Effect of different staining materials on color stability of sapphire brackets bonded with different types of light cure orthodontic adhesives (An in vitro study)

Alaa Faleh Albo Hassan, B.D.S. [(1)]
Nidhal H. Ghaib, B.D.S., M.Sc. [(2)]

ABSTRACT

Background: The demand for better esthetic during orthodontic treatment has increased nowadays, so orthodontists starting using esthetic arch wires, brackets and ligatures.Tooth colored brackets were introduced in different types of materials. Sapphire ceramic brackets are one type of esthetic brackets and their color stability remains the main concern for the clinicians and patients at the same time .

The present study design to evaluate the effect of three different staining materials (pepsi, black tea and cigarette smoke) on the stainability of sapphire ceramic brackets bonded with three types of light cure orthodontic adhesives which include: Resilience, Enlight and Transbond.

Materials and Methods: The sample consisted of three hundred sixty sapphire brackets. The brackets were divided according to bonding materials into three groups each group consist of one hundred twenty brackets, then each subgroup farther subdivided into four groups according to the material they were immersed (distilled water, black tea, Pepsi and cigarette smoke) with thirty brackets each, then Each group with ten brackets farther subdivided according to time interval of immersion in each media into three groups one day, seven days and fourteen days at 37°C in the incubator.A UV-Visible spectrophotometer (Shimadzu, UV -1800) was used to perform a light absorption test.

Results: ANOVA and LSD post Hoc tests were used to identify the significant effects of the staining materials at a significance level $P \leq 0.05$.It was found that the immersion time gradually influenced the color stability of the adhesive materials with sapphire brackets with the highest activity observed at fourteen days interval. The brackets bonded with Resilience light cure adhesive are the most type affected by staining materials, then followed by the brackets bonded with Transbond and finally the brackets bonded with Enlight light cure adhesive. For the staining materials it was found that the cigarette smoke is the most powerful staining material, followed by tea and finally pepsi.

Conclusions: From the above result we can conclude that the type of adhesive must take in consideration when the esthetic brackets have been used.

Key words: Sapphire brackets, color stability, staining materials. (J Bagh Coll Dentistry 2015; 27(2):136-141).

INTRODUCTION

In modern society, the esthetic aspect of orthodontic therapy is becoming increasingly important because of the growing number of adult patients. Ceramic brackets have been developed to improve esthetics during orthodontic treatment [(1,2)]. All currently available ceramic brackets are composed of aluminum oxide and because of their distinct differences during fabrication, two types of ceramic brackets are available, namely the polycrystalline alumina which are binders to thermally fuse the particles together, and the single crystal alumina or monocrystalline alumina or sapphire brackets which are milled from single crystals of sapphire (monocrystalline) using diamond tools [(3-6)].

Color stability is considered an important factor in the success of an esthetic treatment Several factors influence the color stability of contemporary light activated materials, such as the photo initiator system, the resin matrix, the light-curing unit used for polymerization, and the irradiation times [(7)].

(1) Master Student, Department of Orthodontics, College of Dentistry, University of Baghdad.
(2) Professor, Department of Orthodontics, College of Dentistry, University of Baghdad.

However, the optical properties of dental composite resins change because of polymerization, and the extent of change is influenced by the brand and shade of resin composites and the wavelength of curing lights [(8,9)].

Composite resin discoloration is multifactorial, including factors such as intrinsic discoloration and extrinsic staining.

Cigarette smoke, Tea, and pepsi are the most materials used among Iraqi people that have a potential staining ability. Therefore, it is important to assess the effect of these materials on the sapphire ceramic brackets.

MATERIALS AND METHOD

For this study 360 PERFECT CLEAR sapphire brackets (HUBIT/Korea) for maxillary central incisors on the right side were used, Roth type, slot 0.018” x 0.022”. Three types of light cure orthodontic adhesive were used in this studyEnlight light cure orthodontic adhesive (Ormco / Italy), Transbond ™ XT light cure orthodontic adhesive (3M Unitek /USA) and Resilience® Light Cure orthodontic Adhesive System (Orthotechnology/ USA) fig. (1). Black

tea (AHMAD TEA, England), pepsi (Baghdad Company, Iraq), cigarette (Gauloises Blondes, European Union) and distilled water (control media) used as the staining materials.

