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Article

IN-VITRO EVALUATION OF DIFFERENT POLISHING METHODS AFTER BRACKET DEBONDING

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ABSTRACT

This study evaluated the performance of two different polishing methods on the enamel surface roughness of teeth following adhesive removal with a tungsten carbide bur. To this end, we examined 45 premolar teeth, randomly divided into three groups (C, SLD, and BG) with 15 teeth per group. To experiment, we attached stainless steel brackets to all three groups and later removed the brackets with debonding pliers. Afterwards, the composite resin remnant on the enamel surface was removed with a composite finishing tungsten carbide bur in all three groups. Group C did not receive any polishing after adhesive removal. Group SLD and BG underwent a polishing process using Sof-Lex discs (SLD) and Brownie-Greenie (BG), respectively. Subsequently, the areal enamel surface roughness parameters were analysed using the Keyence VK-X100 laser scanning microscope (LSM) at 10x, 20x, and 50x magnification. The results demonstrate significantly less surface roughness following both polishing methods compared to the control group. Furthermore, group SLD showed significantly less surface roughness compared to BG ($p<0.01$).

KEYWORDS: *bonding, dental adhesives, orthodontic brackets, dental resins, surface roughness*

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INTRODUCTION

Currently, the use of fixed appliances for orthodontic tooth correction is the most common treatment method. This method requires bonding and subsequent debonding of the brackets (1–3). The composite remnants are then removed with dental burs (i.e., tungsten carbide burs, diamond burs, composite burs, or stainless-steel burs). The debonding process increases the enamel surface roughness of the teeth and the cracks and removes the outermost fluoride-rich enamel layer that may cause damage to the teeth. In addition, resulting surface roughness, caused by resin removal using dental burs, increases accumulative dental plaque biofilms and food residue attachment.

Consequently, this increases the cariogenicity and risk of white spot lesion formation. Polishing the tooth surface after debonding can reduce these damages (4-8). Therefore, various polishing methods have been suggested, including polishing with Sof-Lex discs (SLD), Sof-Lex spiral wheels polishing brushes, and Brownie-Greenie (7, 9, 10). However, no consensus exists on the most suitable polishing method. There is also a lack of comparative studies regarding surface roughness following the use of SLD and BG.

Furthermore, studies have used different methods of measurement, such as scanning electron microscope (SEM), profilometer, and micro-computed tomography, which are mostly contact type or destructive type methods, making before and after comparisons impossible (11–17). Therefore, this research aims to compare two polishing methods of SLD and BG using a laser scanning microscope (LSCM).

MATERIALS AND METHODS

The present in vitro study was conducted with 45 extracted intact premolar teeth. The exclusion criteria included visible crack lines, caries, restorations, dental anomalies, and a history of previous orthodontic treatments.

The teeth were cleansed from visible blood, food, and tissue debris. They were then cleansed utilising a polishing brush (Nylon brush, Komet Dental, Germany), polishing paste (Super Polish, Kerr Dental, Switzerland), and dried with a mild oil-free air stream. They were then stored in a physiological saline solution at room temperature.

Subsequently, the enamel surfaces of the teeth were etched with a 35% phosphoric acid solution (Ultra-Etch etchant, Ultradent Products, Inc., USA). Afterwards, all tooth surfaces were carefully cleaned and rinsed with water spray for 60 seconds. Following the enamel conditioning procedure, iBond (iBond Self Etch, Heraeus Kulzer, Germany) was applied to the tooth surfaces.

The prepared surfaces were cured by light using a Mini LED (Acteon Groups, Satelec, France) with light for 20 seconds. The light-curing nanohybrid composite Grandio SO (VocoGmbH, Germany) was applied to the back of metal edgewise premolar brackets (Silver Motion, World Class Orthodontics, Ortho Organisers GmbH, Germany), and the prepared brackets were then placed on the teeth. The excess composite was removed with an explorer, and the Mini LED was used to cure the composite for 40 seconds (10 seconds each for the mesial, distal, occlusal, and gingival surfaces).

