

The Effect of Novamin on Surface Roughness Dental Enamel After Debonding Orthodontic Bracket

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ABSTRACT

The acid etching process is required in orthodontic when attaching brackets to the enamel. It will result in microporosity so that the adhesive material enters the structure, and micromechanical retention occurs, which increases the adhesion strength. However, this process causes roughness and hydroxyapatite mineral loss. Removing orthodontic brackets and cleaning the remnants of adhesive material also cause roughness. Hence, Novamin is a synthetic mineral with the same structure as dental minerals, which can help remineralize damaged tooth structures. To determine the potential application of Novamin as a remineralization material to improve enamel roughness after bracket removal. Twenty-five premolar teeth were divided into five groups. Group I (control), II (etching, bracket mounting with Biofix), III (same as group II + Novamin), IV (etching, bracket mounting with Fuji Ortho), and V (same as group IV + Novamin) with 20 seconds of LED polymerization. All samples were placed in artificial saliva for seven days, the brackets were removed, and the remaining adhesive material was cleaned. Novamin application was for 3 minutes every 12 hours for ten days. Changes in the enamel surface were seen using SEM, and the roughness was tested using SR Tester KR220. Data analysis was tested using One-Way ANOVA. Surface roughness showed a significant difference in each group, with a p-value of 0,000 ($p < 0.05$). The highest roughness occurred in group I. There were significant differences between groups II with III and groups IV with V. Novamin plays a role in the remineralization process and affects reducing enamel surface roughness after orthodontic bracket debonding.

Keywords: *Achid Etching, Roughness, Enamel, Fuji Ortho, Biofix, Novamin*

1. INTRODUCTION

One of the orthodontic treatment components using a fixed appliance is a bracket, which functions to receive the orthodontic wire's strength. The resulting force will slowly change the position of the patient's teeth within the dental arch [1]. The bracket attachment process consists of several steps: cleaning the enamel surface, conditioning the enamel surface, and bonding process (bracket attachment).

The bracket's attachment to the enamel surface is preceded by an acid etching process on the enamel surface using phosphoric acid [2]. The acid etching process is the process of rubbing 35% phosphoric acid on the surface of the isolated enamel. This basting process is carried out for 15-30 seconds, after which the surface is rinsed with low-speed water spray and dried [3]. This process aims to remove contaminants and smear layers on the tooth surface and expand the surface to form a bond between the enamel and the resin composite. The acid etching process also aims to produce microporosity on the prismatic enamel surface, which will later function as retention [4].

After the acid etching process, a bonding process is carried out, which requires an adhesive. Orthodontic

adhesives on the market that have advantages include Biofix and Fuji Ortho LC. Biofix is a composite containing material that adheres well to tooth enamel. This material can be easily applied to plastic, metal, or ceramic brackets [5]. Biofix's advantage is that it can release fluoride to prevent or reduce white spots during orthodontic treatment [6]. Fuji Ortho LC has a resin-modified glass ionomer cement as the base material, has adequate adhesion strength, and can release fluoride as a protective tooth from demineralization [7]. The polymerization process of this material is carried out using the light-cured technique. Application of the Fuji Ortho LC material requires an acid etching process and a dry tooth surface to obtain good adhesion strength [8].

The acid etching process can cause damage to the enamel layer. Bishara et al. have conducted a study using the Transbond XT bonding system (3M Unitek) and stated that the estimated damage due to the acid etching process varied between 10-30 μm . Whereas, in applying the resin composite layer, the damage was estimated to reach 50 μm . At the end of the orthodontic treatment, the resin composite initially used as the bracket adhesive with enamel was cleaned again so that no residue was left. This resin composite cleaning process could damage the enamel surface to a depth of 55.6 μm [9]. Research on the acid etching process using 35% phosphoric

acid with an etching time of 15 seconds and 30 seconds showed that the higher the etching time, the deeper the enamel roughness was [10].

Apart from the acid etching process, another orthodontic treatment that can cause enamel damage is the orthodontic bracket removal. There are two kinds of orthodontic brackets: ceramics and metal brackets. Ceramics brackets began to be widely used since 1980, but the use of these bracket types was widely reported to cause enamel damage reaching 63.3%. As for the benefit of metal brackets, enamel damage was reported to be 20-50 µm [11].