Figure 1: Bonding materials used in the present study.

Sample organization

The sample composed of 360 sapphire brackets were used in testing the staining effect of black tea, Pepsi and cigarette smoke. The brackets were divided according to bonding materials into three groups each group consist of 120 brackets:

1. Brackets bonded with Enlight Light-Cure orthodontic adhesive composite.
2. Brackets bonded with Transbond ™ XT light cure orthodontic adhesive composite.
3. Brackets bonded with Resilience® light cure orthodontic adhesive composite.

Then each subgroup farther subdivided into four groups according to the media they were immersed (distilled water as control group, black tea, Pepsi and cigarette smoke) with 30 brackets each, then Each group (with 10 brackets)farther subdivided according to time interval of immersion in each media into three groups (1day,7days and14days)

Bonding procedure

A small amount of the adhesive paste was applied onto bracket base , then by using a clamping tweezer the bracket was placed lightly onto glass slide mounted on the table of surveyor (Dentaurum, Germany) covered by celluloid strip to facilitate detachment of the bracket - adhesive complex with a recovery of the set material

Then a constant load was placed on the bracket for 10 seconds (by fixing the 200 gm load on the upper part of the vertical arm of the surveyor, and fixing the analyzing rod in the lower part of the vertical arm of the surveyor and put it in contact with the bonded bracket), to ensure that each bracket was seated under an equal force and to ensure a uniform thickness of the adhesive. Then any excess adhesive material was removed from around the bracket base with a sharp hand scaler without disturbing the seated bracket.

After that the bracket adhesive was photopolymerized with a light-curing unit (Blue LEX LD-109, Taiwan); the light guide of curing light unit was directed toward the bracket, the light shined through the bracket for 5 ,10, 20 seconds for Transbond ™ XT, Enlight, Resilience® adhesive pastes respectively .The bonded brackets were allowed to bench set for 24 hrs. To ensure complete polymerization of adhesive material, after setting; the celluloid strips were removed and the resultant bracket bonded adhesive were flat surfaces.

Smoke Chamber

The smoke chamber was a plastic container allowing cigarette smoke to enter from one end of the chamber , by a rubber tube that fit the cigarette, the rubber tube positioned to provide a uniform distribution of the entering cigarette smoke, and leave from the other end, by a portable suction device (saliva ejector) (HOO3-C, china) fitted that caused a negative pressure to aspirate the smoke released by the cigarette, thereby leading to impregnation of the brackets with the substances contained in the smoke, for the purpose of reproducing in vitro the conditions of a smoker's oral cavity, for equal exposure of all brackets to cigarette smoke. The brackets were ligated with stainless steel ligature wires and putted into a chamber by fixing onto a supporting stainless steel holder that would allow the samples to remain in the same vertical position, so that the greater part of their surface would be exposed to the cigarette smokefig (2).

Figure 2: Smoking equipment used in the study.

Staining procedure:

- **Preparation of staining solutions :**
- **Tea:**

The tea solution was prepared by immersing 5 teabags in 500 ml of boiling distilled water for 10 minutes

- **Pepsi :**

New cans of Pepsi were used for each day.

