Received: 13th August 2015 Accepted: 23th November 2015 Conflicts of Interest: None

Source of Support: Nil

Original Research

Evaluation of Colored Elastomeric Modules for Leaching Properties when Exposed to Various Dietary Media: "An *In Vitro* Study"

S Dhivya Kanya[1], K Pradeep Babu Kommi[2], S Hanumanth[3], M Senthil Kumar[4], A Nanda Kumar[5], Venkatesan[3], Anoop Mathew[3], S. Priya[3], Aniruth Yashwant[3], Arvinth[3]

Contributors:

[1]Post-graduate Student, Department of Orthodontics and Dentofacial Orthopedics, Indira Gandhi Institute of Dental Sciences, Puducherry, India; [2]Reader, Department of Orthodontics and Dentofacial Orthopedics, Indira Gandhi Institute of Dental Sciences, Puducherry, India; [3]Senior Lecturer, Department of Orthodontics and Dentofacial Orthopedics, Indira Gandhi Institute of Dental Sciences, Puducherry, India; [4]Professor, Department of Orthodontics and Dentofacial Orthopedics, Indira Gandhi Institute of Dental Sciences, Puducherry, India; [5]Professor, Department of Orthodontics and Dentofacial Orthopedics, Meenakshi Ammal Denal College, Chennai, Tamil Nadu, India.

Correspondence:

Kanya SD. Department of Orthodontics and Dentofacial Orthopedics, Indira Gandhi Institute of Dental Sciences, Puducherry, India. E-mail: dhivyakanya@gmail.com.

How to cite the article:

Kanya SD, Babu KP, Hanumanth S, Kumar MS, Kumar AN, Venkatesan, Mathew A, Priya S, Aniruth Y, Arvinth. Evaluation of colored elastomeric modules for leaching properties when exposed to various dietary media: "An *in vitro* study." J Int Oral Health 2016;8(1):58-62.

Abstract:

Background: The purpose of the study was to evaluate leaching properties of the colored elastomeric modules when exposed to various dietary media.

Materials and Methods: Sample size was of 160 color modules (red, blue, green, black, 40 each) which were taken to evaluate the leaching properties by immersing in four dietary media (artificial saliva, artificial saliva with coke, artificial saliva with turmeric, and artificial saliva with coffee). After placing the segment of module strip in the beakers containing different dietary media, all the beakers were kept in the incubator at 37°C for 72 h. After 72 h of incubation, all the segment of module strips was removed from the dietary media. Solutions were checked for the leaching of the die from the modules. Fiber optic spectrophotometer was used to check the quantum of color leached from the color elastomeric module.

Results: Statistical results were obtained using ANOVA and *t*-test in SPSS Software. According to the results obtained, all the four colored modules had significantly leached out in various quantities when it was exposed to dietary media. Black and blue leached more while green leached less in the all the dietary media.

Conclusion: The purpose of the study was to identify the materials which were least vulnerable to changes when exposed to different media. Green color module leached the least than other color module in the dietary medium with blue and black leaching more.

Key Words: Colors, leaching, modules

Introduction

Orthodontic treatment has become one of the essential procedures as increased incidence of orthodontic treatment was noticed in the past few decades. This may be due to the increased demand of esthetics which can be attributed to the social consciousness. The concern for esthetics was not only for post-treatment but also on a course of treatment; this was because of increased in adult orthodontic patients. Children undergoing orthodontic treatment were also more demanding as they should be constantly motivated. Some orthodontists utilize modules for motivation as they come in different colors, which give an esthetic appeal.

The introduction of esthetic colored elastomeric modules started after the advent of polyurethane material[3]. Modules were the elastomeric material which had been widely used in orthodontics to engage wire in the bracket slot. Placement of modules was less time consuming and appealing to the patient.

