Atatürk Üniv Diş Hek Fak Derg (*J Dent Fac Atatürk Uni*)
Cilt:31, Sayı:3, Yıl: 2021, Sayfa: 349-54

EVALUATION OF ORTHODONTIC ADHESIVE COLOR REFLECTION DEGREES OF TRANSPARENT AND TRANSLUCENT CERAMIC BRACKETS

SAYDAM VE YARISAYDAM SERAMİK BRAKETLERİN ADEZİV RENK DEĞİŞİMİNİ YANSITMA MİKTARLARININ DEĞERLENDİRİLMESİ

Dr. Öğr. Üyesi Göksu TRAKYALI*

Makale Kodu/Article code: 4857
Makale Gönderilme tarihi: 08.02.2021
Kabul Tarihi: 02.06.2021
DOI : *10.17567/ataunidfd.947016*

Göksu Trakyali : *ORCID ID:* 0000-0001-7261-5504

ABSTRACT

Aim: The aim of this study was to evaluate the effect of optical characteristics of two different kinds of ceramic brackets in masking and reflecting color of four different adhesives by means of digital measurements in vitro.
Material and Methods: 160 artificial maxillary central incisors were divided into two groups of 80, and assigned to monocrystalline bracket group (Group 1) and polycrystalline bracket group (Group 2). Both groups were further divided into four equal sub-groups according to the adhesives. After bonding, all samples were colorimetrically evaluated before (T0) and after (T1) thermocycling and photoaging. Values for L*, a* and b* parameters were recorded and color differences (ΔE) were calculated. The results were statistically analyzed using the Kruskall–Wallis test. Evaluation among subgroups was performed using Dunn's multiple correlation test ($P<0.05$). The clinical detection threshold for ΔE value was set at 3.7 units.
Results: ΔE values between T0 and T1 showed an increase in all four sub-groups in the monocrystalline group and the highest value was 1.49±0.66 for the Transbond XT group. There was no significant difference in ΔE values in any adhesive sub-group in the polycrystalline group.
Conclusion: Monocrystalline brackets are more likely to reflect color of orthodontic adhesives while polycrystalline brackets have a masking effect Therefore, while treating patients with more esthetic concerns, monocrystalline translucent brackets should be preferred.
Key words: Orthodontics, orthodontic brackets, aluminum oxide, orthodontic adhesives, esthetics

ÖZ

Amaç: Bu çalışmanın amacı, yapısal olarak farklılık gösteren iki farklı estetik braketin optik özelliklerinin dört farklı ortodontik adezivin renk değişimlerini yansıtma veya maskeleme etkilerini dijital olarak in vitro ortamda incelemektir.
Gereç ve Yöntem: 160 adet yapay üst santral keser diş her biri 80 adet olacak şekilde monokristalin ve polikristalin braket uygulanmak üzere sırasıyla Grup 1 ve Grup 2 olarak iki gruba ayrılmıştır. Her iki grup, kullanılan ortodontik adeziv sistemine göre dört eşit alt gruba ayrılmıştır. Braket uygulamasını takiben örnekler termal döngü ve suni gün ışığı uygulamasından önce (T0) ve sonra (T1) olmak üzere iki defa renk ölçümü işlemine tabi tutulmuştur. L*, a* ve b* parametrelerinin değerleri kaydedilip her örnek için renk farkı (ΔE) hesaplanmıştır. ΔE bulguları Kruskall-Wallis testi ile, Alt gruplar ararsı değerlendirme ise Dunn'ın çoklu karşılaştırma testi ile yapılmıştır ($P<0.05$). Klinik olarak tespit edilebilir ΔE değeri 3.7 ünite olarak belirlenmiştir.
Bulgular: Monokristalin braket grubundaki tüm alt gruplarda T0 ve T1 arasındaki ΔE değerlerinde istatistiksel olarak anlamlı bir artış gözleniren, polikristalin braket grubunun alt gruplarında anlamlı bir fark bulunmamıştır. En fazla ΔE artışı monokristalin braket grubunda Transbond için tespit edilmiştir (1.49±0.66).
Sonuç: Seramik braketlerin altından yansıyan ortodontik adeziv sistemlerinin renk değişimi monokristalin braketler tarafından daha fazla yansıtılırken, polikristalline braketlerde maskeleme etkisi nedeni ile daha az olduğu tespit edilmiştir. Estetik kaygısı yüksek olan hastalarda polikristalline braketlerin tercih edilmesi düşünülmelidir.
Anahtar kelimeler: Ortodonti, ortodontik braketler, alüminyum oksit, ortodontik adezivler, estetik