- **Immersion in the staining solutions**

Each bracket was stored in a solution in inert plastic containers and labeled with sticky labels and stored at 37°C in the incubator,all solutions were regularly renewed after every 24 hours of storage. The total storage period was 14 days

- **Cigarette**

For each bracket, 20 cigarettes were used for each day and each cigarette was burned in a standard time of 10 min in a total period of 14 days ,After exposure to every 20 cigarette the brackets were cleaned by ultrasonic cleaner(**VGT-1740QT, china**) to eliminate excesses of substances from the smoke adhered to the bracket surfaces After this, the bracket putted back into its respective container containing distilled water and stored at 37°C in the incubator**(Memmert, Germany)** until the next time it was exposed to smoke

Spectrophotometric analysis

The color change readings were made using a spectrophotometer, Uv-Visible Spectrophotometer **(Shimadzu, UV-1800, Japan)**, with wavelength range 200-800 ŋm with double beam analytical holders. To allow the standard positioning of the brackets during the reading, the bracket of each group and subgroup positioned on black rectangular cardboard segments (40×15×0.2 mm) with a central window at (17 mm) from the bottom to be in the way of the light beam of the spectrophotometer. Before the readings, each bracket was taken out of the immersion media and washed by ultrasonic cleaner for one minute and properly dried on paper towels [10-12].

Before color reading the spectrophotometer was calibrated by opening the chamber and putting two black card boards without window on the two analytical beam holders and then the chamber closed and the device given the order auto zero to eliminate the effect of the black card board

After that the chamber of the spectrophotometer was opened and the bracket was positioned in a standardized upright position with the black card board **fig.(3)**, then the chamber is closed and the machine is given the order to start scanning starting from 800ŋm wavelength in the infra-red zone to 200ŋm Wavelength in the UV zone passing through the entire visible spectrum.

The results appear as a graph from which the amount of light absorption is plotted as a graph and the amount of absorbed light at a specific wavelength was obtained. For all the samples the light absorption at 345ŋm wavelength visible light was obtained and used in the later statistical analysis.

Figure 3: The bracket positioned on the analytical beam holder of the spectrophotometer and the blank on the other analytical beam holder.

Statistical analysis

Data were collected and analyzed using SPSS (statistical package of social science) software version 15 for windows XP Chicago, USA.

The following statistics were used:

A- Descriptive statistic: including mean, standard deviation, statistical tables and graphical presentation by bar charts.

B- Inferential statistics

1- One way analysis of variance test (ANOVA) was used to examine anysignificant difference between more than two groups.

2- LSD test was used to find any statistical significant difference between any two groups.

P value of more than 0.05 was regarded as statistically insignificant as follows:

NS Non-significant $p>0.05$

S Significant $0.05\geq p>0.01$

HS Highly significant $p\leq 0.01$

RESULTS

Comparison between adhesive materials

The amount of incremental increase in light absorption by sapphire brackets bonded with Resilience, Enlight and Transbond adhesives when immersed in staining materials at three time intervals was shown in table 1 and table 2.

Table 1: Descriptive statistics and adhesive difference in each duration for Pepsi, Tea and Cigarette smoke by ANOVA test.

Media	Duration	Adhesives	Descriptive statistics		Comparison (d.f.=29)	
			Mean	S.D.	F-test	p-value
Pepsi - D.W.	1 day	Resilience	-0.001	0.001	0.040	0.961 (NS)
		Enlight	-0.001	0.001		
		Transbond	-0.001	0.002		
	7 days	Resilience	0.005	0.001	31.695	0.000 (HS)
		Enlight	0.001	0.000		
		Transbond	0.002	0.001		
	14 days	Resilience	0.009	0.001	104.871	0.000 (HS)
		Enlight	0.002	0.001		
		Transbond	0.006	0.001		
Tea - D.W.	1 day	Resilience	0.015	0.001	575.446	0.000 (HS)
		Enlight	0.004	0.001		
		Transbond	0.005	0.000		
	7 days	Resilience	0.021	0.001	425.474	0.000 (HS)
		Enlight	0.008	0.001		
		Transbond	0.011	0.001		
	14 days	Resilience	0.028	0.001	197.129	0.000 (HS)
		Enlight	0.015	0.002		
		Transbond	0.020	0.002		
Cigarette Smoke - D.W.	1 day	Resilience	0.021	0.001	128.885	0.000 (HS)
		Enlight	0.011	0.001		
		Transbond	0.016	0.002		
	7 days	Resilience	0.039	0.001	840.875	0.000 (HS)
		Enlight	0.021	0.001		
		Transbond	0.028	0.001		
	14 days	Resilience	0.049	0.001	1324.121	0.000 (HS)
		Enlight	0.025	0.001		
		Transbond	0.038	0.001		