Afterwards, the brackets were debonded with an angulated bracket removing plier (Hu-Friedy, Chicago, USA). Next, the adhesive remnants were removed with a 30-blade ultra-fine tungsten carbide finishing bur with a low-speed contra-angle handpiece (Gentlepower Lux 20 LP 1:1, Kavo Dental, Germany), operating at up to 20,000 rpm, using water coolant for 35 seconds per tooth. Subsequently, teeth were randomly divided into three subgroups (15 teeth per group): group SLD, group BG, and group C as the control group.

The teeth in group C did not receive any polishing treatment. The teeth in group SLD were first polished with Sof-Lex discs (Pop-On, 3M ESPE, USA) for 15 seconds and afterwards with a polishing brush (Komet Dental, Brasseler, Germany) for 7 seconds. Polishing in group BG was performed using Brownie (Shofu Dental, Kyoto, Japan) and Greenie (G Shofu Dental, Kyoto, Japan) for 10 seconds per tooth.

The teeth were then embedded into a silicone key (Silagum Putty, DMG, Germany), and their surface roughness was measured with a VK-X100 3D laser scanning microscope (Keyence, Japan). The samples were placed on the rotating stage, and the laser beam measurements were made in the same level longitudinal slices of the samples. We could then analyse the surface roughness using the VK application by using autofocus to achieve optimal sharpness of the images. The results of this study demonstrated strong inter-rater reliability based on the Intra-Class Correlation Coefficient (ICC) of> 0.9999 and a p-value <0.01.

Data analysis and visualisation were carried out using the statistical program BiAS (Epsilon Verlag, Germany). The areal roughness parameters [3D surface roughness (texture) parameters] were used to compare the quality of the two polishing methods and their differences with the untreated tooth surface. In addition, the arithmetical mean height (Sa), maximum peak height (Sp), maximum pit height (Sv), maximum height (Sz), and surface texture (Str) parameters were considered for all surface measurements for three groups with the conditions in order to analyse the surface roughness. During this research, all operators wore surgical masks to prevent the spread of the respiratory system virus (18) and maintain office hygiene (19, 20).

RESULTS

The Sa parameter is used to determine surface roughness and represents the differences between the height of each point and the arithmetical mean of the surface (21). Factors such as diet, differences in the tooth surface, enamel surface porosity, and iatrogenic damage to the enamel surface during tooth extraction cause changes to the surface roughness and Sa value. The Sa was measured on five teeth with a magnification of 10x, 20x, and 50x.

Although the first and second observations were made on the same tooth at 50x magnification, a difference was observed in the Sa values due to the different adjusted examination fields set under the bracket. Thus, with deviations of up to 0.273 µm, we used the average value for Sa. To determine the inter-rater reliability, we selected two data sets with five teeth in each data set; each tooth was measured three times. During refocusing of the first data set, among the five teeth measured, the maximum difference in the Sa value was 0.002 µm, while the maximum difference during repositioning was 0.004 µm. The ICC obtained in refocusing the first test data set was 0.999962 (p-value <0.01), while the ICC for repositioning was 0.999921. In the second data set, the maximum difference in Sa during refocusing was 0,001µm with an ICC = 0.999981, while the maximum difference for repositioning was 0.003 µm with an ICC = 0.999932. For each sample in the second data set, repositioning and refocusing had a p-value of <0.01. The maximum difference of both test subjects for refocusing was 0.002 µm, and for repositioning was 0.003 µm (ICC= 0.999955 and p-value<0.01).

The comparison of Sa values between the groups SLD and BG showed significant differences in the surface roughness with p<0.01, whilst between groups BG and C (control group) there was a major difference with p<0.01, the difference between groups SLD and C was p<0.05. One of the causes for the differences between the SLD and BG polishing methods may be the rough properties of the BG instruments. Even though polishing with SLD highly reduced the roughness, it did not eliminate the entire microscopic surface grooves. None of the SLD and BG polishing methods was able to remove all the remaining composite residues in some areas of the enamel surface, resulting in the increased roughness of the enamel surface (Fig. 1-3).

