RESEARCH ARTICLES

Received / Geliş Tarihi: 06.07.2023
Accepted / Kabul Tarihi: 24.07.2023
Published / Yayın Tarihi: 31.08.2023

Aydın Dental Journal - Volume **9** Issue **2** - August **2023** (1-9)

Aydın Dental Journal

Journal homepage: http://dergipark.ulakbim.gov.tr/adj
DOI:10.17932/IAU.DENTAL.2015.009/dental_v09i2001

Comparing The Effect Of Two Different Polishing Techniques On The Enamel Color Change After Repeated Debonding Of Metal Brackets

Metal Braketlerin Tekrarlanan Sıyrılmasından Sonra İki Farkli Polisaj Tekniğinin Mine Renk Değişimi Üzerindeki Etkisinin Karşılaştırılması

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ABSTRACT

Objectives: Repeated bracket failure is a common problem during orthodontic treatment of Class II division 2 malocclusions leading to unaesthetic results due to enamel color-change. This study aims to examine the effect of repeated debonding of two different metal-brackets followed by two different polishing procedures on enamel color.

Materials and Methods: Randomly selected 40 intact-non-carious-premolars were separated into two main groups of 20 as Group 1 (G1) and Group 2 (G2). 80-gauge foil-mesh-base and micro-etched-base metal-brackets were bonded to teeth in G1 and G2, respectively. Both groups were subdivided into two subgroups as, A or B, according to polishing techniques with whitestone-bur and sof-lex-discs respectively. Color evaluations were performed using Vita EasyShade before bonding brackets (T0) and after each debonding (T1, T2, T3). Adhesive Remnant Index (ARI) scores were evaluated visually. ANOVA with post-hoc analysis with a Bonferroni adjustment was utilized to compare color difference (ΔE) between time points in each group.

Results: Most significant difference in ΔE (11.7 ± 3) was in G1A at T1. In T2 the most significant difference in ΔE was noticed in G1B and G2A. There was no significant difference in ARI scores according to the brackets or the polishing methods. Repeated debonding of micro-etched-base-brackets followed by adhesive removal with a tungsten-carbide-bur and polishing with sof-lex-discs did not cause any significant change in ΔE.

Conclusion: Repeated bracket bonding after bracket loss may cause damage and subsequent discoloration of the enamel surface causing a negative effect on esthetics if correct cleaning protocols are not followed.

Keywords: *Color, Debonding, Dental polishing, Esthetics, Orthodontic bracket*

ÖZET

Amaç: Tekrarlayan braket kopmaları, mine renk değişikliği nedeniyle estetik olmayan sonuçlara yol açabilir ve Sınıf II divizyon 2 maloklüzyonların ortodontik tedavisi sırasında sıklıkla karşılaşılan yaygın bir sorundur. Bu çalışma, iki farklı metal braketin tekrarlı olarak koparılması ardından iki farklı polisaj işleminin mine rengi üzerindeki etkisini incelemeyi amaçlamaktadır.

Gereç ve Yöntem: Rastgele seçilen 40 sağlam-çürüksüz-küçük azı dişi Grup 1 (G1) ve Grup 2 (G2) olmak üzere 20'şerli iki ana gruba ayrılmıştır. Sırasıyla G1 ve G2'de dişlere 80-gauge folyo örgü tabanlı ve mikro asitli tabanlı metal braketler yapıştırılmıştır. Her iki grup da sırasıyla whitestone-bur ve sof-lex-disc ile polisaj tekniklerine göre A ve B olarak iki alt gruba ayrılmıştır. Renk değerlendirmeleri, braketlerin yapıştırılmasından önce (T0) ve her koparma işleminden sonra (T1, T2, T3) Vita EasyShade kullanılarak yapılmıştır. Yapışkan Kalıntı İndeksi (ARI) skorları görsel olarak değerlendirilmiştir. Her gruptaki zaman noktaları arasındaki renk farkını (ΔE) karşılaştırmak için Bonferroni düzeltmeli post-hoc analizli ANOVA kullanılmıştır.