Even though the quality of these materials was completely tested prior to the clinical use, orthodontists had found that some of these products have numerous changes in their properties when exposed to the oral environment[1]. As these tests were done in western conditions, in India the dietary intake was completely different from those conditions, so we need to evaluate the physical and structural properties. Mainly the property of polyurethane had become the important challenge when it was exposed to various dietary media.[5] The most menacing and important problem encountered with patients seeking treatment with the color modules were a change in color during the course of treatment and very rarely dye allergies.

This study was to evaluate four (blue, black, green and red from American Orthodontics company) color modules in different dietary media. Quantum of die was being leached out from the color modules had to be assessed after exposing the color modules to the dietary medium.[8]

Aim

The aim of the study was to evaluate the leaching properties of different color elastomeric modules by subjecting them in different dietary media such as artificial saliva, artificial saliva mixed with coke, artificial saliva mixed with turmeric and

artificial saliva mixed with coffee and the objective of the study was to access the quantum of color leached from the color modules when immersed in various dietary media.

Materials and Methods

All the four dietary media were divided into four parts (25 ml for each color modules) and each part is stored in separate 50 ml beaker for four different color modules. Four different color modules were procured, those were blue, black, green and red from AO of 40 each and these were immersed in four different dietary media such as artificial saliva, artificial saliva mixed with coke, artificial saliva mixed with turmeric and artificial saliva mixed with coffee.

Incubator power was on and the temperature was set as 37°C. Samples were not placed inside until the fluctuation of the temperature in digital display freeze to 37°C. After placing the segment of module strip in the beakers containing different dietary media, all the beakers were kept in the incubator at 37°C for 72 h.[9]

After 72 h of incubation, all the segment of module strips was removed from the dietary media. Solutions were checked for the leaching of die from the modules. Fiber optic spectrophotometer was used to evaluate the quantum of color leached from the module.

Results

The result of this study showed significant difference in artificial saliva value among blue, black, green and red. Four different color modules were placed in the artificial salivary medium in 37°C for 72 h. Each color modules were placed in separate container. L* (clarity), a* and b* (chromaticity) are getting leached out from the color modules had a statistical significant difference in the medium of artificial saliva. More amount of clarity was in green color modules (102.8) [Table 1]. The color of the module which leached out more amount of a* (red and green) was black color modules (10.9) when placed in artificial salivary medium [Table 2]. b* (blue and yellow) was leached out more from red color modules (2.8) [Table 3].

Significant difference exists in the amount of color leached out from the four color modules when immersed in the artificial salivary medium mixed with coke. Black color modules (92.7) in this medium had more amount of clarity (L*) compared to other color modules [Table 1]. An equal amount of a* and b* was leached out from blue color modules (20.4), this amount of leached color was comparatively more than the color leached from other color modules in the medium of coke with artificial saliva [Tables 2 and 3].

The medium which contain turmeric with artificial saliva gave a statistical significant difference between the amounts of color getting leached out from four different color modules. Increased amount of clarity was from blue color modules (99.7) compared to other three color modules [Table 1]. Black color modules (8.5) leached more amount of a* (red and green) [Table 2]. The modules which leached more amount of b* in the medium of turmeric mixed with artificial saliva was a green color module (11.6) [Table 1].

There was significant difference exists between the leaching properties of the four color modules when placed in an artificial salivary medium with coffee. More amount of clarity (L*) was from red color modules in this medium (54.1) [Table 1]. The amount of a* from leached from green color module (32.8) was more than other color modules [Table 2]. b* leached from blue color module (−0.4) was exaggerated when compared to other three color modules [Table 3].

Discussion

The leaching properties of the colored elastomeric modules were evaluated by spectrophotometry when the light passed through the medium or solution. In this analysis, there were two parameters such as clarity and chromaticity. L* represents clarity and a* and b* represents chromaticity. In a*, the intensity of green, red color and their combination were analyzed. In b*, it was the intensity of blue color, yellow color or their combinations were analyzed.

