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RESEARCH ARTICLE

Evaluation of surface roughness of the bracket slot before and after burning

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ABSTRACT

Slot bracket base is one important element to enable sliding movement of the archwire. Bracket reconditioning by means of burning changes the surface roughness of slot bracket base. The heat above 450 °C shows microstructure changes of the slot surface. On this basis, the present study aims to evaluate surface roughness changes of the slot bracket base before and after reconditioning by means of burning. Sixteen premolar brackets standard edgewise were divided into two groups each consisting of eight brackets. These two groups were tested at three different points using Scanning Electron Microscopy (SEM), with 3000 times of magnification. Subsequently, group A was burned for 5 seconds (approximately 450 °C) and group B was burned for 10 seconds (approximately 643 °C). After treatment, these two groups were tested for the second time using Scanning Electron Microscopy (SEM), with 3000 times magnification and the images were analyzed using a discrete scale quantitative classification. Afterwards, the data were analyzed using ANOVA ($p \leq 0.05$) and post hoc analysis. The result showed that surface roughness of the slot bracket base burned for 10 seconds experienced more significant change than that of bracket burned for 5 seconds and that of the control bracket ($p \leq 0.05$). Bracket reconditioning using burning either for 5 to 10 seconds change the surface roughness of the slot bracket base.

Keywords: Scanning Electron Microscopy (SEM); slot bracket base; surface roughness

INTRODUCTION

Orthodontists often have to deal with the bracket that comes loose from the patient's teeth to be reattached to its position.[1] This problem may lead to various disturbances, time-consuming maintenance and additional cost for the repair. When the previously used mesh bracket is not damaged, the orthodontists only need to recondition the bracket.[2] Reconditioning the bracket is mainly chosen because it does not affect the retractive properties of the bracket base to the teeth.[3]

Previous research reveals that the ideal temperature level that affects metal elements in bracket reconditioning ranges from 400 °C to 900 °C because at this temperature levels, the microstructure changes in bracket surface, size and mechanical properties of the bracket take place. The heat used in the reconditioning process causes chromium to bind to carbon to form deposits of chromium carbide ($Cr_{23}C_6$) on the surface, resulting in reduced surface roughness and ability to resist corrosion. This image of microstructural elements on the surface is referred to as an "island formation" which is an arrangement of metal grains bounded by a carbide area called the grain boundary.[2,4]

MATERIALS AND METHODS

As an experimental laboratory research, the researcher conducted the in vitro test and shooting process at the Center for Textiles, Bandung in June 2017. This study used sixteen standard premolar edgewise brackets as the research sample which was determined based on the formula. First, these sixteen standard edgewise premolar bracket pieces were divided randomly into group A and B. These samples were tested to classify their surface roughness in three different basic slots using a 3000x magnification SEM. These tested bracket pieces were divided into 3 areas, namely the center of the left side, the center of the center and the center of the right side.

In the following stage, the base surface of the slot was scanned to be presented on a computer screen to represent the basic topography of the micro-size slot with 3000x magnification. The resulted image was then subjected to visual evaluation using a special quantitative scale classification (discrete scale quantitative classification) which was divided into 4 scores,[5] 0: very rough surfaces (It contains damages or enlargement of grain boundaries with obvious scale/ cracks/ deformation); 1: rough surface (If/when it shows apparent grain boundaries or sensitization, and inclusion); 2: smooth surface (If it has no visible grain boundary/transition area between two adjacent granules, and the surface is uneven); 3: Very smooth surface (if there is no obvious grain boundary).

The bracket passing the first surface roughness test was then burned for reconditioning. Group A was burned using a torch for 5 seconds with a temperature of approximately 450 °C and group B was burned for 10 seconds using a temperature of approximately 643 °C.

The level of temperature used in this study was resulted from the temperature measurement of the flame produced by the torch using thermocouple. The measurement in was done by placing the flame torch at the end of the thermocouple which was repeated for 3 times. The longer the burning time, the higher the temperature on the thermocouple screen. The average temperature obtained at the 5th second was ± 450 °C, and at the 10th second the average temperature was ± 643 °C.

After being burned, the bracket was cooled to room temperature. Once the reconditioning stage was completed and it had returned to normal temperature, the slot bracket was then tested for the second time using SEM to determine its base surface roughness. The base surface of the slot was scanned and the results were presented on a computer screen that represented the base topography of the slot at 3000 x magnifications. The resulted image was then subjected to a visual evaluation using a special quantitative scale classification (discrete scale quantitative classification).