* Department of Orthodontics, Faculty of Dentistry, Istanbul Yeni Yüzyıl University, Istanbul

Kaynakça Bilgisi: Trakyalı G. Saydam ve yarısaydam seramik braketlerin adeziv renk değişimini yansıtma miktarlarının değerlendirilmesi. Atatürk Üniv Diş Hek Fak Derg 2021; 31: 349-54.
Citation Information: *Trakyali G.* Evaluation of orthodontic adhesive color reflection degrees of transparent and translucent ceramic brackets. *J Dent Fac Atatürk Uni 2021; 31: 349-54.*

INTRODUCTION

The improved physical advantages of ceramic brackets provide an enticing option specially for adults seeking for more esthetic solutions during orthodontic treatment with fixed appliances.[1] Esthetic brackets made of high quality ceramic material became increasingly popular with the increasing demand for an esthetic look during orthodontic treatment with fixed appliances since the 1980s.[2] Ceramic brackets are more preferred due to their ability to resist against fractures while having a high optical esthetic, being resistant to staining and discoloration.[3] Another advantage of ceramic esthetic brackets is that they can be used in patients who require a routine head and neck MRI scanning without causing artifacts.[4]

The two main structural forms which the ceramic brackets can be found are polycrystalline and monocrystalline forms. The structural form of polycrystalline brackets is basically made of fused aluminum oxide (Al_2O_3) crystals at high temperatures.[5] This fusing process leads to formation of a microstructure network of crystal grain boundaries that reflect light which makes them translucent rather than transparent.[6] In contrast, monocrystalline brackets are composed of a single of Al_2O_3 crystal fused at a much higher temperature and cooled down very slowly. This process enables control of crystallization which leads to passage of light making transparent.[7]

There is a strong relationship between translucency and color of esthetic brackets which should be considered in clinical use. It is hard to match the color of translucent brackets and natural teeth.[7] While using monocrystalline brackets there is no need to match tooth color because of the optical characteristics being transparent they will reflect the tooth color on which being placed. In other words, the optical clarity of monocrystalline brackets is higher than polycrystalline brackets, however, a disadvantage of transparent brackets is that they would allow the underlying tooth color or orthodontic adhesive color to shine through them.[7] As a result they may show the slightest discoloration of the underlying adhesive which may be derived from material related factors such as water absorption, incomplete polymerization of the adhesives, brand, tone or extrinsic factors such as coloration effect of food dyes, mouth rinse use, saliva composition, nicotine, heat, time and polymerization intensity.[8,9]

Color stability of orthodontic adhesives is an important issue during orthodontic treatment with esthetic brackets as the color change of the adhesive will be visible through the esthetic brackets which may lead to patient complaints.

Color change is scientifically defined using color coordinates and measurable data referring to the mathematical structured color identification system, CIE (Commission Internationale de l'Eclairage) which uses coordinates on three dimensions (L*, a*, b*) to represent a human visual color; one vertical black (0=pure black) to white (100=diffuse white) axis for lightness (L*) and two horizontal dimensions for color plane (a* and b*) indicating green (- a*) to red (+ a*) and blue (- b*) to yellow (+ b*).[10] The CIE*L*a*b** color space has also been used in the field of esthetic dentistry specially to detect color alterations in restorative materials which is found to be not reliable when performed by the naked human eye. In color research articles it has been advised to use an instrumental system that is able to record detailed and standardized data of color parameters to evaluate color changes scientifically.[11]

The present study aimed to evaluate the effect of different structural differences of polycrystalline and monocrystalline brackets in reflecting the color alterations of four different orthodontic adhesives induced by photo aging and thermal cycling procedures by means of digital colorimetric measurements.