Bulgular: ΔE'deki (11.7 ± 3) en önemli fark, T1'de G1A'da ve T2'de ΔE'deki en önemli fark G1B ve G2A'da tespit edilmiştir. Braketlere veya polisaj yöntemlerine göre ARI skorlarında anlamlı fark gözlenmemiştir. Mikro asitle pürüzlendirilmiş tabanlı braketlerin tekrarlanan koparılması, ardından bir tungsten-karbit-frez ile yapışkanın çıkarılması ve sof-lex-disklerle cilalama uygulandığında, ΔE'de en az değişikliğe neden olmuştur.

Sonuç: Braket kaybından sonra tekrarlanan braket yapıştırılması, doğru temizlik ve cila protokollerine uyulmazsa, mine yüzeyinde hasara ve ardından estetik üzerinde olumsuz etkiye neden olacak şekilde renk bozulmasına neden olabilir.

Anahtar Kelimeler: *Braket koparılması, Dental polisaj, Estetik, Ortodontik braket, Renk*

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Introduction

One of the most important points to be considered in orthodontic treatment is to finalize the treatment with minimum damage to the enamel surface. Application and removal of orthodontic brackets may lead to enamel loss and tooth color change if these procedures are not performed correctly.[1,2]

Debonding of the bracket should be performed with care not to damage the enamel structure. Therefore, the most preferred way of debonding is to use a specially designed bracket removal plier or ultrasonic devices which aim to cause fracture sites in the composite used between the bracket base and tooth surface and leaving the enamel structure intact. Additional cleaning and polishing procedures are then applied to eliminate the residual adhesive composite on the tooth surface. The most popular way used to clean residual adhesive composite is using a low-speed tungsten-carbide-bur followed by enamel polishing procedures.[3,4]

Polishing procedures are important due to the knowledge that the rougher the enamel surface, the darker becomes the color of the tooth.[5,6] Specular reflection at the surface is playing a direct role in the general color of an object, besides, it is well known that changes in surface roughness and morphology of the enamel structure may cause color alterations which may lead to unsatisfactory treatment results,[7,8] studies evaluating the interaction between surface morphology and color changes are necessary.

During orthodontic treatment bracket loss problems are frequently encountered. Therefore, it is important to understand how the enamel surface is affected by the repeated cleaning/polishing and bracket rebonding procedures, to follow the most appropriate cleaning protocol in repeated bracket bonding procedures. Otherwise, tooth discolorations become inevitable for orthodontic patients with frequent bracket loss.

This study aimed to detect any relevancy between repeated bonding-debonding of two different mesh-based metal-brackets and enamel color abnormalities by utilizing a digital spectrophotometer and to investigate the adhesive remnant (ARI scores) after adhesive resin removal followed by two different finishing procedures utilizing either sof-lex discs or whitestone-bur. The null hypothesis that was aimed to be evaluated is that repeated bracket debonding, cleaning, and polishing procedures will cause enamel loss leading to discoloration clinically, and that the whitestone-bur would be more effective in minimizing the enamel discoloration when used for the polishing procedure.

Materials and Methods

Ethical approval for this study (Ethical Committee No: 2020/ 10-508) was provided by the Ethical Committee for Health Science Research of Yeni Yuzyil University, Istanbul, Turkey on 7 October 2020. This research was performed according to the rules of Helsinki and the Guiding Principles in the Care and Use of Animals (DHEW Publication, NIH, 80-23).

Among 56 extracted premolar teeth stored in distilled water after extraction, 40 that had been found as adequate for selection criteria presenting the absence of demineralization lesions, fractures, or restorations on the buccal surfaces were chosen as the study sample.

The extracted teeth were impeded vertically in self-curing orthodontic acrylic within a specially designed cubic container from the apex till the cement-enamel junction so that the crowns were completely above the acrylic surface in distilled water at room temperature to prevent dehydration.

After prophylaxis with pumice with a prophylaxis brush using a slow handpiece for 10 seconds and then randomly divided into two groups as G1 and G2, equally, according to the mesh base metal bracket system used. Then both main groups were further subdivided into two equal subgroups as G1A, G1B, G2A, and G2B according to the polishing method used after adhesive removal (Table 1).

Table 1. Study groups.