Enamel damage due to acid etching can be prevented using enamel prophylaxis, a pumiced application using a rubber cup [12]. Research conducted by Mohanty et al. in 2014 stated that Novamin could help the remineralization process of demineralized enamel on teeth with orthodontic treatment [13]. Novamin is a material that can be used to prevent enamel damage because it contains CPP-ACP (casein phosphopeptide-amorphous calcium phosphate), nano complexes such as carbonate-hydroxyapatite nano-crystals, and calcium sodium phosphosilicate [13]. Novamin is a synthetic mineral consisting of calcium, sodium, phosphorous, and silica. The silica contained in Novamin can release crystalline hydroxyl-carbonate apatite (HCA), which has a mineral-like structure in teeth. Novamin components have a size of fewer than 20 microns [14]. This study will look at differences in enamel surfaces using a Scanning Electron Microscope for in vitro microscopic examination and a KR 220 Surface Roughness Tester to measure surface roughness. It is hoped that the Novamin material applied to the enamel after removing the brackets will improve the enamel roughness after orthodontic treatment.

2. MATERIALS AND METHODS

Twenty-five premolar teeth extracted were stored soaked in 0.9% saline solution, which was changed periodically until the teeth were to be used for research. They were divided into five:

- Group 1 as the control group, the teeth were not given any treatment.
- Group 2 and 3: the teeth were cleaned, then applied acid etching in the form of phosphoric acid 37% for 30 seconds using a micro brush (Figure 1A), then rinsed and dried until it was completely dry. Then, a composite resin-based adhesive was applied, namely Biofix, then the bracket was positioned in the right place and polymerized with a light cure LED for 20 seconds.
- Groups 4 and 5: the teeth were cleaned, then applied acid etching in the form of phosphoric acid 37% for 30 seconds using a micro brush, then rinsed and dried until it was completely dry. Then, the resin-modified glass ionomer-based adhesive was applied, namely Fuji Ortho LC, then the bracket was

positioned in the right place and polymerized with a light cure LED for 20 seconds.

- The samples were immersed in artificial saliva for seven days to condition the brackets in the oral cavity (Figure 1B). The orthodontic bracket removal used bracket removal (Figure 2A) and remaining adhesive material cleaning employed orthodontics pliers (Figure 2A), followed by smoothing the labial surface of the tooth using a debonding bur (Figure 2C). The Novamin application (Sensodyne Repair & Protect Whitening) as an enamel remineralization material in the sample groups 3 and 5 utilized a brush for 3 minutes (Figure 3A), carried out every 12 hours for a period of 10 days. Surface roughness was tested using the KR 220 SR Tester (Figure 3B).

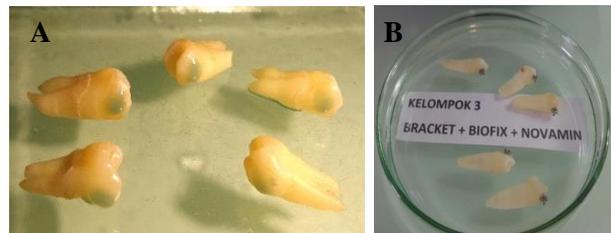


Figure 1. A. The etching acid process on the premolar teeth's enamel surface, B. Bracket installation and all samples immersion in artificial saliva

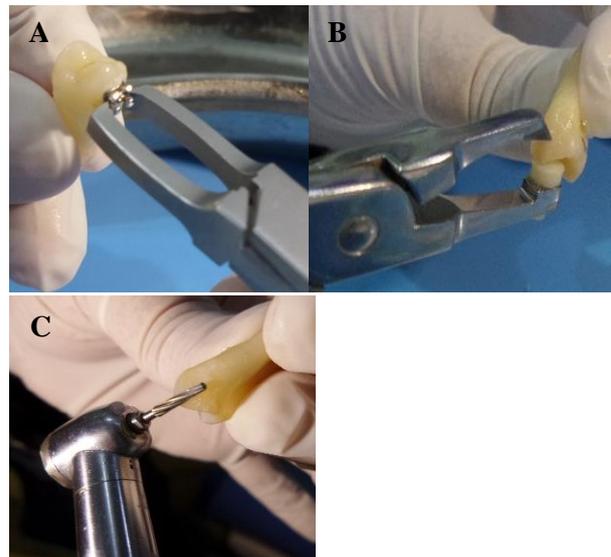


Figure 2. A. Removing the bracket with bracket removal, B. Cleaning the surface with orthodontic pliers, C. Cleaning the remaining adhesive material with a carbide bur