MATERIALS AND METHODS

In order to standardize tooth color variable, one hundred and sixty artificial maxillary right incisors KaVo Model Teeth, KaVo Dental GmbH, Biberach, Riß, Germany) made of plastic with the same color were used in this study. The vestibular surfaces of the teeth were covered with a black colored tape leaving only the vestibular surface area, where the brackets will be placed, open. All digital color data was collected from the exposed tooth window to standardize the teeth surface intended for analysis.

Exposed surfaces of all teeth were rinsed and dried for 10 seconds before the application of 38% phosphoric acid etching gel (Etch-Rite Etchant gel, Pulpdent, Watertown, Massachusetts, USA) for 30 seconds. After etching procedure all teeth were cleaned with water, and dried with compressed air.

All prepared samples were divided into two main groups of 80. Inspire ICE Clear Braces and Clarity Ceramic Brackets were used for Group 1 and Group 2 respectively and then both main groups were further diverged into four subgroups of 20 each

according to the adhesives used. Ceramic brackets and adhesives used in the present study are listed in Table 1.

Table 1. Ceramic bracket and adhesive combination used in the two groups.

Group	n	Brackets	Adhesive	n
Group 1	80	Inspire ICE Clear Braces, Ormco Corporation, Orange, California, USA	Transbond XT Light cure adhesive, 3M Unitek	20
			Brace Paste, American Orthodontics, Sheboygan, Wisconsin USA	20
			Blugloo, Ormco Corporation	20
			Light Bond, Reliance Orthodontic Products Inc., Itasca, Illinois, USA	20
Group 2	80	Clarity Ceramic Brackets, 3M Unitek, Monrovia, California, USA	Transbond XT Light cure adhesive	20
			Brace Paste, American Orthodontic	20
			Blugloo, Ormco Corporation	20
			Light Bond, Reliance Orthodontic Products Inc.	20

Upper central incisor were placed onto the teeth surfaces any peripheral excess adhesive material around the bracket was removed with an explorer. Transbond XT, Light Bond and Brace Paste were cured for 40 seconds and then Blugloo for 15 seconds as recommended by the manufacturers. The same visible light-curing unit (Optilux ™ XT, 3M Unitek, Monrovia, California, USA) was used for all samples. The combination of two different esthetic ceramic brackets and four different adhesives are shown in Table 1.

All bonded artificial teeth were numbered for identification. Initial calorimetrically evaluation of all samples was performed by using the VITA Easyshade Advance 4.0 (VITA Zahnfabrik, Bad Sackingen, Germany) digital spectrophotometer. All colorimetric measurements were performed by the same operator (GT) and recorded as ΔE1. All measurements were repeated five times as advised by the CIE *L*a*b** system.[12]

After initial color evaluation (T0), all samples were stored in water for two days and then exposed to an artificial light source (Sunset CPS plus, Atlas Material Testing Technology, Gelnhausen, Germany). To imitate the oral environment, all samples were stored in artificial saliva for 30 days and then thermal cycled at 5±2°C and 55±2°C for 10000 cycles with 30 seconds of dwell time and 15 seconds of transfer time. After photo aging and thermal cycling process, a second digital color measurement was performed by the same operator (GT) (T1) and recorded as ΔE2.

The color changes (ΔE values) were calculated according to the following formula: LİT1[13]

$$\Delta E = [(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{0.5}$$

The Ethics Committee of Science, Social and Non-invasive Health Sciences Research of Istanbul Yeni Yuzyil University approved the study design at the 7th of October in 2019. The present investigation was conducted in conformity with Helsinki Declaration.