Main Groups (n=20)	Bracket Type	Subgroups (n=10)	Polishing Method
Group 1 (G1)	80-gauge foil-mesh base metal brackets (American Master Series ,American Orthodotics, Sheboygan, Wis)	G1A	Whitestone polishing bur (Abrasice Technology, Inc., Lewis Center, Ohio, USA)
		G1B	Sof-lex finishing discs (3M, ESPE, USA)
Group 2 (G2)	Micro-etched base brackets (3M Unitek Miniature Twin Brackets, 3M USA)	G2A	Whitestone polishing bur (Abrasice Technology, Inc., Lewis Center, Ohio, USA)
		G2B	Sof-lex finishing discs (3M, ESPE, USA)

The digital color evaluation was performed using a spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Sackingen, Germany) by a single operator before first bracket bonding (T0). The digital color evaluation was carried out on the mid-third of the buccal surface of the teeth. A stone tray was used to standardize the position of the digital colorimeter. Every digital color measurement was repeated five times to minimize operator errors.[9]

Prior to bracket bonding, the mid-third of the buccal surface of all teeth were etched using 38% phosphoric acid etching gel (Etch-Rite) for 30 seconds followed by rinsing and drying with compressed air.

All teeth were bonded using Transbond XT (3M Unitek, CA, USA) orthodontic adhesive. Upper premolar metal brackets were placed onto the etched surfaces and light curing for 40 seconds (Optilux™ XT, 3M Unitek) was performed.

To induce variations in moisture and temperature in the oral environment, all specimens were thermally cycled in deionized water solution at 5±2ºC to 55±2ºC for 500 cycles. The total period of exposure to both 5±2ºC and 55±2ºC was 10 seconds, with a dwell time of five seconds in each bath.

After the thermocycling procedure, a bracket removal plier was used to remove brackets (Inspire Ice Debonding Kit, Ormco, Glendora, California, USA). The site of adhesive fracture with the adhesive remnant index (ARI) was measured visually. A high-speed orthodontic debonding carbide bur was used for all samples in all groups by a single operator to remove adhesive remnants.

After the enamel surface was polished (T1) with White-stone polishing bur in G1A and G2A, and sof-lex finishing discs (3M, ESPE, USA) in G1B and G2B (Abrasive Technology, Inc.

Lewis Center, Ohio, USA), the second color measurement was performed. These procedures and measurements were repeated two more times (T2 and T3).

The color changes (ΔE) were calculated from the measured color parameters L*a* and b* according to the following formula which is used to determine the three-dimensional L*a*b* color space:[10,11]

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

Statistical analysis was performed with SPSS V.25 (IBM, New York, NY). Statistical significancy was set as $p<0.05$. The findings were measured within a confidence interval of 95%. All ΔE data were normally distributed as assessed by Shapiro-Wilk's test. Independent samples t-tests were used to compare ΔE between study groups. ANOVA with post-hoc analysis with a Bonferroni adjustment was used to compare ΔE between time points in each group. Mann-Whitney U t-tests were used to compare ARI scores between study groups. Friedman's tests with post-hoc analysis with a Bonferroni adjustment were used to compare ARI score between time points in each group. Finally, the whole sample size was retested for total color difference in each group to be compared with original study results for four times at each time point (T0, T1, T2, and T3) by using independent samples t-test.

Results

The result showed that there were statistically significant differences between T1 and T2 in groups G1B and G2A according to ΔE values (Table 2). In G1B and G2A, ΔE values at T2 were statistically significantly higher than T1 by 4,7 units (p=0.022) and 5,6 units (p=0.002) respectively (Table 2).

Discussion

In the present study, the null hypothesis was confirmed. There was a difference between the two polishing techniques in means of surface roughness, and the results showed that the enamel color change was significantly higher after the third bracket debonding as expected.

Table 2. Mean and Standard deviations for ΔE values at T0, T1, T2, and T3.

Time Point	G1A Mean±SD n=10	G1B Mean±SD n=10	G2A Mean±SD n=10	G2B Mean±SD n=10
T0	17.1±4.3	13.6±4.2	16.6±5.6	15.2±4.5
T1	11.7±3	12.3±3	11.5±4	11.3±4.7
T2	13.2±3.7	17±4	17.1±4.4	11.7±3.1
T3	12.2±4.8	12.2±3.2	11.5±3.3	14.6±5
p	*.002**	*.003**	*.000**	*.059**

*Repeated measures ANOVA *p<0.05*

Regarding the bracket base mesh, the results showed that only in T2 the ΔE in G2A was statistically significantly higher than G1A by 3.9 units (p=0.045). Moreover, only in T2 the ΔE in G1B was statistically significantly higher than G2B by 5.3 units (p = 0.004), (Tables 3 and 4).

