective hours.



Graph 10: Comparison of colour stability of ORMCO brackets when placed in Tea in respective hours.



Graph 11: Comparison of colour stability of ORMCObrackets when placed in Cola in respective hours.

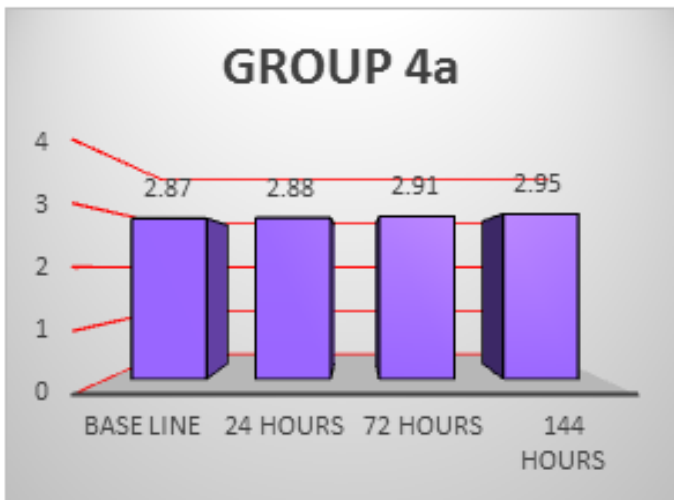


Graph 12: Comparison of colour stability of ORMCO brackets when placed in turmeric solution in respective hours.

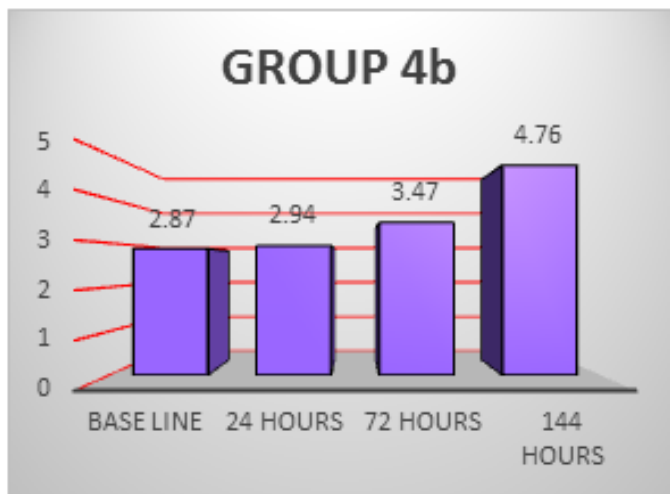
Table 5: Group 4 Ceramic Bracket GAC Intra-Group Comparison

Group 4	Time Period	N	Mean	Standard Deviation	p-value	
Group 4	Baseline	10	2.87	0.56	–	
Group 4a	Baseline	24 Hours	10	2.88	0.51	0.278
		72 Hours	10	2.91	0.29	0.459
		144 Hours	10	2.95	0.49	0.298
Group 4b	Baseline	24 Hours	10	2.78	0.73	0.011*
		72 Hours	10	3.47	0.43	0.025*
		144 Hours	10	4.76	0.54	0.045*
Group 4c	Baseline	24 Hours	10	3.11	0.65	0.039*
		72 Hours	10	3.29	0.29	0.021*
		144 Hours	10	3.45	0.47	< 0.001*
Group 4d	Baseline	24 Hours	10	4.11	0.99	< 0.001*
		72 Hours	10	4.67	0.78	< 0.001*
		144 Hours	10	5.01	0.27	< 0.001*

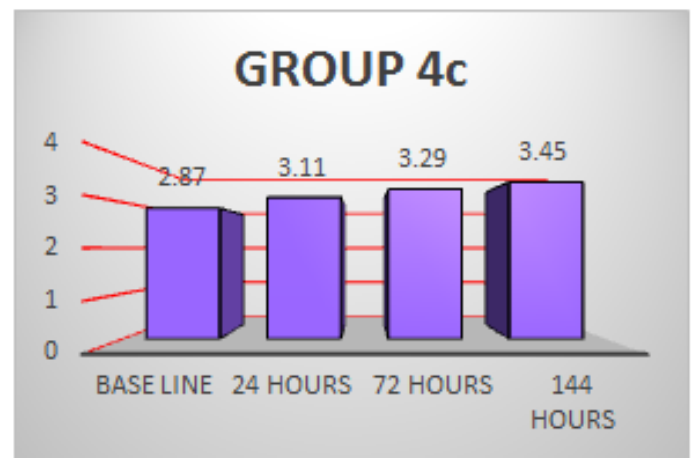
p-value based on ANOVA (Analysis of Variance) after adjusted for multiple comparisons using Bonferonni Correction (Post-hoc analysis)* = Statistically Significant (p < 0.05)