Statistical analysis

Statistical analysis of this study was administered using the NCSS-PASS statistical software package version 2007 (Kaysville, Utah, USA). Besides mean and standard deviation calculations, a Friedman test was used for examining consecutive measurements. A Kruskal–Wallis test was used for the inter-group comparison. The differences among subgroups were calculated using the *post hoc* Dunn's multiple comparison tests and Mann-Whitney-U tests. The reliability among repeated measurements was indicated using Intra-class correlation coefficient (ICC). The statistical significance level was set at $P<0.05$ and confidence interval was established as 95 per cent. The visible clinical significance of level was set at ΔE>3.7 units.

RESULTS

All ICC values were greater than or equal to 0.90 and within the confidence limits of 95 per cent which indicated that the operator was consistent in the repeated measurements.

Color changes calculated at T0 and T1 for Inspire Ice brackets combined with four different adhesives and Clarity brackets combined with the same four adhesives are shown in Table 2 and Table 3 respectively.

All ΔE values were under the clinically observable level for the human eye (ΔE<3.7) A significant difference in absolute values of ΔE differences (ΔE1-ΔE 2) was observed between all subgroups when two groups were compared (Table 4). ΔE differences were significantly higher for all subgroups in Group1 (Graphic 1). The lowest ΔE difference was detected in the Clarity bracket and Light Bond adhesive combination and the highest ΔE was observed in the Inspire ICE bracket and Transbond XT adhesive. These results were statistically significant ($P<0.001$) although, not clinically observable.

DISCUSSION

The focus of this investigation was to evaluate level of transmitted color alteration of four different adhesives used to bond two different ceramic brackets

Table 2. Delta E (ΔE) measurements for Group1, ΔE1 and ΔE2 calculated for the first and second colorimetric measurements

ΔE	Time Point	Transbond XT Mean±SD (n=20)	Blugloo Mean±SD (n=20)	Light Bond Mean±SD (n=20)	Brace Paste Mean±SD (n=20)	*P* value	Significance
ΔE 1	T0	0.65±0.47	0.44±0.31	0.57±0.54	0.44±0.28	0.061	NS
ΔE 2	T1	1.49±0.66	1.32±0.98	1.24±0.75	1.26±1.39	0.509	NS
P value		0.006	0.034	0.042	0.032		
Significance		**	*	*	*		

SD. Standard deviation; NS, not significant **P<0.05; **P<0.01*

Table 3. Delta E (ΔE) measurements for Group2, ΔE1 and ΔE2 calculated for the first and second colorimetric measurements.

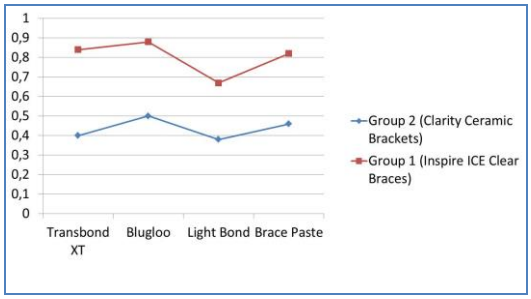
ΔE	Time Point	Transbond XT Mean±SD (n=20)	Blugloo Mean±SD (n=20)	Light Bond Mean±SD (n=20)	Brace Paste Mean±SD (n=20)	*P* value	Significance
ΔE 1	T0	0.76±0.45	0.44±0.31	0.69±0.55	0.56±0.26	0.063	NS
ΔE 2	T1	1.09±0.76	1.04±0.94	1.05±0.67	1.02±1.37	0.469	NS
P value		0.212	0.449	0.462	0.420		
Significance		NS	NS	NS	NS		

SD. Standard deviation; NS , not significant
**P<0.05; **P<0.01*

Table 4. ΔE Differences (ΔE1-ΔE2) for Group 1 and 2 at T0 and T1.

