Original Article

ENAMEL LOSS AND SUPERFICIAL ASPECT DURING BONDING AND DEBONDING OF METALLIC BRACKETS

PERDA DE ESMALTE E ASPECTO SUPERFICIAL DURANTE COLAGEM E DESCOLAGEM DE BRÁQUETES METÁLICOS

Emanuelle de Fátima FERREIRA[1]; Giselle Naback Lemes VILANI[1]; Wellington Corrêa JANSEN[2]; Hélio Henrique de Araújo BRITO[3]; Ricardo Alberto NETO FERREIRA[4]; Flávio Ricardo MANZI[5]; Dauro Douglas OLIVEIRA[6]

1. Private practice, Belo Horizonte, Brazil. vilani.bhe@gmail.com; 2. Associate professor and program diretor of Prosthodontics, Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil; 3. Associate professor of Orthodontics, Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil; 4. Research fellow, Center for Nuclear Technology Development, National Comission of Nuclear Energy (CDTN/CNEN), Belo Horizonte, Brazil; 5. Associate professor and program director of Dental Radiology, Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil; 6. Associate professor and program director of Orthodontics, Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil.

ABSTRACT: To evaluate the cumulative enamel loss during bonding and debonding procedures of orthodontic metallic brackets and to analyze the enamel superficial roughness. Forty-seven maxillary first premolars were obtained for quantitative and qualitative analysis. For quantitative analysis, forty premolars were weighed at each stage of treatment and the equivalent thickness of enamel loss was measured. The amount of tooth mass loss in each stage was divided by the density value to obtain the corresponding enamel volume lost. Subsequently, these volumes were divided by a circular area with a diameter of 7 mm, thus obtaining the equivalent thickness of enamel loss. They were assessed under the following conditions: as sound enamel, after acid conditioning, following the removal of residual resin composite, after final polishing with high or low-speed, and with or without water refrigeration. A rugosimeter was used to obtain a graphic registration of the enamel superficial roughness before and after acid conditioning. The data were analyzed with the Quantikov software and the Shapiro Wilk's and Wilcoxon statistical tests were used to evaluate enamel superficial roughness. The one-way ANOVA followed by Bonferroni Post-Hoc tests were used to analyze the amount of enamel loss. For qualitative analysis, scanning electron microscopy (SEM) of the enamel surfaces was performed on seven premolars, one in each step. Acid conditioning significantly increased enamel surface roughness ($p<0.01$). Based on the dental mass weighed after each stage of evaluation, enamel loss was statistically significant in all stages ($p<0.01$). However, when the 4 different final polishing methods were compared, no statistically significant differences were registered regarding loss of mineralized structure ($p=0.72$). The SEM analysis revealed that the tungsten-carbide bur with water refrigeration and low-speed rubber points caused less damage to the enamel. The greatest amount of enamel loss was due to acid conditioning. The losses relative to abrasion with composite removal or after the 4 polishing protocols were similar. Finally, none of the enamel surfaces was restored to their original aspects after bonding and debonding metallic brackets.

KEYWORDS: Dental Enamel. Brackets. Dental Polish.

INTRODUCTION

One of the orthodontist's main concerns after debonding fixed appliances is to reestablish the original smoothness of the enamel surface and to perform procedures that would cause the least amount of enamel loss (BISHARA et al, 1994; SESSA et al, 2012). Removal of the remaining composite from tooth surfaces may damage the external layer of the enamel (MAHDAVIE et al, 2014), which presents higher mineral content than do the deeper layers (KARAN et al, 2010; PONT et al, 2010). Such damages may diminish the enamel resistance and increase the potential for biofilm accumulation and decalcification, thus compromising both function and esthetics (ZACHRISSON; ARTHUN, 1979).

Different methods to remove the remaining composite and to polish the enamel surface after bracket debonding have been reported in the literature, such as tungsten carbide burs at low or high speed, green stones, diamond or steel burs, hand instruments, ultrasonic tools or lasers, and Soft-lex discs (GWINNET; GORELICK, 1979; RETEIF; DENYS, 1979; ZACHRISSON; ARTHUN, 1979; BISHARA et al, 1994; CAMPBELL, 1995; ZARRINIA et al, 1995; RYF et al, 2012; JANISZEWSKA-OLSZOWSKA et al, 2014). No consensus exists regarding the most efficient method that is also the least damaging to the dental enamel. Although many authors have made recommendations based on the characteristics of the enamel surface after debonding, only a few studies have quantitatively and directly measured the actual enamel loss related to such procedures

Received: 28/05/15
Accepted: 20/01/16

(RYF et al, 2012; JANISZEWSKA-OLSZOWSKA et al, 2014).