Various dietary media used in this study was artificial saliva (50 ml), artificial saliva with coke (50 ml of coke mixed with 50 ml artificial saliva), artificial saliva with turmeric (1 g of turmeric mixed with 50 ml of artificial saliva), and artificial saliva with coffee (1 g of coffee powder mixed with 50 ml of artificial saliva). Coke was taken as one of the

Table 1: Mean value of L* of all four color modules in various dietary media.

L*	Black	Blue	Green	Red
Artificial saliva	101.8	101.3	102.8	101.2
Coke with artificial saliva	92.7	82.1	87.9	92
Turmeric with artificial saliva	98	99.7	94.4	80.4
Coffee with artificial saliva	48.5	54.2	42.9	54.1

Table 2: Mean value of a* of all four color modules in various dietary media.

a*	Black	Blue	Green	Red
Artificial saliva	10.9	10.7	10.9	10.9
Coke with artificial saliva	10.1	20.4	14.9	11.1
Turmeric with artificial saliva	8.5	3.9	6.4	8.3
Coffee with artificial saliva	32.7	32.1	32.8	31.7

Table 3: Mean value of b* of all four color modules in various dietary media.

b*	Black	Blue	Green	Red
Artificial saliva	0.4	−0.8	2.7	2.8
Coke with artificial saliva	11.6	20.1	18	12.8
Turmeric with artificial saliva	9.2	10.2	11.6	2.1
Coffee with artificial saliva	−8.4	−0.4	−15.3	−0.37

dietary media to check the effect of pH on the elastomeric rings. The primary ingredients of coke includes high fructose syrup or sucrose derived from cane sugar, caramel color, caffeine, phosphoric acid, coca extract, lime extract, vanilla, and glycerin. Coke used in this study was tested for the pH and it was 2.5.

With a color meter, we could obtain numerical color data in various color spaces. In spectrophotometer for measurement, not only numerical data, but also spectral reflectance graph for that color could be obtained. Further with its high precision sensor and the inclusion of data for a variety of illumination condition, a spectrophotometer could provide numerical color data using various light sources.

The method for expressing color numerically was developed by as international organization concerned with light and color, the Commiddion International of the Eclairage (CIE). The two most widely known of these methods was the Yxy color space, devised 1931 based on the tristimulus values XYZ defined by CIE, and the L*, a*, b* color space, devised in 1976 to provide more uniform color differences in relation to visual differences. After various improvements, color spaces such as these are now used throughout the world for color communication.[7]

In CIE 2000, color difference formula was not an attempt to build a color space in which the widths of the color discrimination threshold of the human eye was uniform, instead, it defines a calculation so that the color difference calculated by color meters becomes close to the color discrimination threshold of the human eye on the solid color space of CIE Lab (L*, a*, b* color space). The calculation incorporates the characteristics of the human eye on the color space.[7]

Artificial salivary medium with a green color module had more clarity (L*) (102.84) than other three artificial salivary medium. Since the artificial salivary medium with green color modules show high intensity of clarity, this color module had least leaching property. The amount of clarity (L*) was reduced in the artificial salivary medium with black color module (101.84) compared to the medium with green color module. Blue color modules (101.35) in this medium gave less clarity (L*) compared to this medium with black color modules and green color modules. Medium with red color modules (101.20) gave out least clarity compared to other artificial salivary medium with other three color modules.

The amount of clarity (L*) in the coke mixed with artificial salivary medium was analyzed. In this medium, black color module (92.7) gave more amount of clarity compared to other three medium. Quantity of clarity (L*) from the medium with red color module (92.04) was less than medium with black color modules. Compared to medium with red color modules and black color modules, green color modules (87.9) medium showed less amount of clarity. Clarity from the medium with red color module was more than the medium which had blue color modules (82.1) in it. More amount of clarity was in the medium of artificial saliva with coke in which black color modules were placed. This shows that leaching of black color module in this medium was considerably reduced. Blue color module medium had least amount of clarity compared to other medium with color module. Ardeshna and Vaidyanathan in Journal of Orthodontics in 2009 suggested that cola had a reduced effect on discoloration particularly on the black color module.[9]