Groups	Transbond XT Mean±SD	Blugloo Mean±SD	Light Bond Mean±SD	Brace Paste Mean±SD
Group 1 (Inspire ICE Clear Braces)	0.84±0.47	0.88±0.52	0.67±0.38	0.82±0.42
Group 2 (Clarity Ceramic Brackets)	0.40±0.49	0.50±0.45	0.38±0.45	0.46±0.48
p	*	*	*	*

SD. Standard deviation **P<0.05.*
Visible clinical significance of ΔE1-ΔE2 level was set at 3.7.



Graphic 1. Comparison of ΔE differences for Group 1 and Group 2.

by evaluating color change induced by photo aging and thermal cycling procedures *in vitro*.

Besides having the disadvantage of being difficult to perform, results of clinical testing may not be comparable due to a combination of many varied intrinsic and extrinsic factors. Therefore in the present study an in vitro investigation was undertaken.

In the literature, a variety of artificial ageing procedures have been used in testing color stability of teeth and dental materials.[14,15] In the present study, in order to stimulate color alteration possible to be seen in the oral cavity, artificial photo aging and thermal cycling was used. Thermal cycling for 10000 cycles resembles 1 year of clinical service to accelerate the aging process. This method was previously used in the literature to test color stability of esthetic restorative materials.[16,17]

Photo aging used in this study is a process in which the tooth surface is exposed to a one day illuminance in a continuous manner of approximately 135.000 Lux at 400 nm. which is equal to sun irradiation exposure in Central Europe for 30 days.[18] In a previous study it was emphasized that photo aging induced color changes in different kinds of orthodontic adhesives.[19]

Color changes can be detected visually or by using a digital device like a colorimeter. The human eye is limited in detecting minor color differences and the interpretation of visual color comparisons is limited to the human perception of color.[11] For this reason, digital colorimetric measurements are preferred to achieve reproducible results for color determination.[20] In this study, the detection of discoloration between T0 and T1 was evaluated digitally using the VITA Easyshade instrument, which is reported to be one of the most dependable and exact instruments for measuring tooth color. [21]

Numerus studies evaluating long-term discoloration of brackets and adhesives mainly concluded that ceramic brackets undergo color change when exposed to colorants, like food dyes, which are generally present in people's daily diet. [22,23] However, results of a recent study indicated that the crystalline structure, either monocrystalline or polycrystalline do not interfere in how brackets are stained.[24] In this study the relationship between degree of transparency and adhesive color change by time seen through the esthetic bracket was investigated. Therefore, no additional colorant solutions were used.

In a previous study it was found that translucency was significantly influenced by the brackets' physical properties like composition, and thickness.[25] Therefore, in the present study, ΔE values calculated for the first and second measurements for combination of same adhesive and different ceramic brackets were not compared.

Results of this study revealed that color changes for all four adhesives are more visible through Inspire ICE Brackets and that Clarity Brackets masked the adhesive color change making it less visual for the naked eye during the orthodontic treatment. These findings were parallel to the results of previously performed researches.[25,26] This could be due to the different structure of these brackets.[6] Inspire Ice brackets are crystal clear, completely transparent monocrystalline brackets which means when light encounters this bracket material, almost all of it passes directly through them while Clarity Ceramic brackets are translucent polycrystalline brackets which means they are slightly opaque and allow only some light to travel through them. Lack of formation of grain boundaries in the monocrystalline ceramic bracket structure could be the reason why these brackets are transparent, which can lead to unaesthetic results after the color of the underlying orthodontic adhesive changes.

In Group 1 and Group 2 the highest ΔE value was recorded for Transbond adhesive as 1.49±0.66 and 1.09±0.76 respectively, which may be due to the composition and inorganic filler level of the adhesive.[14] These results were parallel to the findings of a previous research in which it was also stated that ΔE values limited to one unit are accepted as exact color matches because they cannot be clinically identified by the human eye.[26] It has been emphasized that color differences above two units may demonstrate a color change for restorative materials, however, most recent studies set the acceptable color matching limit to 3.7 units and emphasized that ΔE values higher than 3.7 units are accepted to be visible by the human eye.[27] In this study, the ΔE threshold was set at 3.7 units.