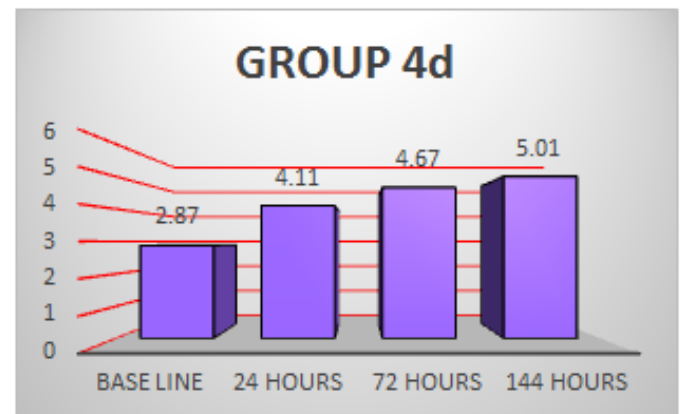
Graph 13: Comparison of colour stability of GAC brackets when placed in Packed drinking water in respective hours.



Graph 14: Comparison of colour stability of GACbrackets when placed in Tea in respective hours.



Graph 15: Comparison of colour stability of GACbrackets when placed in Cola in respective hours.

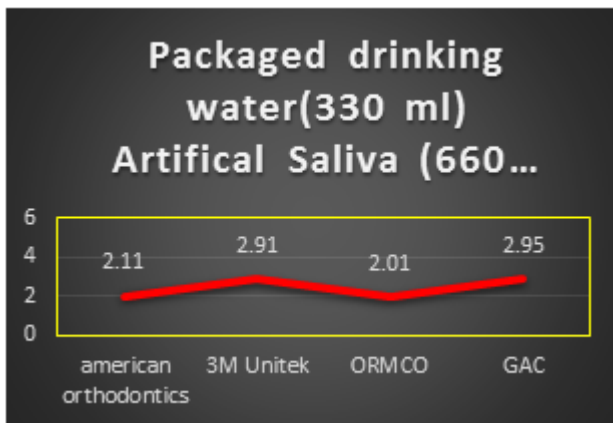


Graph 16: Comparison of colour stability of GACbrackets when placed in turmeric solution in respective hours.

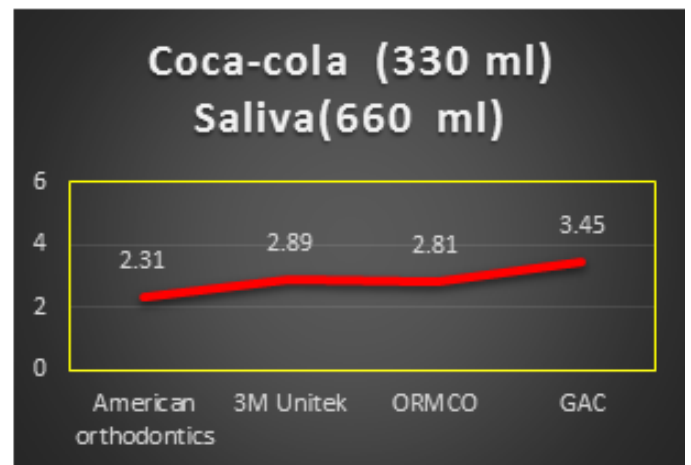
Table 6: Intra-Group Comparison after 144 Hours

Group	Group	N	Mean	Standard Deviation	p-value
Packaged Drinking Water (330 ml) Artificial Saliva (660ml) [Group a]	American Orthodontics	10	2.11	0.61	0.239
	3M UNITEK	10	2.91	0.99	
	ORMCO	10	2.01	0.29	
	GAC	10	2.95	0.49	
Tea (330 ml) Artificial Saliva (660ml) [Group b]	American Orthodontics	10	2.47	0.29	0.027*
	3M UNITEK	10	2.89	0.88	
	ORMCO	10	3.01	0.19	

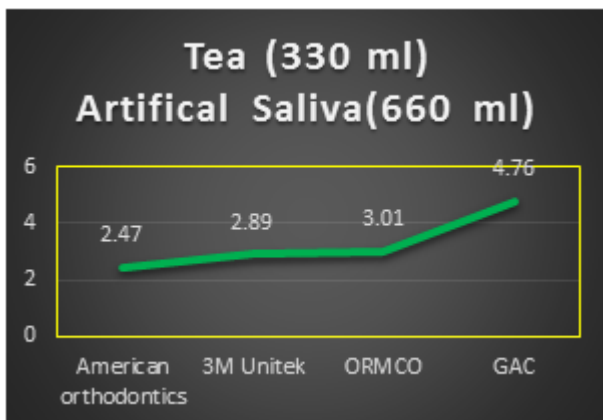
	GAC	10	4.76	0.54	
Coca-Cola (330 ml) Artificial Saliva (660ml) [Group c]	American Orthodontics	10	2.31	0.21	0.042*
	3M UNITEK	10	2.89	0.78	
	ORMCO	10	2.81	0.29	
	GAC	10	3.45	0.47	
Turmeric Solution (330 ml) Artificial Saliva (660ml) [Group d]	American Orthodontics	10	3.78	0.37	0.001*
	3M UNITEK	10	4.31	0.36	
	ORMCO	10	3.99	0.86	
	GAC	10	5.01	0.27	
p-value based on ANOVA (Analysis of Variance) * = Statistically Significant (p < 0.05)					