In the medium of turmeric powder with artificial saliva, blue color module (99.7) had more amount of clarity (L*) compared to other medium. The second highest amount of clarity was from the turmeric with artificial salivary medium with black color module (98.01). Medium with blue color modules and black color module was followed by medium with green color module (94.4) in the amount of clarity (L*). Red color module in this medium (80.4), less amount clarity was in the medium with red color module comparatively. Blue color module had more clarity in this medium. For the patients with blue color modules, addition of turmeric to the diet could be advised. Red color modules had least amount of clarity when exposed to this medium.

Quantity of clarity (L*) from different color modules in coffee mixed with artificial salivary medium is analyzed. More amount of clarity (L*) was from the medium with blue color module (54.2), followed by the medium with red color modules (54.1). Black color module medium (48.5) had less amount of clarity (L*) compared with red color modules and blue color module medium. Least amount of clarity (L*) was from the medium with green color modules (42.9) than other medium. Ardeshna and Vaidyanathan in Journal of Orthodontics in 2009 suggested visual darkening of the blue color modules.[9]

Chromaticity analyses was done on the dietary medium for assessing a* and b*. a* (red and green) was analyzed in the leaching property of color modules in various dietary media. In artificial salivary medium, black color modules, green color modules and red color modules leached equal amount (10.9) of a*. Amount of a* leaching was more reduced in blue color modules (10.7) compared to other artificial salivary medium.

When color modules were immersed in the coke mixed with artificial salivary medium for chromaticity analysis, the color modules leached a* in specific quantity. More quantity of a* was leached from the blue color module (20.1) in this medium. Patients with blue color modules should be advised to reduce the intake of coke in their diet. The amount of a* leached from blue color modules was followed by green color module (14.9). Compared to green color module and blue color module, red color module (11.1) leached less amount of a*. Black color modules (10.1) leached least amount of a*, when exposed to

this medium than other medium. Leandro Tiexiera *et al.*, in the journal of contemporary dental practice 2008 analyzed the properties of coke on elastomeric modules.[4]

Quantity a* was leached out from color modules when these were exposed to the medium of turmeric with artificial saliva was analyzed. Black color modules (8.5) leached more amount of a* compared to other three color modules in this medium. When the patient prefers black color modules, dentist could advise the patient to avoid or reduce the frequent consumption of turmeric in the diet. Compared to black color modules, red color modules (8.3) leached less amount of a*. Green color module (6.1) in this medium leached less amount of a* compared to red color modules and black color modules in this medium. a* was released in less amount in blue color modules (3.9) compared to other three color modules in this medium.

Coffee with artificial saliva was another medium in which the red and green (a*) color leaching was measured. Black color modules (32.7) releases comparatively more amount of a*. Frequency of coffee intake could be reduced by the patients with back color modules. Black color module was followed by blue color module (32.1) to release less amount of a* in this medium. Green color module releases (31.8) less amount of a* compared to blue and black color modules in this medium. While comparing the leaching of a* among all the color modules, red color (31.7) leached less amount of a*. Ardeshna and Vaidyanathan in Journal of Orthodontics in 2009 analyzed that black color module showed slight changes in the medium of coffee.[9]

Assessment of chromaticity for b* (blue and yellow) color leaching. In artificial salivary medium, red color module (2.8) leached more amount of b* compared to other color modules in the artificial salivary medium. Green color modules leached (2.7) less amount of b* compared to red color modules. Less amount of b* was leached from black color modules (0.4) than the medium with red color modules and green color modules. Comparatively least amount of b* was leached from blue color (−0.8) modules in this medium.