Therefore, the present study performed a quantitative and qualitative analysis of possible enamel loss at each stage of bonding and debonding of orthodontic metallic brackets and analyzed the enamel superficial roughness after different protocols for final polishing of the enamel.

MATERIAL AND METHODS

Forty-seven maxillary first premolars were obtained from the Human Teeth Bank (Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil). The teeth were cleaned by removing the soft tissues and stored in distilled water at room temperature until they were ready for use. As inclusion criteria, the teeth should have intact buccal surfaces, without carious lesions, cavitation, and/or restoration. Forty teeth were submitted to quantitative analysis and 7 to qualitative analysis. All experimental procedures were approved by the Institutional Review Board of our university.

The 40 initial teeth were dried with a hair dryer (PRO 1500, Tany, Porto Alegre, Brazil) for 4 minutes to dehydrate and eliminate the influence of water on their weight. The teeth were then individually weighed on a scale with 10^{-5} g resolution (AT201, Mettler-Toledo Ind. e Com. LTDA, Barueri, Brazil).

The premolars were then immobilized with a rigid fixation system to ensure that the profile of the buccal enamel to be probed by the rugosimeter (Talysurf 10, Rank Taylor Robson, Leicester, UK) feeler was in the same position before and after acid conditioning of the enamel (Figure 1). Before each reading, the enamel surface was dried with the hair dryer.

Figure 1. Premolars were immobilized with a rigid fixation system to standardize the position in which the profile of the buccal enamel was probed by the rugosimeter feeler.

After surface roughness measurement of the sound enamel, and without removing the tooth from the fixation system, acid conditioning was performed with 37% phosphoric acid (Condac 37, FGM Produtos Odontológicos, Joinville, Brazil) for 15 seconds in the area where the brackets would be bonded. After rinsing with water for 10 seconds and completely drying the tooth, a new enamel surface roughness reading was obtained. The teeth were dried again with the hair drier for another 4 minutes, before they were weighed to calculate the loss of enamel mass following the acid conditioning. This third drying was necessary to control the interference of humidity in the weighing of the teeth.

The graphic representation of the enamel surface pre- and post-acid conditioning were scanned and measured with Quantikov, a software package developed by the School of Engineering of the Federal University of Minas Gerais (Belo Horizonte, Brazil). The Quantikov software converts the rugosimeter's graphic readings into a linear measurement, enabling statistical comparisons.

Standard Edgewise metallic brackets (0.022 x 0.028-in Mini-Master Series, American Orthodontics, Sheboygan, WI, USA) were bonded with Transbond XT® (3M/Unitek, Monrovia, CA, USA). Brackets were placed in the center of the buccal surfaces of prepared teeth with sufficient pressure to obtain the thinnest layer of composite resin between brackets and teeth. Any adhesive excess was removed from the bracket margins with an explorer. The resin was cured with a light-curing unit (Ultralux EL, Dabi Atlante, Ribeirão Preto, Brazil) for 40 seconds. The light intensity was tested using a radiometer to insure that the correct wavelength (above 450 nm) was used. The exposure to light was made on each margin of the bracket for 10 seconds at a maximum distance of 1 mm. Specimens were left undisturbed for 10 minutes, and later stored in film canisters containing distilled water at room temperature for 24 hours until the bracket were removed.

All debonding procedures were performed by the same operator (EFF) that was previously calibrated by a more experienced orthodontist (DDO). All brackets were debonded with a pin and ligature cutter plier (Orthopli, Philadelphia, PA, USA) that was used to apply shear forces to the bracket base. Removal of the remaining composite was performed with a 12-blade high-speed tungsten carbide bur (Renew System, Reliance Orthodontic Products, Inc., Itasca, IL, USA) with refrigeration. The removal of this resin was controlled by visual inspection and with the aid of an explorer until the presence of resin was no longer observed. After resin removal, the premolars were dried and weighed. The same bur was used to remove the remaining composite of 10 teeth.

The final polishing was performed with polishing rubber-points (Renew Finishing System, Reliance Orthodontic Products, Inc. Itasca, IL, USA) and each rubber point was used to polish ten teeth. Twenty premolars were polished with high-speed rubber points, 10 teeth with refrigeration (air/water) and 10 without it. The other 20 premolars were polished with low-speed rubber points. After polishing, the teeth were dried and weighed again.