Table 2: Difference between the different adhesives for light absorption after immersion in Pepsi, Tea and Cigarette smoke by LSD test

Media	Duration	Adhesives		Mean Difference	p-value
Pepsi - D.W.	7 days	Resilience	Enlight	0.004	0.000 (HS)
			Transbond	0.003	0.000 (HS)
		Enlight	Transbond	-0.001	0.013 (S)
	14 days	Resilience	Enlight	0.007	0.000 (HS)
			Transbond	0.003	0.000 (HS)
		Enlight	Transbond	-0.004	0.000 (HS)
Tea - D.W.	1 day	Resilience	Enlight	0.012	0.000 (HS)
			Transbond	0.010	0.000 (HS)
		Enlight	Transbond	-0.001	0.001 (HS)
	7 days	Resilience	Enlight	0.013	0.000 (HS)
			Transbond	0.010	0.000 (HS)
		Enlight	Transbond	-0.003	0.000 (HS)
	14 days	Resilience	Enlight	0.013	0.000 (HS)
			Transbond	0.009	0.000 (HS)
		Enlight	Transbond	-0.004	0.000 (HS)
Cigarette Smoke - D.W.	1 day	Resilience	Enlight	0.010	0.000 (HS)
			Transbond	0.005	0.000 (HS)
		Enlight	Transbond	-0.005	0.000 (HS)
	7 days	Resilience	Enlight	0.019	0.000 (HS)
			Transbond	0.011	0.000 (HS)
		Enlight	Transbond	-0.007	0.000 (HS)
	14 days	Resilience	Enlight	0.024	0.000 (HS)
			Transbond	0.011	0.000 (HS)
		Enlight	Transbond	-0.013	0.000 (HS)

DISCUSSION

It has been shown that the brand, the solution and storage time influence the degree of color change of the materials and this is coming in agreement with Villalta et al. [13].

According to Villalta et al. [13] and Soares et al. [14], the staining capacity of the composite resin is related to extrinsic factors, such as the pigment agent is subjected to, andto intrinsic factors, such as loading particles and resinous matrix. The structure of the composite resin and the characteristics of its particles have a direct impact on its susceptibility to staining by external agents.

All types of adhesives tested in the present study stained by the staining media but with different extent, the Enlight stained less than Resilience and Transbond and the Transbond less than Resilience.

There is a correlation between discoloration and the filler component in resin composites, the higher contents of the filler in dental Composites resulted in lesser discoloration than lower filled polymers , So a possible reason for the better color stability of Enlight adhesive could be the elevated filler content of approximately70-80 percent by weight, while for Resilience adhesive the filler content approximately 41 percent by weight and this is coming in agreement with[15-19], while For Transbond adhesive the filler content of approximately70-80 percent by weight(as Enlight adhesive) but it contain silane treated silica and silane treated quartz as a filler which explain the more stainability of this adhesive than Enlight adhesive, It has been suggested that silanization of filler particles plays an important role in discoloration. This is due to the fact that silane has high water absorption levels and this is coming in agreement with [20].

Every component of resin may be implicated in discoloration. It has been shown that the resin matrix plays a major part in the color stability of composites and water sorption rate is of particular importance [21-23].

It was found that incorporation of greater amounts of TEGDMA resulted in an increase in water uptake in Bis-GMA based resins; Kalachandra [24] and Mazato et al. [25] reported that this was due to increased surface hydrophilicity. Hydrophilic groups such as the ethoxy group in TEGDMA are thought to show affinity with water molecule by hydrogen bonding to oxygen [26], which may explain the better color stability of Enlight adhesive.