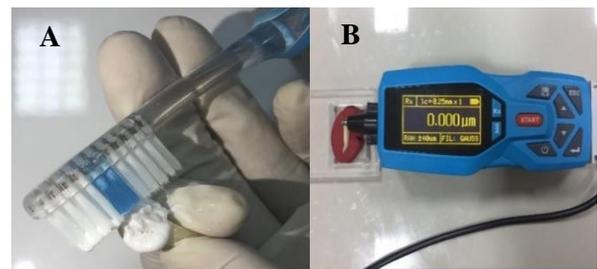


Figure 3. A. Novamin application in groups 3 and 5, B. Testing with the KR 220 SR Tester

3. RESULT

The descriptive analysis results in this study are shown in Table 1.

Table 1. Mean (unit μM) and standard deviation of surface roughness in each group

Group	N	Mean \pm Std. Dev
Control (I)	5	0,77 \pm 0,091
Biofix (II)	5	0,43 \pm 0,015
Biofix-Novamin (III)	5	0,29 \pm 0,091
Fuji Ortho (IV)	5	0,20 \pm 0,056
Fuji Ortho-Novamin (V)	5	0,05 \pm 0,023

Based on the table above, the highest mean surface roughness value was in Group I of 0.77, and the lowest was in group V. It was continued with bivariate analysis to determine and test whether there was any influence between the independent variable and the dependent variable.

The normality test used the Shapiro-Wilk test because the number of samples was less than 50 samples. The results of the surface roughness normality test in this study can be seen in Table 2 below:

Table 2. Normality test results with shapiro-wilk

Group	N	Shapiro-Wilk		
		Statistic	df	Sig.
Kontrol (I)	5	.981	5	.940
Biofix (II)	5	.920	5	.532
Biofix-Novamin (III)	5	.958	5	.794
Fuji Ortho (IV)	5	.780	5	.055
Fuji Ortho-Novamin (V)	5	.787	5	.063

Based on the table above, it can be seen that the probability value for all groups could be said to be normal because $p > 0.05$. Thus, it could be concluded that all groups had normal data distribution. Therefore, data processing would be continued with the homogeneity test and the One Way Anova test.

The homogeneity test results on each sample group's surface roughness can be seen in Table 3 below:

Table 3. Homogeneity test results

Levene Statistic	df1	df2	Sig.
2.815	4	20	.053

From the homogeneity test results, the significance showed a $p\text{-value} > 0.05$. The conclusion that could be drawn was that the data variance was the same, so that the One-Way ANOVA test could be carried out.

The One-Way ANOVA test results on each sample group's surface roughness can be seen in Table 4:

Table 4. One-way ANOVA test results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.505	4	.376	90.63	.000
Within Groups	.083	20	.004		
Total	1.588	24			

From the One-Way ANOVA test results, it was found that the $p\text{-value} = 0.000$ ($p < 0.05$) so that it could be interpreted that there was a significant difference in surface roughness in each sample group. Then, the Post-Hoc Tukey follow-up test was conducted to find out which group pairs had significant differences.

The Tukey test was a test employed to compare across pairs of group means, carried out after the One-Way ANOVA test. The Tukey test results on each sample group's surface roughness can be seen in Table 5 below:

Table 5. Tukey test results

Surface Roughness	Group		Mean		Sig.
	I	II	0.77	0.43	0.000
	I	III	0.77	0.29	0.000
	I	IV	0.77	0.20	0.000
	I	V	0.77	0.05	0.000
	II	III	0.43	0.29	0.009
	II	IV	0.43	0.20	0.000
	II	V	0.43	0.05	0.000
	III	V	0.29	0.05	0.000
	IV	V	0.20	0.05	0.008

Based on the Tukey test results, it can be seen which groups had significant differences in surface roughness, with the condition $p\text{-value} < 0.05$. Thus, it could be concluded that there was a significant difference in surface roughness between the Control Group (I) and the Biofix Group (II), Control (I) and the Biofix-Novamin Group (III), the Control Group (I) and the Fuji Ortho Group (IV), Control Group (I) and Fuji Ortho-Novamin Group (V), Biofix Group (II) and Biofix-Novamin Group (III), Biofix Group (II) and Fuji Ortho Group (IV), Biofix Group (II) and Fuji Group Ortho-Novamin (V), Biofix-Novamin Group (III) and Fuji Ortho-Novamin Group (V), and Fuji Ortho Group (IV) and Fuji Ortho-Novamin Group (V).