In order to measure the quantity of enamel loss at each stage of bracket bonding and debonding, “equivalent thickness of enamel loss” was used as a comparative parameter, measured in micrometers. This was necessary because most of the studies evaluated the enamel loss in thickness. The value of 3.0 g/cm^4 for enamel density was used (MANLY et al, 1939). Mass loss in each stage was divided by the density value to obtain the corresponding enamel volume. Subsequently, these volumes were divided by a circular area with a diameter of 7 mm, thus obtaining the equivalent thickness of the enamel loss.

For the qualitative analysis, 7 premolars were randomly selected and divided into the following groups: Group 1 – sound tooth; Group 2 – after acid conditioning; Group 3 – after removal of the remaining resin with a bur and refrigeration; Group 4 – after high speed polish without refrigeration; Group 5 – after high speed polish and refrigeration; Group 6 – after slow speed polish without refrigeration; and Group 7 – after slow speed polish and refrigeration. All teeth were submitted to the same procedures for bonding and debonding of brackets described in the quantitative analysis.

A scanning electronic microscope (SEM) (JEOL JSM-5310, Musashino Chome Akishima, Tokyo, Japan) was used to obtain the images. All teeth were submitted to a gold metallic coating using the deposition method of Corporate Headquarters Desk II cathodic pulverization (Denton Vacuum LLC, Moorestown, NJ). The images were obtained at magnifications of 15, 100 and 1,000 times in SEM.

The same operator (EFF) executed each step of this experiment, always supervised by a more experienced researcher (RANF) to minimize the chance of measurement error. The data were statistically analyzed using the GraphPad prism 5.03 software (GraphPad Software Inc, La Jolla, CA, USA).

The roughness readings of the buccal enamel surfaces were converted using the Quantikov software and submitted to the Shapiro-Wilk Test, which verified a non-normal distribution of the sample. Thus, the Wilcoxon non-parametric test was used ($p<0.01$).

Tooth mass was measured at each stage before the data were submitted to the Shapiro-Wilk Test, which verified a normal distribution of the sample. Therefore, the ANOVA 1 criteria with the repetition test and post hoc Bonferroni were used ($p<0.01$).

Finally, the ANOVA 1 criteria were used to evaluate effects of the 4 polishing methods ($p >0.05$).

RESULTS

The length of the buccal enamel roughness profile was evaluated, which displayed a statistically significant difference between the lengths before and after acid conditioning ($p<0.01$). It also showed an increase in the buccal enamel roughness profile, suggesting that the enamel surface was significantly rougher after acid conditioning (Table 1). Figure 2 presents an example of the reading performed with the rugosimeter.

Table 1. Average Profile Length, Standard Deviation and Significance

Premolar	Average Profile Length (µm)	Standard Deviation	Significance (Wilcoxon)
Sound enamel	1588.90	441.44	p<0.0001
After acid conditioning	1736.17	531.99	

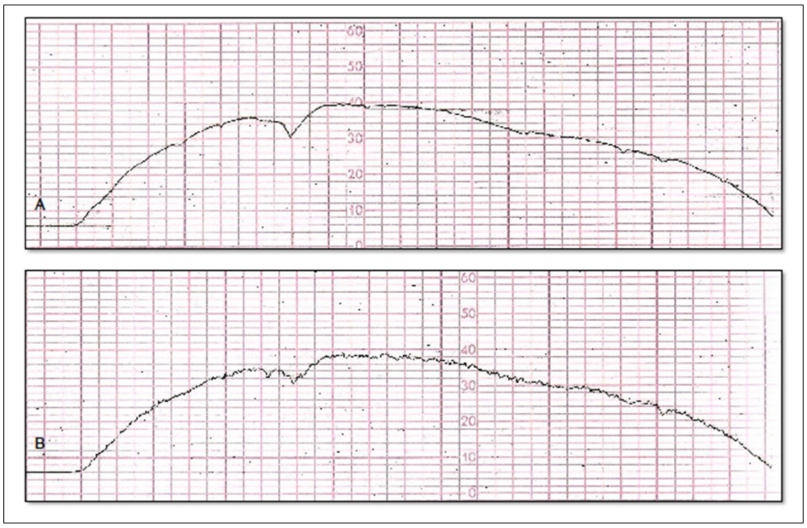

Figure 2. Rugosimeter reading. (A) sound tooth; (B) after acid conditioning.

There were no statistically significant differences between the increase in the profile length and mass loss, as determined using the Student's t-test (p>0.05).