RESULTS

The results of the statistical analysis indicated that the group before burning had a better or finer surface condition than group A because the group before burning had a higher mean value than group A with a significant difference p-value of <0.05. The group before burning has a better or smoother surface than group B because the group before burning has a higher mean value than group B with a significant difference of p-value <0.05. Statistical results between group A and B reveal that group A had better or finer surface roughness than group B with a significant difference, p-value of <0.05.

The highest mean value in the three groups indicates that the group before burning has the lowest level of base surface roughness of the bracket slot. Group B has the lowest average value, so it can be concluded that group B has the roughest surface as compared to the group before burning and group A due to microstructural damage. The surface roughness obtained from shooting using SEM shows a picture of 2 Dimension (2D) bracket surface bases that vary in each group.

Table 1. Evaluation of base surface roughness of the bracket slot between Group before burning and Group A.

Grp	x	N	jr	p-value
K	16.5	16	264	0.000*
A	4.5	8	36	

Grp : Group
x : average value
n : Number of samples
jr : Total Average values
K : Group before burning
A : Group after 5 second-burning

*) the difference is significant if p < 0.05

Table 2. Analysis of base surface roughness of the bracket slot between group before burning and group B

Grp.	x	n	jr	p-value
K	16.5	16	264	0.000*
B	4.5	8	36	

Grp : Group
x : Average Value
n : Number of samples
jr : Total Average values
K : Group before burning
B : Group after 10 second-burning

*) the difference is significant if p < 0.05

Table 3. Analysis of base surface roughness of the bracket slot between group A and group B

Grp	x	n	Jr	p-value
A	11	8	88	0.0045*
B	6	8	48	

Grp : Group
x : Average value
n : Number of samples
jr : Total Average values
K : Group before burning
B : Group after 10 second-burning

*) the difference is significant if $p < 0.05$

Tabel 4. Analysis of surface roughness between the three groups using Kruskal-Wallis Test.

Grp	r	n	Med	p-value
K	24.50	16	3.00	0.000*
A	11.00	8	1.00	
B	6.00	8	0.00	

Grp : Group
x : Average Value
n : Number of samples
med : Median
K : Group before burning
A : Group after 5 second-burning
B : Group after 10 second-burning

*) the difference is significant if $p < 0.05$

Based on Figure 1 above, it is revealed that the base surface of the slot from the group before burning looks smooth without having obvious damages caused by the burning process. Figure 2 shows that the base surface of the slot from group A which has been burned for 5 seconds with a temperature of ± 450 °C indicates an apparent sensitization process on the base surface of the bracket slot as marked with visible grain boundaries due to the burning process and visible small holes.[6] Other visible damages are in the form of deformation with elongated grooves.

Figure 3 shows a surface damage in the form of sensitization with a marked grain boundary and small hole damage known as inclusion. Figure 4 is a picture taken from a group B showing a sensitization process that is marked by visible grain boundaries, holes caused by the release of metal elements (inclusions) and also cracks on the

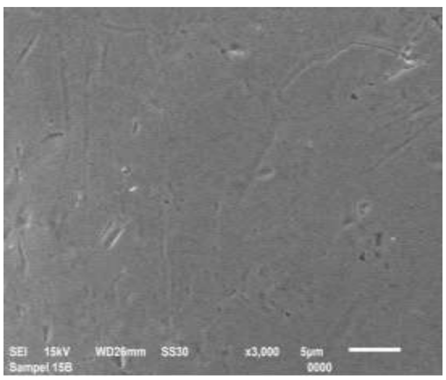

Figure 1. SEM 2 Dimensions of the base surface of the Group bracket slot before burning

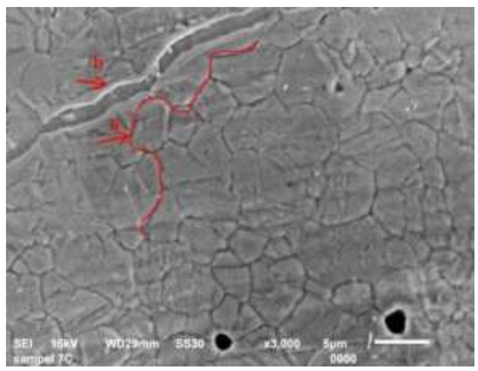

Figure 2. Surface damage in one sample of Group A. The damage is in the form of (a). Sensitization (b) surface deformation

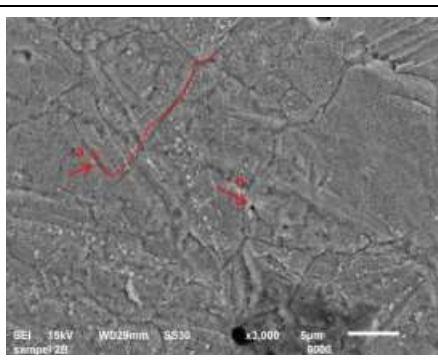

Figure 3. The damage in group A is in the form of (a) Sensitization (b) inclusion.