Scanning Electron Microscope (SEM) Image Results

The scanning electron microscope image was carried out with magnifications of 27x, 500x, and 1500x. Figure 4 illustrates group I, where the intact teeth sample without treatment showed grooves on the enamel surface and the opening of the dentinal tubules. Group II in Figure 5, a tooth sample fitted with orthodontic brackets using acid etching in the form of 37% phosphoric acid and Biofix adhesive

material, shows an irregular enamel surface and enamel prism edges could not be defined. Group III, seen in Figure 6A, a tooth sample fitted with orthodontic brackets with Biofix and applied Novamin material for ten days, shows a smoother surface. Also, at 6 C, the enamel topography was seen after remineralization. There was an area with mineral deposits and spread on the enamel surface that had porous. Figure 7 illustrates of group IV, namely a tooth sample that had been installed with an orthodontic bracket with Fuji Ortho LC adhesive. The SEM image at 1500x magnification showed the enamel surface, which formed like rocks (cobblestone) with the enamel prism line that had disappeared. Group V (Figure 8) was a tooth sample installed with orthodontic brackets with Fuji Ortho LC adhesive and applied with Novamin material for ten days. SEM images revealed a smoother enamel surface and closed dentinal tubules due to the remineralization process.

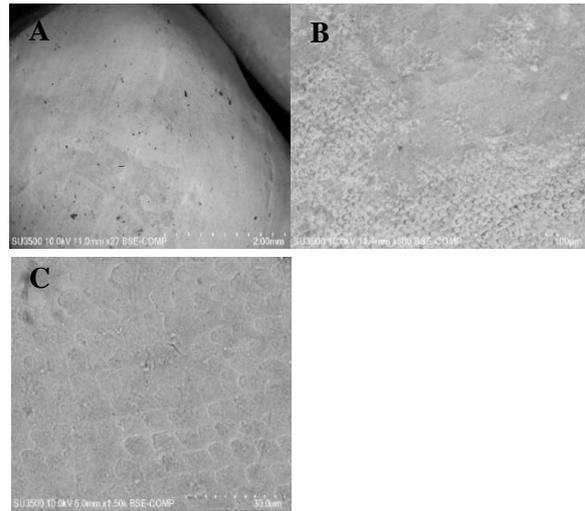


Figure 6. SEM image of the Biofix-Novamin (III) group with magnifications: A. 27x, B. 500x, C. 1500x

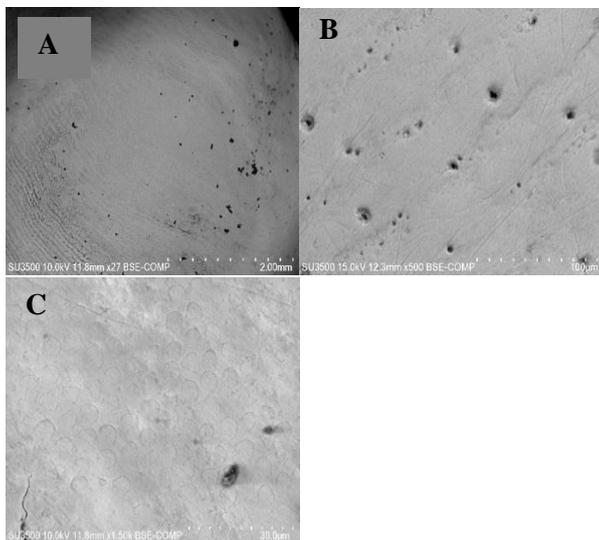


Figure 4. SEM image of Control Group (I) with magnifications: A. 27x, B. 500x, C. 1500x