Table 3. Effect of bracket mesh base type on ΔE in White Stone group.

Time Point	G1A Mean±SD n=10	G2A Mean±SD n=10	Mean Difference	p
T0	17.1±4.3	16.6±5.61	0.5	0.5
T1	11.7±3	11.5±4	0.2	0.2
T2	13.2±3.7	17.1±4.4	-3.9	-3.9
T3	12.2±4.8	11.5±3.3	0.6	0.6

*Repeated measures ANOVA *p<0.05*

Table 4. Effect of bracket mesh base type on ΔE in Sof-lex group.

Time Point	G1A Mean±SD n=10	G2A Mean±SD n=10	Mean Difference	P
T0	13.6±4.2	15.2±4.5	-1.6	*0.424*
T1	12.3±3	11.3±4.7	1.0	*0.594*
T2	17±4	11.7±3.1	5.3	*0.004**
T3	12.2±3.2	14.6±5	-2.4	*0.215*

*Independent samples t-test *p<0.05.*

Regarding the polishing methods, the results of the mean study revealed that in T2 the ΔE in G1B was statistically significantly higher than G1A by 3.8 units (p=0.043). Furthermore, in T2 the ΔE in G2B was statistically significantly higher than G2A by 5.4 units (p=0.005), (Tables 5 and 6).

In the present study, the ARI score was either 0 or 1 in T1 after the first debonding procedure for all groups (Table 6).

Table 5. Effect of polishing method on ΔE in American Master bracket group.

Time Point	G2A Mean±SD n=10	G2B Mean±SD n=10	Mean Difference	P
T0	17.6±4.3	13.6±4.2	3.5	*0.082*
T1	11.7±3	12.3±3	-0.6	*0.680*
T2	13.2±3.7	17±4	-3.8	*0.043**
T3	12.2±4.8	12.2±3.2	-0.1	*0.971*

*Independent samples t-test *p<0.05.*

Table 6. Effect of polishing method on ΔE in 3M Unitek bracket group.

Time Point	G2A Mean±SD n=10	G2B Mean±SD n=10	Mean Difference	P
T0	17.6±4.3	13.6±4.2	3.5	*0.082*
T1	11.7±3	12.3±3	-0.6	*0.680*
T2	13.2±3.7	17±4	-3.8	*0.043**
T3	12.2±4.8	12.2±3.2	-0.1	*0.971*

*Independent samples t-test *p<0.05.*

Discussion

In the present study, the null hypothesis was confirmed. There was a difference between the two polishing techniques in means of surface roughness, and the results showed that the enamel color change was significantly higher after the third bracket debonding as expected.

Most of the researches in the literature has focused on evaluating the tooth color changes using different bracket types and adhesive cleaning methods, but no study has evaluated the effect of repeated bonding procedures along with bracket types and adhesive residuals' cleaning methods.[12] Thus, the aim of this study was to investigate if there was any relationship between repeated brackets bonding and enamel color changes by using a digital spectrophotometer and to evaluate the adhesive remnant (ARI scores) after adhesive resin removal followed by two different finishing procedures utilizing either sof-lex discs or whitestone-bur in order to find the most efficient and less harmful procedure to be used for repeated loss of brackets.

In a study conducted by Karamouzos et al.[1], L* values decreased, but a* and b* values increased when tooth color was measured before and after orthodontic treatment, with tooth color darkening and moving toward more red and yellow color ranges. However, in the present study, a significant color change was only observed after the third bracket debonding procedure. This could be explained by the different residual adhesive cleaning and polishing methods used in the two studies.