Regarding the variation in thickness, obtained by the mass value, after each of the 4 stages (i.e., from bracket bonding to the final polish), an average loss of 42.4 µm (0.38%) was observed due to the acid conditioning. When the high speed multi-bladed bur was used to remove the remaining resin, the average loss was 34 µm (0.32%), totaling 76.4 µm or 0.70% of the enamel. Finally, additional loss due to the final polish procedures averaged 34.3 µm (0.31%). Therefore, the total loss was 110.7 µm, corresponding to 1.01% of the average thickness of the tested teeth. Tooth mass was measured at each stage, which showed a statistically significant difference at all stages (p<0.01) (Table 2).

Table 2. Average Weight, Standard Deviation and Thickness Loss and Significance level of 4 steps .

Premolar	Average (g)	Standard Deviation	Average Loss in Thickness (µm)	ANOVA 1 criterion repeat
Sound enamel	1.261 A	0.225	-	0.0001
After acid conditioning	1.256 B	0.224	42.4	
After bur	1.252 C	0.224	34.0	
After polishing	1.248 D	0.223	34.3	

Mean followed by different letters differ by Bonferroni test (p<0,0001)

The evaluation of loss of thickness among the 4 types of polish ranged from 0.28% to 0.34%. Low speed polish with water showed an average loss of 30.7 µm or 0.28% of the enamel; average loss without water was 31.2 µm or 0.32%. With high speed polish with water, average loss was 34.8 µm or 0.31%, whereas average loss without water was 40.4 µm or 0.34%. Statistical tests did not indicate significant differences between the polish types ($p>0.05$) (Table 3).

Table 3. Average Weight, Standard Deviation and Thickness Loss and Significance level for different polishes

Premolar	Average (g)	Standard Deviation	Average Loss in Thickness (μm)	Significance (ANOVA 1 criterion)
With high-speed Without refrigeration	1.339	0.183	40.4	
With high-speed With refrigeration	1.258	0.214	34.8	p>0.05
With low-speed Without refrigeration	1.125	0.199	31.2	p = 0.72
With low-speed With refrigeration	1.270	0.264	30.7	

Figure 3 shows the photographs of the surfaces. Although, the enamel surfaces of the teeth appear clinically smooth and shining, they present with irregularities at the microscopic level (Figure 3, A1, B1, C1). Acid conditioning caused roughness at the end of the prisms of the enamel and increased the size of the micro spaces between them, as can be observed in Figure 3, A2, B2, C2.

The debonding procedure followed by the removal of the remaining resin with a multi-bladed tungsten carbide bur resulted in a slightly roughened surface, with irregularities on the enamel surface at different levels, as indicated by the arrows in Figure 3, A3, B3, C3.

Clinically, the polishing procedures provide increased shine and smoothness to the enamel, which was observed microscopically. A comparison of the high speed and slow speed polishes showed that the former led to a rougher surface, as observed in Figure 3, A4, B4, C4, A5, B5, C5, A6, B6, C6, A7, B7, C7.

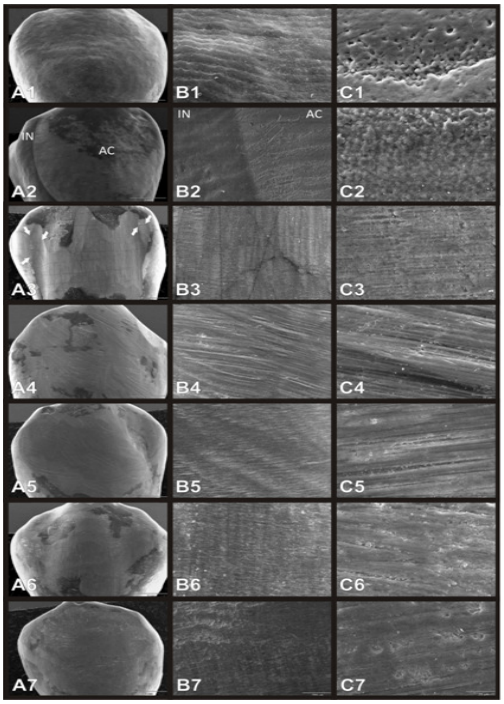

Figure 3. SEM increases of 15, 100 and 1000 times. A1, B1, C1 - Premolar sound enamel (IN). A2, B2, C2 - After acid conditioning (AC) (C2). A3, B3, C3 - after removal of residual resin composite. A4, B4, C4 - After final polishing with high-speed, and with refrigeration. A5, B5, C5 - After final polishing with high-speed, and without refrigeration. A6, B6, C6 - After final polishing with low-speed, and without refrigeration. A7, B7, C7 - After final polishing with low-speed, and with refrigeration.