From this study we can conclude that:

1. The color of sapphire brackets bonded with any type of the three adhesive materials significantly became darker with increased immersion time in the staining media from 1 day to 14 days.
2. Resilience adhesive was the most type of materials affected by staining media followed by Transbond and finally Enlight.
3. Cigarette smoke was the most potent staining medium followed by tea and lastly pepsi.

REFERENCES

1. Ziuchkovski JP, Fields HW, Johnston WM, Lindsey DT. Assessment of perceived orthodontic appliance attractiveness. Am J Orthod Dentofacial Orthop 2008; 133:68–78.
2. Rosvall MD, Fields HW, Ziuchkovski J, Rosenstiel SF, Johnston WM. Attractiveness, acceptability, and value of orthodontic appliances. Am J Orthod Dentofacial Orthop 2009; 135:276.e1-12.
3. Kusy RP. Morphology of polycrystalline alumina brackets and its relationship to fracture toughness and strength. Angle Orthod 1988; 58:197-203.
4. Swartz ML. Ceramic brackets. J Clin Orthod 1988; 22: 82–8.
5. Birnie D. Ceramic brackets. Br J Orthod 1990; 17:71–5.
6. Cacciafesta V, Sfondrini MF, Ricciardi A, Scribante A, Klersy C, Auricchiom F. Evaluation of friction and stainless steel aesthetic self-ligating brackets in various bracket-archwire combinations. Am J Orthod Dentofacial Orthop 2003; 124: 395-402.
7. Janda R, Roulet JF, Latta M, Steffin G, Rüttermann S. Color stability of resin-based filling materials after aging when cured with plasma or halogen light. Eur J Oral Sci 2005; 113:251-7
8. Taira M, Okazaki M, Takahashi J. Studies on optical properties of two commercial visible-light-cured composite resins by diffuse reflectance measurements. J Oral Rehabil 1999; 26: 329-37.
9. Kim IJ, Lee YK. Changes in color and color parameters of dental resin composites after polymerization. J Biomed Mater Res B Appl Biomater 2007; 80: 541-6.
10. Mendonça MR, Fabre AF, Goiatto MC, Cuoghi OA, Martins LP, Verri ACG. Spectrophotometric evaluation of color changes of esthetic brackets stored in potentially staining solutions. RPG Rev Pós Grad 2011; 18(1): 20-7.
11. Filho HL, Maia LH, Araujo MV, Elias CN, Ruellas ACO. Colour stability of aesthetic brackets: ceramicand plastic. Aust Orthod J 2013; 29(1):13-19.
12. Patil SS, Dhakshaini MR, Gujjari AK. Effect of cigarette smoke on acrylic resin teeth. J Clin Diagn Res 2013; 7(9): 2056-9.
13. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. J Prosthet Dent 2006; 95(2):137-42.
14. Soares LES, Cesar ICR, Santos CGC, Cardoso AL, Liporoni PCS, Munin E, et al. Influence of coffee on reflectance and chemistry of resin composite protected by surface sealant. Am J Dent. 2007; 20: 299-304.
15. Ruyter IE, Svedsen SA. Remaining methacrylate groups in composite restorative materials. Acta Odontol Scand 1981; 39: 329 –32.

16. Wilson AD, Prosser HJ, Powis DR. Mechanisms of adhesion of polyelectrolyte cements to hydroxyapatite. J Dent Res 1983; 62: 590 –2
17. Ruyter IE, Nilner K, Moller B. Color stability of dental composite resin materials for crown and bridge veneers. Dent Mater 1987; 3:246 –51.
18. Setz J, Engel E. Clinical studies of discoloration of veneering resins .Deutsche ZahnärztlicheZeitschrift 1994; 49: 735 –58.
19. Eldiwany M, Friedl KH, Powers JM. Colour stability of light-cured and post-cured composites. Am J Dent. 1995; 8: 179 –81.
20. Rueggeberg FA, Craig RG. Correlation of parameters used to estimate monomer conversion in a light cured composite. J Dent Res1988; 67:932-7.
21. De Gee A, Hagenaar E, Davidson C. Color dye identification of incompletely cured composite resins. J Prosthet Dent 1984; 52: 626-31.
22. Øysæd H, Ruyter I. Water sorption and filler characteristics of composite for use in posterior teeth. J Dent Res 1986; 65: 1315–18.
23. Choi K, Ferracane J, Hilton T, Charlton D. Properties of packable composites. J Esthet Dent 2000; 12: 216–26.
24. Kalachandra S, Turner DT. Water sorption of polymethacrylate networks: bis-GMA/TEGDM copolymers. J Biomed Mater Res 1987; 21:329–38
25. Mazato S, Tarumi H, Kato S, Ebisu S. Water sorption and colour stability of composites containing the antibacterial monomer MDPB. J Dent1999; 27:279–83.
26. Arima T, Hamada T, McCabe JF. The effects of cross-linking agents on some properties of HEMA-based resins. J Dent Res 1995; 74:1597–601.