Medium of coke with artificial saliva was analyzed to detect for the amount of b* leached from the color modules. Blue color module (20.1) leached more quantity of b* when compared to other color modules in this medium. When patient prefer blue color modules, dentist could advise the patient to reduce the intake of coke in their diet. In the amount of b* leaching was less in green color modules (18) compared to blue color modules. Next higher amount of b* was from red color module (12.8) and least amount of b* was released from black color modules (11.6). Leandro Tiexiera *et al.*, in the journal of contemporary dental practice 2008 assessed the influence of coke to alter the property of elastomeric modules.[4]

Turmeric with artificial saliva was another medium to find the amount of b* leached from the color modules. Green color modules (11.6) leached more amount of b* in this dietary medium compared to other color modules. The patient could be advised to reduce the intake of turmeric in their diet while using green color modules, due to its high intensity of leaching. Less amount of b* was leached from blue color modules (10.2) compared to green color modules. Black color modules (10.2) leached b* in a lesser amount than green color module and blue color modules. Reduced amount of b* was released from red color module (9.2) in this medium. Red color module could be used since it had least amount of color leaching property in this medium.

Measured amount of coffee was mixed with artificial saliva and used as a medium to analyze the amount of b* from the color module. Increased amount of b* was leached from red color module (−0.3) compared to other color modules in this medium. Next higher amount of b* leaching was from blue color modules (−0.4). Black color module (−8.4) leached less amount of b* than red color modules and blue color modules. Green color module (−15.3) leached least amount of b* in this medium. Ardeshna and Vaidyanathan in Journal of Orthodontics in 2009 assessed that the green color was the least in leaching.[9]

The clarity test done on these modules showed the amount of leaching properties exhibited by all the four modules in all the four dietary media. Ideally, the module should exhibit the least amount of color leaching in the oral clarity because it might cause esthetic concern to the patients secondly the leached color in the oral cavity might cause health concerns if released in high quantity such as redness, allergies, ulcers, etc.[8]

Conclusion

In the test for evaluating the leaching properties, green color elastomeric module exhibited the highest clarity with less color leaching properties compared to other elastomeric color modules. Black and blue color module exhibited significant increase in color leaching compared to other modules which were esthetically not acceptable.

References

1. Nattrass C, Sherriff M, Ireland AJ. The effect of environmental factors on elastomeric chain and nickel titanium coil springs. Eur J Orthod 1998;20:169-76.
2. Dowling PA, Jones WB, Lagerstrom L, Sandham JA. An investigation into the behavioural characteristics of orthodontic elastomeric modules. Br J Orthod 1998;25(3):197-202.
3. Brantley WA. Orthodontic Materials Scientific and Clinical Aspects, Stuttgard: Thieme; 2001.
4. Matasa CG. Screening orthodontic polymers f or leaching. World J Orthod 2003;4:1-5.

5. Beattie S, Monaghan P. An *in vitro* study simulating effects of daily diet and patient elastic band change compliance on orthodontic latex elastics. Angle Orthod 2004;74(2):234-9.
6. Bytes T. Color management for perfect color images. Am J Orthod Dentofacial Orthop 2005;129:311-4.
7. Teixeira L, Pereira Bdo R, Bortoly TG, Brancher JA, Tanaka OM, Guariza-Filho O. The environmental influence of light coke, phosphoric acid, and citric acid on elastomeric chains. J Contemp Dent Pract 2008;9(7):17-24.
8. Kim SH, Lee YK. Measurement of discoloration of orthodontic elastomeric modules with a digital camera. Am J Orthod Dentofacial Orthop 2009;31:556-62.
9. Ardeshna AP, Vaidyanathan TK. Color changes of orthodontic elastomeric module materials exposed to *in vitro* dietary media. J Orthod 2009;36:177-85.
10. Kroczek C, Kula K, Stewart K, Baldwin J, Fu T, Chen J. Comparison of the orthodontic load systems created with elastomeric power chain to close extraction spaces on different rectangular archwires. Am J Orthod Dentofacial Orthop 2012;141(3):262-8.