DISCUSSION

The reestablishment of the original dental enamel characteristics is a goal of any orthodontist at the end of treatment (BISHARA et al, 1994; SESSA et al, 2012). Different methods, such as tungsten carbide burs at low or high speed, Arkansas stone, green stones, diamond burs, steel burs, hand instruments, ultrasonic tools and laser, Soft-lex discs, have been described regarding the removal of the remaining composite resin adhered to the tooth after bracket debonding, although controversies exist regarding the methods that are most efficient and least damaging to the enamel (GWINNET; GORELICK, 1979; RETEIF; DENYS, 1979; ZACHRISSON; ARTHUN, 1979; CAMPBELL, 1995; ZARRINIA et al, 1995; RYF et al, 2012; JANISZEWSKA-OLSZOWSKA et al, 2014). The present study quantitatively analyzed enamel loss after steps associated with orthodontic bracket bonding and debonding, as well as among four different final enamel-polishing protocols.

Length variations of the profiles of enamel loss after acid conditioning presented with large amplitudes. This suggests that many samples may have had greater resistance to acid conditioning due to difference in the influence of exogenous and endogenous factors on teeth, including tooth maturation and exposure to different levels of fluoride (DIEDRICH, 1981). Such length increases in the enamel roughness profiles after acid exposure were significant.

All brackets were bonded with light-cured composite resin, which is considered the gold standard in contemporary orthodontics. The enamel was not pumiced prior to bonding. Some studies have reported enamel loss ranging from 3.78 µm (BARRY, 1995) to 14.38 µm (THOMPSON; WAY, 1981) after using a mixture of water and pumice. Some authors (THOMPSON; WAY, 1981) have also mentioned that deposition of pumice residue is often seen on the surface, indicating an apparent gain in tooth thickness of up to 1.07 µm. Therefore, the present study did not incorporate prophylaxis, since other studies have shown that the use of pumice before bracket bonding does not have any influence on the number of failures associated with bonding (BARRY, 1995). Furthermore, eliminating this stage of the bonding technique prevents additional enamel loss, which would be one more independent variable that could influence the results (BARRY, 1995; THOMPSON; WAY, 1981).

Conditioning with 37% phosphoric acid in this study led to enamel loss equivalent to 42.4 µm, which is compatible with other studies that reported variation from 4 µm (SILVERSTONE, 1974) to 170 µm (DIEDRICH, 1981). Another study reported smaller losses, ranging from 1.1 µm to 4.57 µm (HOSEIN et al, 2004). Despite differences in enamel loss described in the literature depending on acid concentration and/or methodology, studies show agreement that this stage causes greater structural loss (SILVERSTONE, 1974; DIEDRICH, 1981; HOSEIN et al, 2004; IRELAND et al, 2005). Clinically, any orthodontist should minimize the loss of enamel during the etching procedures. Phosphoric acid is produced in both a liquid or gel form. The liquid form may spread over larger areas of enamel surface under the influence of gravity, demineralizing unnecessarily areas, which may facilitate plaque and bacterial retention. With the gel form, only the area equivalent to the bracket base is etched (BRAMSNTROM et al, 1982). Another important aspect is the etching time, since only 15 to 30 seconds is sufficient to create a retentive enamel surface (CARSTENSEN, 1986, GARDNER; HOBSON, 2001). Another interesting aspect of the current study involved limiting the area of acid conditioning in the gel by 7 mm for the posterior bracket bonding. Thus, it was not necessary to limit the area with adhesive tape due to the relatively low viscosity of the gel used.

After bracket removal, almost all of the resin remained adhered to the enamel. The multi-bladed tungsten carbide bur was used with refrigeration for the resin removal, based on studies that recommended it due to the decreased surface abrasion and heat generation on teeth (RETEIF; DENYS, 1979; ZARRINIA et al, 1995). Cumulative loss at this stage was 34 µm, which is compatible with studies that showed an average loss of 55.6 µm (FITZPATRICK; WAY, 1977). However, this was also different from other studies that presented average losses ranging from 14.3 µm (HOSEIN et al, 2004) to 149.87 µm (KREL et al, 1993), perhaps due to the use of burs with high or slow speed. Another important matter was the methodology used to obtain loss of mass in µm, between indirect quantification using a rugosimeter and direct quantification by weighing.

The final polish led to an average loss of 34.3 µm. Because several previous studies (ZACHRISSON; ARTHUN, 1979; HOWELL; WEEKES, 1990; ZARRINIA et al, 1995) had presented qualitative data regarding this stage, the present study was an attempt to provide quantitative data for this stage, which is critical to the end of orthodontic treatment. The final polish was evaluated according to different polish methods (e.g., high or low speed), as well as with or without refrigeration. The average enamel loss levels from these polish methods were as follows: 40.4 µm with high speed but without refrigeration, 34.8 µm with high speed and with refrigeration, 31.2 µm with slow speed but without refrigeration, and 30.7 µm with slow speed and with refrigeration.