Although, thermal cycling and artificial photo aging combination was used in the present study it should be considered that the micro environmental characteristics of the oral cavity cannot be reliably simulated. Also, it must be noted that, orthodontic treatment usually continues for at least 1 to 2 years and longer aging periods should be studied.

Especially adult patients with great concerns on their facial esthetics wish to have an orthodontic treatment with less visible mechanics. In this case, monocrystalline brackets being transparent are logically less visible and therefore more often preferred by these patients. However, it should be considered that more transparency causes more reflection of even the slightest color change of the orthodontic adhesive between the esthetic bracket and tooth surface. Therefore, polycrystalline brackets which are less transparent but still less visible than metallic brackets should be considered for patients with higher esthetic anxiety during orthodontic treatment with fixed appliances.

Color changes induced by colorants *in vivo* were not included in the present study design. Therefore future studies should be designed to assess the effect of different colorants on the combination of different ceramic brackets and adhesives.

The present study was performed on artificial teeth which may not completely imitate natural teeth. This could be a limitation of this study.

CONCLUSION

Transparent monocrystalline brackets may seem to be more esthetic at the beginning of the orthodontic treatment, however, by time orthodontic adhesives in the oral environment tend to change color and this discoloration is more visible under more transparent brackets. Patients with higher esthetic demands during fixed orthodontic treatment should be advised to use more opaque and tooth colored or less translucent polycrystalline ceramic brackets in order to eliminate illuminated adhesive discoloration. However, it must be noted that the present study design did not include the color change induced by any colorant on brackets.

Acknowledgement
I would like to thank Dişmat Diş Malzemeleri Sanayi ve Ticaret A.Ş. for their technical support and for providing the VITA Easyshade Advance 4.0 for use in this study.

REFERENCES

1. Birnie D. Ceramic brackets. Br J Orthod 1990; 17: 71–5.
2. Swartz ML. Ceramic brackets. J Clin Orthod 1988; 22: 82-8.
3. Camporesi M, Baccetti T, Franchi L. Forces released by esthetic preadjusted appliances with low-friction and conventional elastomeric ligatures. Am J Orthod Dentofac Orthop 2007; 131: 772–5.
4. Kurt M, Kolsuz M, Öz U, Avsever İ, Örmeci T, Şakul B, Orhan K. Evaluation Of Intraoral Orthodontic Brackets' Effects On Magnetic Resonance Imaging –A Cadaveric Study At 3 Tesla. Ata Diş Hek Fak Derg. 2020; 30: 12-9.