Thus, roughness plaque accumulation may occur in all methods due to the increased enamel surface. However, it is possible to manage plaque accumulation following the SLD polishing method with adequate oral hygiene. Nevertheless, while the SLD method showed better results than the group BG, both polishing methods significantly improved the enamel roughness compared to the control group C.

Sp describes the highest point of the defined area from the enamel surface (21). Therefore, the Sp value shows that the

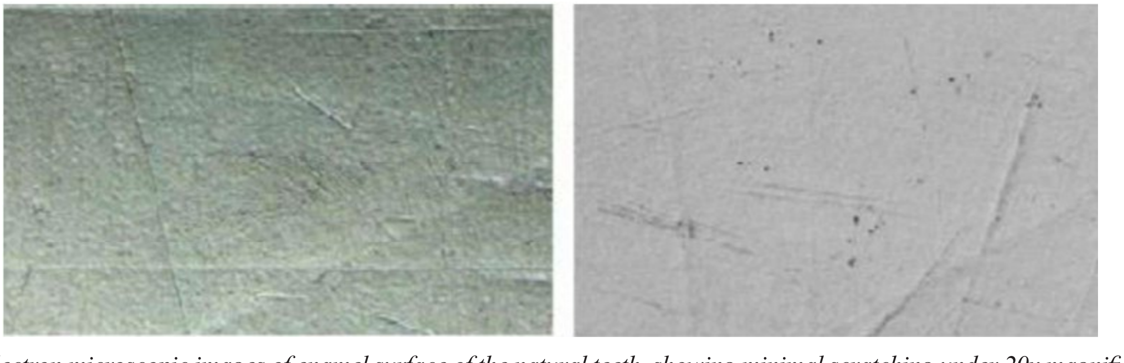

Fig. 1. *Electron microscopic images of enamel surface of the natural teeth, showing minimal scratching under 20x magnification.*

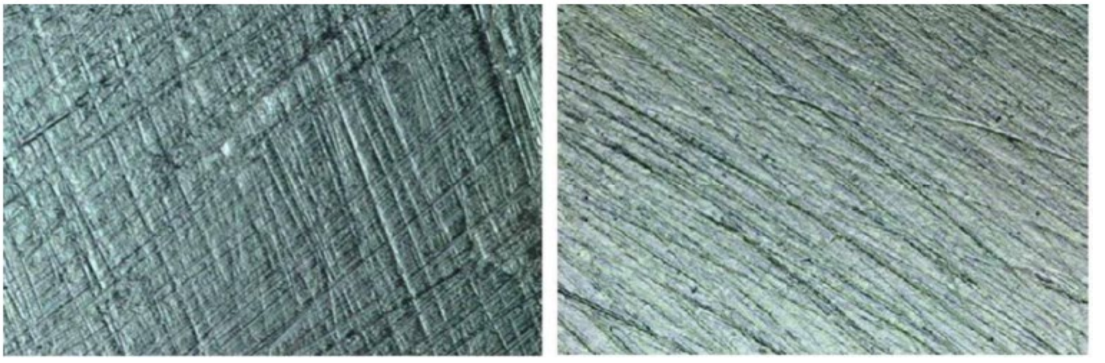

Fig. 2. *Electron microscopic images of enamel surface after adhesive remnant removal with SLD method, showing deep cracks and extensive scratching under 20x magnification.*