الخلاصة

الخلفية:لقد ازدادت الحاجة الى استعمال الاجهزة التقويمية التجميلية في هذه الايام مما دفع مقومي الاسنان الى البدء باستخدام الاسلاك التجميلية والحاصرات التجميلية بالاضافة الى الاشرطة المطاطية التجميلية.

الحاصرات التقويمية الشبيهة بلون الاسنان انتجت من انواع مختلفة من المواد,والحاصرات التقويمية الخزفية (Sapphire)هي نوع من انواع الحاصرات التقويمية التجميلية ويبقى استقرار لونها هو الشغل الشاغل للاطباء والمرضى على حد سواء.

اجريت هذه الدراسة لتقييم تأثير ثلاثة مواد ملونة مختلفة هي (الشاي الاسود,البيبسي ودخان السجائر) على قابلية تلوين الحاصرات التقويمية الخزفية (Sapphire)المرتبطة مع ثلاث انواع من المواد اللاصقة الضوئية التصلب هي (Resilience, Enlight and Transbond).

المواد والطرق:تكونت هذه الدراسة من ثلاثمائة وستون حاصرة تقويمية ياقوتية , تم تقسيم هذه الحاصرات وفقا لمواد الربط الى ثلاث مجموعات رئيسية تتكون كل مجموعة من مائة وعشرون حاصرة تقويمية وثم قسمت كل مجموعة الى اربع مجاميع فرعية وفقا لمواد الغمر(الماء المقطر,الشاي الاسود ,البيبسي ودخان السجائر) بواقع ثلاثون حاصرة لكل منهم ثم كل مجموعة الى عشرة حاصرات حسب الفترة الزمنية للغمر (يوم واحد, سبعة ايام واربعة عشر يوما) في درجة حرارة 37م° باستعمال الحاضن.

تم استخدام الاشعة الطيفية المرئية فوق البنفسجية (Shimadzu, UV -1800) لاجراء اختبار امتصاص الضوء.

النتائج:واستخدمت العملية الاحصائية(ANOVA وLSD) لتحديد تأثير المواد الملونة عند مستوى دلالة $P \leq 0.05$.

وقد وجد ان وقت الغمر يؤثر تدريجياً على الاستقرار اللوني للمواد اللاصقة مع الحاصرات التقويمية (Sapphire) وقد لوحظ اعلى نشاط في الفترة الزمنية اربعة عشر يوماً.

الحاصرات التقويمية المثبته باللاصق الضوئي التصلب Resilience هي الاكثر تلوناً ثم تليها المثبته باللاصق Transbond واخيراً الحاصرات المثبته باللاصقEnlight.وقد وجد ان دخان السجائر هو اقوى المواد الملونة يليها الشاي الاسود واخيرا البيبسي.

الاستنتاجات:نستطيع ان نستخلص من النتائج اعلاه ان نوعية المواد اللاصقة يجب ان تؤخذ بنظر الاعتبار عند استخدام الحاصرات التقويمية التجميلية.

الكلمات المفتاحية:الحاصرات الياقوتية,الاستقرار اللوني,المواد الملونة.