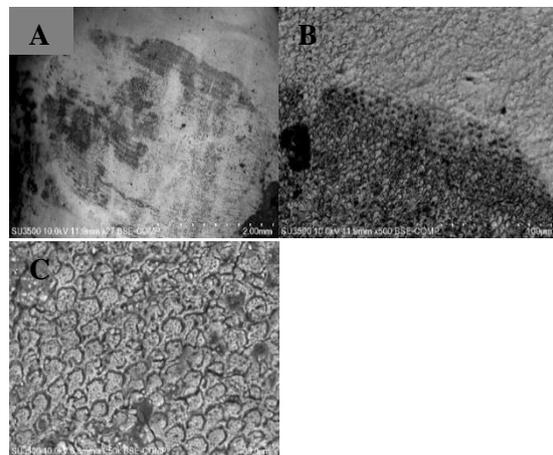


Figure 7. SEM image of the Fuji Ortho (IV) group with magnifications: A. 27x, B. 500x, C. 1500x

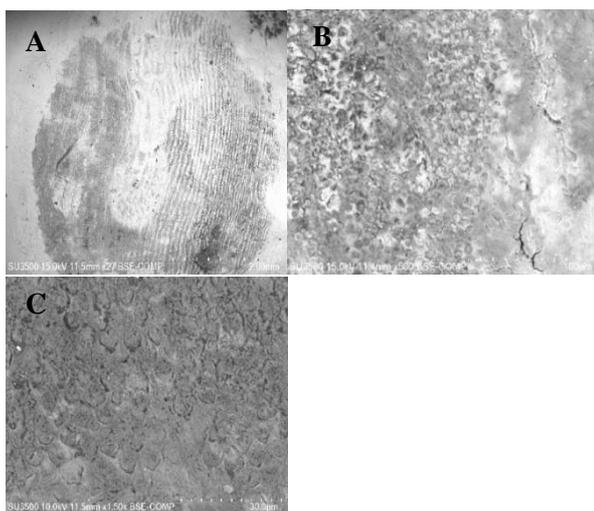


Figure 5. SEM image of the Biofix (II) group with magnifications: A. 27x, B. 500x, C. 1500x

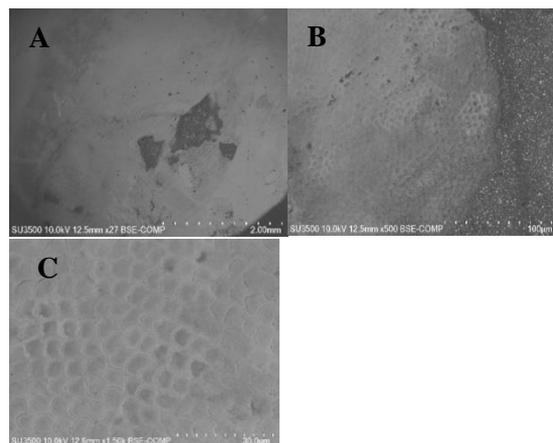


Figure 8. SEM image of the Fuji Ortho-Novamin (V) group with magnifications: A. 27x, B. 500x, C. 1500x

4. DISCUSSION

The surface roughness measurement in this study showed that there were several pairs of groups with significant differences in surface roughness: groups I and II, groups I and

III, groups I and IV, and groups I and V. Group I showed the highest enamel surface roughness rate if compared with the other four groups. Group I was the control group, namely intact teeth without treatment, while the other four groups were the group treated with brackets using orthodontic adhesives. After installing the brackets, the brackets were removed, or commonly known as the orthodontic debonding process. SEM images of group I showed a normal enamel surface characterized by enamel crystal surfaces, which tended to be homogeneous, accompanied by pits and grooves. The presence of pits and grooves can occur due to dental activity in the oral cavity [15]. The orthodontic bracket removal process consists of removing the bracket and removing the remaining adhesive material. Several safe methods and often used for the removing bracket process include the use of scalers, pliers, tungsten carbide burs with a handpiece, or a polishing disc. After the orthodontic bracket removal, it is hoped that the enamel surface will be smoother so that it does not increase the plaque accumulation, which can cause discoloration, and does not become bacterial retention that can cause decalcification [16], [17]. It explained why the group with bracket attachment had a lower roughness than group I, where the reduction in roughness was due to the bracket removal process, which ended with polishing.