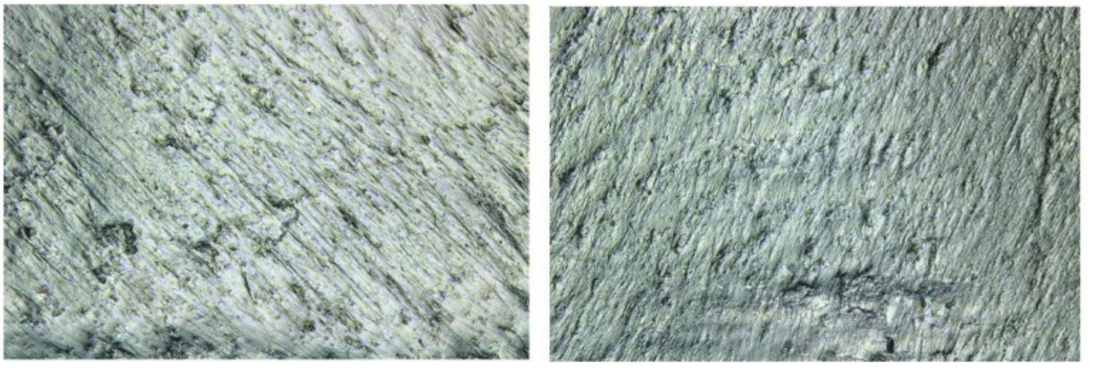

Fig. 3. *Electron microscopic images of enamel surface after adhesive remnant removal with BG method, showing spotting and dents under 20x magnification.*

roughness levels of groups SLD and BG are not significantly different ($p>0.05$). Furthermore, the Sp value for group C (control group) was lower than groups SLD ($p>0.05$) and BG ($p<0.01$).

Sv expresses the deepness of the pits from the enamel surface (21), and the value differs significantly in group BG ($p<0.01$). There was also a significant difference between groups SLD and C ($p<0.05$) for Sv. Due to the BG method's inability to smooth the pits and grooves on the surface evenly, the observed grooves and pits were caused mainly by mechanical damage during the treatment and polishing processes.

Sz is the sum of the Sp and Sv values within the defined area and it presents the value of the surface irregularity (21). As expected from the Sp and Sv results for group BG, this method has the maximum Sz value ($p<0.01$). In addition, a significant difference between groups SLD and C ($p<0.05$) for Sz was also observed.

Str explains the isotropy and anisotropy of the surface texture (21). When the Str values are near zero, this shows high texture uniformity. Contrarily, when the Str values are closer to one, this indicates a low texture uniformity. Group SLD had the lowest Str values in contrast to groups BG, and C. Group C did not show any significant differences from the other groups ($p>0.05$). Thus, group SLD showed the most recurring patterns on the surface.

DISCUSSION

We aimed to compare the effects of two adhesive remnant removal methods in an in vitro experiment using LSCM. The topic of adhesive remnant removal after bracket debonding remains relevant today since no consensus on the most suitable method of adhesive removal exists.

Similar studies have shown an increase in surface roughness regardless method used. A single study, however, has shown a decrease in the roughness after adhesive removal, which could be due to the operator's skills (22). Similar to other studies, we also showed a higher surface roughness after polishing with SLD and BG compared to the natural teeth surface. However, SLD seems to be the superior method, as it shows less surface roughness compared to BG. Other studies have adopted different methods of surface roughness evaluations. The methods include scanning electron microscopy (SEM) (17, 23-25), contact profilometry (26), or atomic force microscopy (27). These methods are destructive and abrasive, thus, making before and after comparisons impossible. They are also subjective assessments and do not provide the possibility of quantitative objective evaluations, thus creating bias in the results of these studies. LSCM, on the other hand, is a non-destructive method that makes quantitative measurements possible. Therefore, the risk of bias in our measurements is lower than in other studies.

CONCLUSION

Group SLD and BG differ significantly concerning their Sa values ($p<0.01$). The comparison of group C with group SLD revealed a significant difference for Sa ($p<0.05$), whilst group BG showed a highly significant difference ($p<0.01$) compared to group C. Under objective evaluation, the SLD method achieved superior polishing results, yielding a less rough surface than the BG method. This investigation also revealed a significant difference in surface roughness for both polishing groups compared to untreated teeth. Nevertheless, treated and polished teeth using SLD and a polishing brush can show a similar surface roughness to some untreated teeth.

Competing interests

The authors declare that they have no financial or non-financial competing interests.

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