5. Jena AK, Duggal R, Mehrotra AK. Physical properties and clinical characteristics of ceramic brackets a comprehensive review. Trends Biomater Artif Organs. 2007; 20: 101–15.
6. Karamouzos A, Athanasiou AE, Papadopoulos MA. Clinical characteristics and properties of ceramic brackets: A comprehensive review. Am J Orthod Dentofacial Orthop. 1997; 112: 34–40.
7. Lopes Filho H, Maia LEG, Araujo MVA, Ruellas ACO. Influence of optical properties of esthetic brackets (color, translucence, and fluorescence) on visual perception. Am J Orthod Dentofacial Orthop 2012; 141: 460-7.
8. Çelīk N, Sağsöz Ö, Gündoğdu M. Farkli İçeceklerin Posterior Kompozitlerin Renk Değişikliği Ve Yüzey Pürüzlülüğü Üzerine Etkisinin Değerlendirilmesi. Ata Diş Hek Fak Derg. 2017; 27: 27-33.
9. Guignone BC, Silva LK, Soares RV, Akaki E, Goiato MC, Pithon MM, Oliveira DD. Color stability of ceramic brackets immersed in potentially staining solutions. Dental Press J Orthod. 2015; 20: 32-8.
10. McLaren K. The development of the CIE 1976 (L*a*b*) uniform colour-space and colour-difference formula. J Soc Dyers Colour 1976; 92: 338-41.
11. Pietrobon N, Paul SJ, Pack N. New approaches to shade communication. In: Romano R, Bichacho N, Touati B. The art of the smile: intergrading prosthodontics, orthodontics, periodontics, dental technology and plastic surgery in esthetic dental treatment. 1st ed., Quintessence Publishing Co., Ltd., Berlin, 2005, 420-1110.
12. Baltzer A, Kaufmann-Jinoian V. The determination of the tooth colors. Special Reprint. Quintessenz Zahntechnik 2004; 7: 725-40.
13. International Organization for Standardization, Dental materials: determination of colour stability of dental polymeric materials. Geneva, ISO DIN EN 27491.
14. Stober T, Gilde H, Lenz P. Color stability of highly filled composite resin materials for facings. Dent Mater 2001; 17: 87-94.
15. Sham AS, Chu FC, Chai J, Chow TW. Color stability of provisional prosthodontic materials. J Prosthet Dent 2004; 91: 447-52.
16. Karadaş M, Sağsöz Ö. Influence Of Home And Office Bleaching Agents On Color And Translucency Of Composite Resins. Ata Diş Hek Fak Derg. 2019; 29: 238-43.
17. Lee YK, Lim BS, Kim CW. Difference in the color and color change of dental resin composites by the background. J Oral Rehabil 2005; 32: 227-33.
18. Atlas Suntest Bulletin. Atlas material testing solutions. Corporate bulletin, Gelnhausen, Germany, 1998.
19. Maijer R, Smith DC. Corrosion of orthodontic bracket bases. Am J Orthod 1982; 81: 43-8.
20. Rinke S, Hüls A, Kettler MJ. Colorimetric analysis as a means of quality control for dental ceramic materials. Eur J Prosthodont Restor Dent 1996; 4: 105-10.
21. Corciolani G, Vichi A, Louca C, Ferrari M. Color match of two different ceramic systems to selected shades of one shade guide. J Prosthet Dent 2011; 105: 171-6.
22. Akyalcin S, Rykiss J, Rody WJ, Wiltshire WA. Digital analysis of staining properties of clear aesthetic brackets. J Orthod 2012; 39: 170-5.
23. Yu B, Lee YK. Aesthetic color performance of plastic and ceramic brackets: an in vitro study. J Orthod 2011; 38: 167-74.
24. Oliveira CB, Maia LGM, Santos-Pinto A, Gandini-Júnior LG. In vitro study of color stability of polycrystalline and monocrystalline ceramic brackets. Dental Press J Orthod 2014; 19: 114-21.
25. Lee YK, Yu B. Translucency and color match with a shade guide of esthetic brackets with the aid of a spectroradiometer. Dental Press J Orthod 2016; 21: 81-7.
26. Seghi RR, Hewlett ER, Kim J. Visual and instrumental colorimetric assessments of small color differences on translucent dental porcelain. J Dent Res 1989; 68: 1760-4.
27. Trakyali G, Ozdemir FI, Arun T. Enamel colour changes at debonding and after finishing procedures using five different adhesives. Eur J Orthod 2009; 31: 397-401.

Sorumlu Yazarın Yazışma Adresi
Göksu Trakyali
Department of Orthodontics, Faculty of Dentistry, Istanbul Yeni Yüzyıl University, Sütlüce mahallesi, Binektaşı sokak, No:10, 34445, Beyoğlu, İstanbul, Turkey
Phone: +90 (212) 255 60 06
Gsm: +90 (532) 612 69 50
e-mail: goksutrakyali@gmail.com
goksu.trakyali@yeniyuzyil.edu.tr