SEM evaluation showed that all enamel surfaces presented irregularities at the end of polishing. However, the best result was obtained with the use of polishing rubber at low speed with refrigeration, with enamel surface showing less scratches and grooves, exhibiting a shiny and smooth surface. A previous study (RYF et al., 2012) reported that multi-step rubber polishing kits seem to have advantages in preventing enamel loss. Other study (MAHDAVIE et al, 2014) concluded that some alternatives should not be used as the white-stone finishing bur (Arkansas stone), green stones, diamond burs, steel burs and laser because they caused greater damage, with extensive grooves to the enamel.

The total average enamel loss was 110 µm, which is similar to results in the literature, though other studies have presented a fairly wide range of values (DIEDRICH, 1981; HOSEIN et al, 2004). Ryf et al, in 2012, achieved a mean enamel loss of 4,1 µm in all samples, 2,9 µm when burs were combined with polishers and 7,9 µm when only burs were used for eliminating resin, which is considerably less than in other studies. Although quantitatively small, these structural loss values must be considered in relation to the total enamel thickness of the buccal surface of premolars (1500 to 2000 µm) (THOMPSON; WAY, 1981), which can be uneven when comparing different elements. A previous study showed that the concentration of fluoride in the enamel surface decreases very rapidly from the outer surface. Thus, the loss of 100 µm could remove the fluoride-rich layer of the teeth (KOCH; PETERSON, 1971). One must also be aware of possible bracket rebonding procedures during orthodontic treatments. The percentage values presented in this study must be analyzed as the loss in grams for each tooth. When considering a total loss of 110 µm in a tooth with an enamel thickness of 1500 µm, we must realize that the average loss amounts to 7%. As such, three rebondings during treatment could correspond to as much as 21% enamel loss on the buccal surface.

The literature reports abrasion due to physiological occlusion as 15 µm per year (LAMBRECHTS et al, 1989). Applying this to buccal surfaces, abrasion during an orthodontic session (110 µm) may be equivalent to 7 years and 3 months of physiological abrasion.

All stages, from bonding to polish, involved structural loss of the enamel, which was statistically significant between the studied groups. Although different polishing methods did not present with statistical differences, the protocol that caused the least loss of mass was that using slow speed polish with refrigeration. It is important to take into account possible heating of dental structures at this stage, which suggests the use of refrigeration.

Due to the large variations in irregularities on sound enamel surfaces and after orthodontic procedures, quantification is difficult, although the final polish presents itself as essential in improving enamel roughness. Roughness increases during the debonding process (MAHDAVIE et al, 2014) and does not depend on the removal method used, causing irreversible effect on the enamel texture (ELIADES et al, 2004; JANISZEWSKA-OLSZOWSKA et al, 2014).

Among the correlation limitations of results between in vitro studies and in vivo conditions of daily orthodontic practice, the results of the present study reinforce the need for the professional to look for ways to minimize potential damages from bracket bonding and debonding processes on the surface of the dental enamel.

Further studies with a larger sample, comparing high and low speed, are necessary to validate the most effective protocol for clinical orthodontists. Studies analyzing the loss of enamel with different techniques and materials for polishing should be performed and compared to this study, in order to preserve the volume and surface enamel smoothness.

As clinical relevance, practitioners should note that the bonding stage is of great importance to orthodontic treatment. Thus, rebonding should ideally be less often as possible. The use of light-curing composite resin for positioning adequate and indirect bonding could help the professionals. Another recommendation is that clinicians should still take caution with the idea of eliminating folds, since they assist in the reduction of rebonding.

CONCLUSIONS

The following conclusions can be drawn based on the results of this study:

Dental enamel was lost after every step of the bonding and debonding procedures evaluated in this study; It was greater after acid conditioning.

No significant differences were observed among the different tested methods of final enamel polishing tested.