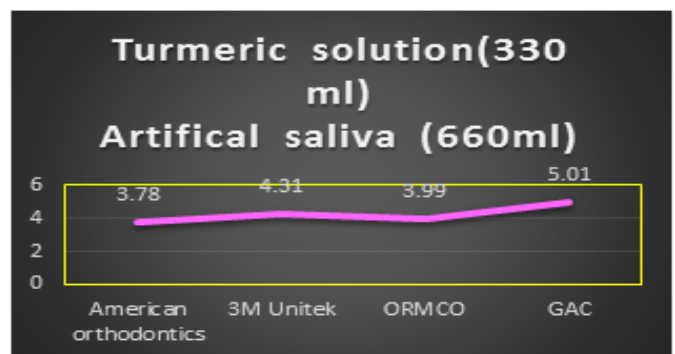
Graph 17: Comparison of various ceramic brackets colour stability in packaged drinking water.



Graph 19: Comparison of various ceramic brackets colour stability in Cola.



Graph 18: Comparison of various ceramic brackets colour stability in Tea.



Graph 20: Comparison of various ceramic brackets colour stability in Turmeric.

Discussion

Growing trend in orthodontics is patient seeking orthodontic treatment with an esthetic approach which is

proved by ceramic brackets¹. Color stability is key parameter in which esthetic is influenced. Any change in the color stability can be examined with spectrometer and colorimeters¹³. Lee¹⁴ in his study found out that the color stability of the ceramic brackets were questionable in long term due to the color changes. Kind of material and crystal structure for ceramic brackets did not influence color stability, but color stability was mainly brand-dependent. Therefore, color stability of esthetic brackets should be considered for their long-term use.

Bishara¹⁵ found that tea, coffee, wine stain the ceramic bracket which alter the color stability. Singh¹⁶ conducted color stability test on denture base using turmeric solution, which is commonly used in India. His results showed that the turmeric solution has highest potential staining solution when compared to the other stain solution such as tea, coffee.

In this present study four groups with four different ceramic brands are used to check the color stability. Four different staining solutions such as packed water, tea, coke, turmeric solution has been used. To check for the long-term stability, they are immersed in the solution for 24 hours, 72 hours and 144 hours respectively. The highest color change occurred with turmeric solution (d group) in all the brands at the end of 144 hours. The mean value with least change in turmeric solution is American orthodontic bracket with $E=3.78$, second least is ORMCO bracket $E=3.99$ followed by 3M Unitek of $E=4.31$ and the highest change was recorded by GAC bracket with $E=5.01$. In orthodontics there are no articles which back up the result, but Gupta¹⁷ in provisional restoration, Singh¹⁶ in denture base in their study found out that the turmeric solution is highly potential stain solution when compared with other common food stain solution such as tea, coffee, coke, etc

The second most common stain solution was in tea (b group) in end of 144 hours. The highest $E=4.76$ value which is recorded under GAC brackets which is highly susceptible to color. The least was recorded by American orthodontic bracket with $E=2.47$, while the 3M Unitek $E=2.89$ and ORMCO $E=3.01$. The previous study conducted by Yadav¹², Oliveira¹⁸ in ceramic brackets found out the tea stain is high when compared to other staining solution (with exception of coffee). Tea has yellow dye, but with different polarities, which differs in their interaction with material surface.

The third common stain solution was Coca-Cola (in C group) in end of 144 hours. The highest $E=3.45$ value was recorded in GAC brackets. The least was recorded by American orthodontic bracket with $E=2.31$, while the 3M Unitek $E=2.89$ and ORMCO $E=2.81$ values respectively. It has been shown that even though Coke has a lower pH value that can damage surface integrity of material, it does not promote clinically significant color changes like coffee and black tea do, possibly due to lack of yellow dye in its constitution.¹⁹

The fourth solution was packed water (A group) in the end of 144 hours. As the hours increase the base value also drastically increased the highest value was recorded by GAC with $E=2.95$ value. The least was recorded by ORMCO with $E=2.01$, while the 3M Unitek $E=2.91$ and American orthodontic bracket $E=2.11$ values respectively.

Conclusion

From this present study it can be concluded that most potentially staining solutions are turmeric solution, followed by Tea, then coke and the least is the packaged drinking water. While when comparing the color stability of ceramic bracket, the least color changes as occurred in American orthodontics ceramic brackets ($E=3.78$) followed by ORMCO brackets ($E=3.99$), 3M Unitek ($E=4.31$) GAC brackets showed the highest color changes ($E=5.01$).

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