According to Eliades et al.[6] debonding and cleaning techniques are responsible for enamel color changes and enamel color variations are often due to permanent penetration during the cleaning process of the colored residual composite. Orthodontic adhesive mechanisms and the burs used to remove and clean the residual composites from the tooth surfaces are also responsible for changes in teeth color, as removal of adhesive resin may also result in physical enamel modification, varying from surface roughening to microscopic defects like microcracks.[13,14] One of the primary goals of orthodontics therapy is to achieve maximum preservation of tooth structures with minimum defect during bracket removal and polishing procedure.[15] Enamel impairment during bonding and debonding processes makes the color of yellow dentin more noticeable, or the surface irregularities created by the polishing techniques can alter the reflection of light and modify the color of the teeth. Moreover, several repeated bracket bonding is often required in patients that have bad parafunctional oral habits or Class II, Division 2 malocclusion where upper incisors meet with the lower incisor brackets.[16]

According to the results of the present study, it was observed that the enamel color significantly differed at the second debonding event when either the 80-gauge foil-mesh base metal brackets in addition to sof-lex discs (G1B) were used or the Micro-etched base brackets in addition to white stone burs (G2A) were used. The bracket type did not have any significant effect on the enamel color difference unless the debonding procedure happened for the second time. This result supports the findings of a previous study conducted by MacColl et al.[17], where it has been indicated that the micro-etched bracket base is more retentive and causes more enamel roughness after removal when compared to 80-gauge foil-mesh base brackets. Interestingly, no statistically significant difference at any time point was seen for G2B group, indicating that the combination of the Micro-etched base brackets and sof-lex discs did not affect the total color enamel at any time point. These results indicate that the polishing type did not have an effect on the enamel color unless the debonding procedure happened for the second time. Earlier studies advocated that the polishing procedure using sof-lex discs restored the enamel surface closer to its pretreatment condition with less enamel surface damage.[18] Controversially, other researchers claimed that sof-lex discs cause more damage to the enamel surface as they were used in a dry condition[19]. Similar to Mohebi et al.[20], findings, the results of the present study showed that, polishing with whitestone bur used on a low-speed handpiece after the second debonding and cleaning procedures was found to be more effective in achieving a smoother enamel surface ending up with increased light reflection and less detectable color alteration.

Henkin et al.[21], evaluated the ARI score in seven different types of orthodontic brackets, and only one single type, UNIDEN™, showed a significantly lower ARI score. From the previous studies, it might be hypothesized that a special conditioning of the bracket base by micro etching, for instance, might

affect the results of either enamel color change or ARI scores.[21] Thus, in the current study, two different types of metal brackets which have different mesh bases were chosen as were 80-gauge foil-mesh base metal brackets (American Master Series, American Orthodontics, She-boygan, Wis) and micro etched base brackets (3M Unite Miniature Twin Metal Brackets, 3M United States). In the present study, the ARI score was either 0 or 1 in T1 after the first debonding procedure for all the studied groups. Similarly, Henkin et al.[21] evaluated the ARI score after debonding procedure for more than a hundred teeth with different bracket types and designs and they found that the ARI score was between 0 and 1 for most of the studied sample. Results of the present study showed that the ARI score in T3 was statistically significantly higher than both in T1 and T2, however, no statistically significant difference was found between T1 and T2. These results indicate that the debonding procedure did not affect the ARI score unless the debonding happens for the same bracket more than two times. In other words, the amount of remaining composite will be higher after the third bracket debonding procedure which indicates that repeated bracket bonding on the same tooth due to repeated bracket loss may cause more enamel roughness which may also affect the tooth color.

Conclusion

Even though there are potential methodological limitations, according to the results of the present study, the following conclusions were drawn:

- Repeated bracket applications have an effect on enamel color even if not visible by the naked eye.
- The bracket base type does not affect the amount of residual adhesive after properly performed debonding procedures.
- The amount of residual adhesive increases significantly after the third debonding procedure in all groups which indicates that repeated bonding of brackets needs more detailed enamel polishing, increasing the risk of scratching the enamel surface.

In the limitations of this study, it was concluded that repeated loss of bracket of the same tooth causes additional adhesive residual on the tooth surface, which could be successfully removed by tungsten carbide bur and sof-lex discs. Therefore, clinicians should clean all adhesive remnants carefully before applying a new bracket after repeated bracket loss.

Repeated bracket loss due to abnormal occlusal forces observed especially in Class II, division 1 malocclusion with deep bite, is a common problem in fixed orthodontic treatment which negatively affects the esthetic results of the treatment. Enamel color change is one of the problems faced in repeated bracket loss due to irregularities on the enamel surface. To overcome this problem additional polishing methods should be used after every bracket loss.

Conflict of interest

None of the authors of this article has any relationship, connection or financial interest in the subject matter or material discussed in the article.

Sources of Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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