RESUMO: Determinar a perda de esmalte durante os procedimentos de colagem e descolagem de bráquetes ortodônticos e analisar a rugosidade superficial do esmalte. Quarenta e sete primeiros pré-molares superiores foram obtidos para análise quantitativa e qualitativa. Para a análise quantitativa, quarenta pré-molares foram pesados em cada uma das etapas do tratamento e a espessura equivalente do esmalte foi medida. A perda de massa em cada fase foi dividida pelo valor de densidade do esmalte para obter o volume correspondente. Em seguida, o volume foi dividido pela área circular de 7 mm de diâmetro, obtendo-se assim a espessura equivalente da perda de esmalte. Os dentes foram avaliados nas seguintes condições: esmalte íntegro, após condicionamento ácido, depois da remoção da resina remanescente e após o polimento final em alta e baixa rotação, com e sem refrigeração. Ainda foi utilizado um rugosímetro para obtenção dos registros gráficos de perfis da rugosidade superficial do esmalte antes e após o condicionamento ácido. Os dados foram analisados utilizando-se o software Quantikov, para determinação e comparação dos comprimentos dos registros obtidos antes e após o condicionamento ácido, o teste Shapiro Wilk e o Wilcoxon para rugosidade superificial do esmalte e, por fim, o ANOVA um fator seguido pelo Bonferroni Post-Hoc para perda de esmalte. Para a análise qualitativa, foi empregada a microscopia eletrônica de varredura nas superfícies de esmalte de sete pré-molares, um dente para cada etapa. O condicionamento ácido promoveu o aumento do comprimento do perfil de superfície do esmalte, ou seja, o aumento da rugosidade ($p<0,01$). Na avaliação da massa dos elementos dentários, percebeu-se que a perda de esmalte foi estatisticamente significante em todas as etapas do experimento ($p<0,01$). Entretanto, ao comparar os diferentes métodos de polimentos, verificou-se que não há diferença estatisticamente significante na perda de estrutura mineralizada ($p=0,72$). Na análise da microscopia eletrônica de varredura, a remoção da resina com broca carbide de tungstênio multilaminada com refrigeração e o polimento em baixa rotação sob refrigeração apresentaram menos dano ao esmalte. A maior perda de esmalte foi devida ao condicionamento ácido. As perdas referentes ao desgaste com a broca e o polimento são semelhantes e os 4 protocolos de polimento testados resultaram em diminuições similares na espessura do esmalte. Nenhuma das superfícies de esmalte foi restaurada ao seu aspecto original após a colagem e descolagem de bráquetes metálicos.

PALAVRAS-CHAVE: Esmalte dentário. Bráquetes. Polimento Dentário.

REFERENCES

BARRY, G. R. P. A clinical investigation of the effects of omission of pumice prophylaxis on band and bond failure. **Br J Orthod.**, London, v. 22, n. 3, p. 245-248, 1995.

BISHARA, S. E., FONSECA, J. M., FEHR, D. E., BOYER, D. B. Debonding forces applied to ceramic brackets simulating clinical conditions. **Angle Orthod**., Appleton, v. 64, n. 4, p. 277-282, aug.1994.

BRANNSTROM, M., MALMGREN, O., NORDENVALL, K. J. Etching of young permanent teeth with an acid gel. **Am J Orthod**., St Louis, v. 82, N. 5, p. 379-83, 1982.

CAMPBELL, P. M. Enamel surfaces after orthodontic bracket debonding. **Angle Orthod.**, Appleton, v. 65, n. 2, p. 103-110, apr. 1995.

CARSTENSEN, W. Clinical results after direct bonding of brackets using shorter etching times. **Am J Orthod.,** St Louis, v. 89, n. 1, p. 70-72, 1986.

DIEDRICH, P. Enamel alterations from bracket bonding and debonding: a study with the scanning electron microscope. **Am J Orthod**., St Louis , v. 79, n. 5, p. 500-523, may 1981.

ELIADES, T., GIOKA, C., ELIADES, G., MAKOU, M. Enamel surface roughness following debonding using two resin grinding methods. **Eur J Orthod**., Oxford, v. 26, n. 3, p. 333-338, jun. 2004.

FITZPATRICK, D. A., WAY, D. C. The effects of wear, acid etchings, and bond removal on human enamel. **Am J Orthod**., St Louis , v. 72, n. 6, p. 671-680, dec. 1977.

GARDNER, A., HOBSON, R. Variations in acid-etch patterns with different acids and etch times. **Am J Orthod Dentofacial Orthop**., St Louis, v. 120, n, 1, p. 64-7, 2001.

GWINNET, A. J., GORELICK, L. Microscopic evaluation of enamel after debonding. **Am J Orthod**. , St Louis, v. 71, n. 6, p. 651-665, jun. 1979.

HOSEIN, I., SHERRIFF, M., IRELAND, A. J. Enamel loss during bonding, debonding, and cleanup with the use of a self-etching primer. **Am J Orthod Dentofacial Orthop**., St Louis , v. 126, n. 6, p. 717-724, dec. 2004.