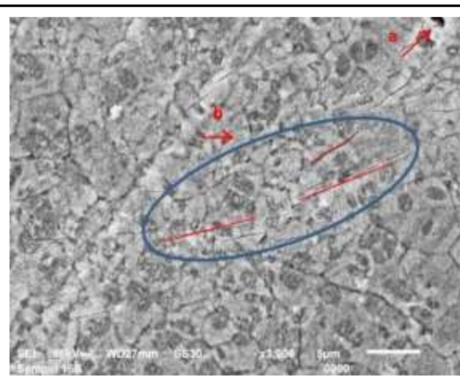

Figure 4. The damage to the surface of group B is in the form of (a) hole (Inclusion) and (b) cracks

surface that passes through grain parts caused by the high temperature of the burning process (transgranular fracture). The picture above also depicts a contrasting black and white color where white colors form a mist known as scale.[7,8]

DISCUSSIONS

Irregular surface or surface roughness can increase the number of areas for friction.[9,10] In addition, surface roughness due to corrosion on metal surfaces can lead to friction in orthodontic treatment.[10,11] Corrosion is resulted from the interaction between metal material and the surrounding environment, one of which is the impact of high heat exposure when reconditioning the bracket.

The temperature level that is proven to affect the metal elements in the bracket ranges from 400 °C to 900 °C. The heat used in the reconditioning process makes chromium bind to carbon to form deposits of chromium carbide ($Cr_{23}C_6$) on the surface. Chromium carbide deposits ($Cr_{23}C_6$) are formed by metal disintegration which then weakens the metal structure.[4,12]

This research was conducted to find out the description of 2D damage to bracket metal surfaces made of austenitic stainless steel caused by the reconditioning process using the Torch's flame source. The torch is commonly used every day by practitioners to remove residual adhesive attached to the bracket. The temperature level used in this study was obtained through temperature testing using thermocouple. To get the average temperature, the process was repeated for 3 times. The average temperature at the 5th second is ± 450 °C and at the 10th second is ± 643 °C.

Based on 2D images taken using SEM, we can see an image of "island formation" which is an arrangement of metal grains bounded by carbide regions called grain boundaries.[4,6] The group images that have not been burned do not indicate any damage or deformation and their surface image seems to be smooth. 2D images taken using SEM indicates light damage to the surface of the bracket burned for 5 seconds. The grain boundary is clearly visible due to high temperatures in the burning process which is referred to as sensitization. Some samples appear to be damage as indicated by some holes known as inclusion. The bracket that has been burned for 10 seconds indicates the roughest base surface of the bracket slot as compared to the bracket that has not been burned and that burned for 5 seconds. The 2D images taken using SEM illustrates the damage in the form of a sensitization as marked by visible grain boundaries, holes caused by the release of metal elements (inclusion), damage due to combustion that looks like crust (scale) and also cracks on the surface that passes through the body parts of the grain resulted from high combustion temperatures (transgranular fracture).

The impact caused by the bracket reconditioning process depends on the used reconditioning method, the type of metal, and the shape of the bracket base (for retention).[12] Judging from the type of metal, this study used austenitic stainless steel. The advantages of this type of metal is that it can easily be formed and tends to be more stable in hot and cold temperatures than other types of stainless steel metal.[13,14] Therefore, further research is needed on the factors to damage the austenitic stainless steel which is burned by temperatures below melting point (above 1000 °C).

Considering the method of bracket reconditioning, there are several alternative options to be used besides reconditioning the bracket by means of burning, for example using 10% hydrofluoric acid for 60 seconds, using a mixture of 32 % hydrofluoric acid and using 55 % nitric acid for 15 seconds. These methods are considered to be relatively safer because they do not cause any damage that is often triggered by reconditioning by mechanical or thermal means.[15,16]

CONCLUSION

Out of the other bracket groups, the bracket group without burning and the bracket group burned for 5 seconds, it is revealed that the roughest change of surface roughness is shown by the bracket group that has been burned for 10 seconds. The longer the burning process and the higher the temperature used, the rougher the base surface of the bracket slot due to microstructural changes. Hence, orthodontic practitioners are expected to no longer recondition the bracket by means of burning when the bracket comes loose to avoid adverse effects that can hinder treatment or adversely affect the patients.

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