The orthodontic bracket removal process in this study used a carbide bur. Palmer et al. (2018) stated that the carbide bur usage in the bracket removal process showed a significant difference in surface roughness by producing a smoother enamel surface than the enamel surface before orthodontic treatment [18]. The bur ability used to clean the remaining adhesive material depends on several factors, such as the handpiece speed, the pressure on the handpiece during preparation using the bur, the bur type used, and the speed at which water coolant spray is sprayed on the prepared area [17].

Significant differences in surface roughness also occurred in Group II and Group III, as well as Group IV and Group V. Group II and Group III were the groups treated with orthodontic bracket installation using two different adhesive materials: Biofix and Fuji Ortho LC. Whereas for Group IV and Group V, the sample groups were treated in the form of orthodontic bracket installation with Biofix and Fuji Ortho LC adhesive, and the Novamin remineralization material application was added. After the Novamin remineralization material application in Group IV and Group V, the surface roughness score showed a significant decrease in surface roughness. It is in line with Wang et al. research (2016), which proved that the Novamin remineralization agents' application could reduce enamel surface roughness [19].

Wang et al. (2016) research aimed to determine the remineralization ability between Colgate Sensitive Pro-Relief, NovaMin, and GC Tooth Mousse. The research results showed that Colgate Sensitive Pro-Relief and Novamin could remineralize well, as seen from a significant increase in surface hardness and a significant decrease in surface roughness. One of the benchmarks to know the

demineralization process was to look at surface hardness. The demineralized enamel surface tended to have low surface hardness due to mineral loss. Novamin released sodium, calcium, phosphorus, and silica to form hydroxyapatite deposits. This hydroxyapatite deposit would later remineralize demineralized enamel and increase surface hardness [19].

Another group with a significant difference was group II with group IV. Group II was the group treated with orthodontic bracket installation using Biofix adhesive, while Group IV was the group treated with orthodontic bracket installation using Fuji Ortho LC adhesive. Compared with Group I, both groups experienced a decrease in surface roughness due to the orthodontic bracket removal using a carbide bur. The difference in surface roughness between Group II and V was that the enamel surface of Group V tended to be smoother than Group II. It was due to the difference between the two orthodontic adhesives used, namely Biofix and Fuji Ortho LC. Group V using Fuji Ortho LC adhesive had a smoother surface because it released more fluorine than Biofix material. The fluorine released served to increase the demineralization process. When the demineralization process occurred, the enamel surface would form new mineral deposits, which would increase the enamel surface hardness. Increasing enamel surface hardness would be followed by decreasing enamel surface roughness [19].

The remineralization process by Novamin has also been described in groups III and V. The two groups were groups treated in the form of orthodontic bracket installation using an adhesive, then a Novamin remineralization material was applied. Novamin is a ceramic material consisting of amorphous sodium-calcium-phosphosilicate, which is highly reactive to water. The fine grains of Novamin powder can close the exposed dentinal tubules. Novamin would start to remineralize when it reacted with saliva. Then, there would be sodium ions' release, which exchanged with hydrogen cations and caused the release of calcium and phosphate ions from Novamin particles. The sodium ions' release would increase pH, which would precipitate the released calcium and phosphate ions. The calcium and phosphate ions that settled would later form a new apatite hydroxycarbonate layer, which functioned to close the dentinal tubules [20]. As a result of the remineralization process, the enamel surface looked more homogeneous due to new mineral deposits covering the dentinal tubules. The enamel prism edges that were lost due to the acid etching process began to thicken and became more visible [21]. It is in accordance with this study's results, which could be seen in the SEM images' results in the group added with the Novamine application, where the surface was smoother, and the enamel topography had undergone remineralization. An area with mineral deposits was seen spreading on the enamel's former surface that had porous and closed dentinal tubules due to the remineralization process.

5. CONCLUSION

There were differences in surface roughness changes before and after orthodontic bracket installation using two different adhesives, and there were differences in surface roughness changes before and after the Novamin application to the enamel surface after the orthodontic bracket removal. It suggested that Novamin had the potential to remineralize the enamel surface and reduced enamel surface roughness after the orthodontic bracket removal.

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