HOWELL, S., WEEKES, W. T. An electron microscopic of the enamel surface subsequent to various deboning procedures. **Aust Dent J**., Sidney, v. 35, n. 3, p. 245-252, jun. 1990.

IRELAND, A. J., HOSEIN, I., SHERIFF, M. Enamel loss at bond-up, debond and clean-up following the use of a conventional light-cured composite and a resin-modified glass polyalkenoate cement. **Eur J Orthod**., Oxford, v. 27, n. 4, p. 413-419, aug. 2005.

JANISZEWSKA-OLSZOWSKA, J.; SZATKIEWICZ, T.; TOMKOWSKI, R.; TANDECKA, K.; GROCHOLEWICZ, K. Effect of orthodontic debonding and adhesive removal on the enamel- current knowledge and future perspectives – a Systematic Review. **Med Sci Monit**., Warsaw, v. 20, p. 1991-2001, Out. 2014.

KARAN, S.; HANCIOGLU, K.; TASDELEN, B. Enamel surface roughness after debonding. **Angle Orhod**., Appleton , v. 80, n. 6, p. 1081-1087, nov. 2010.

KOCH, G.; PETERSON, L. G. Fluoride content of outermost enamel layers in teeth exposed to topical fluoride application. **Odontol. Revy**., v. 22, n. 4, p. 351-362, 1971.

KREL, K. V.; COUREY, J. M.; BISHARA, S. E. Orthodontic bracket removal using conventional and ultrasonic deboning techniques, enamel loss, and time requirements. **Am J Orthod**., St Louis, v. 103, n. 3, p. 258-266, mar. 1993.

LAMBRECHTS, P.; BRAEM, M.; VULYLSTEKE-WAUTERS, M.; VANHERLE, G. Quantitative in vivo Wear of Human Enamel**. J Dent Res.,** Washington, v. 68, n. 12, p. 1752-1754, dec. 1989.

MAHDAVIE, N. N.; MANASSE, R. J.; VIANA, G.; EVANS, C. A.; BEDRAN-RUSSO, A. B. Enamel scarring by debonding burs: an SEM and profilometric study. **JCO**, Boulder, v. XLVIII, n. 1, p. 14-21, jan. 2014.

MANLY, R. S., HODGE, H. C., ANGE, L. E. Density and refractive index studies of dental hard tissues. **Density of dental hard tissues**., v. 18, n. 3, p. 203-211, jun. 1939.

PONT, H. B.; OZCAN, M.; BAGIS, B.; REN, Y. Loss of surface enamel after bracket deboning: An in-vivo and ex-vivo evalution. **Am J Orthod Dentofacial Orthop**., St Louis, v. 138, n. 4, p. 387.e1-387.e9, oct. 2010.

RETEIF, D. H., DENYS, F. R. Finishing of enamel surfaces after debonding of orthodontic attachments. **Angle Orthod**., Appleton, v. 49, n. 1, p. 1-10, jan. 1979.

RYF, S.; FLURY, S.; PALANIAPPAN, S.; LUSSI, A.; VAN MEERBEEK, B.; SIMMERLI, B. Enamel loss and adhesive remnants following bracket removal and various clen-up procedures in vitro. **Eur J Orthod**., Oxford , v. 34, n. 1, p. 25-32, feb. 2012.

SESSA, T.; CIVOVIC, J.; PAJEVIC, T.; JULOSKI, J.; BELOICA, M.; PAVLOVIV, V.; GLISIC, B. Scanning electron microscopic examination of enamel surface after fixed orthodontic treatment: in-vivo study. **Srp Arh Celok Lek**., Belgrade, v. 140, n. 1-2, p. 22-28, jan-fev. 2012.

SILVERSTONE, L. M. Fissue selants. Laboratory studies. **Caries Res**., Basel, v. 8, n. 1, p. 8-26, 1974.

THOMPSON, R. E.; WAY, D. C. Enamel loss due to prophylaxis and multiple bonding/debonding of orthodontic brackets. **Am J Orthod**., St Louis , v. 79, n. 3, p. 282-295, mar. 1981.

ZACHRISSON, B. U.; ARTHUN, J. Enamel surface appearence after various deboning techniques. **Am J Orthod.** , St Louis , v. 75, n. 2, p. 121-137, aug. 1979.

ZARRINIA, K.; EID, N. M.; KEHOE, M. J. The effect of different debonding techniques on the enamel surface: an in vitro qualitative study. **Am J Orthod Dentofacial Orthop.** , St Louis , v. 108, n. 3, p. 284-293, sep. 1995.