Comparison of Polishing Methods Used in Extrinsic Discolouration of Primary Teeth in Terms of Surface Roughness

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Research Article

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Abstract

Background

Surface roughness is one of the main factors affecting bacterial adhesion, biofilm growth, plaque formation and coloration on the tooth surface. Improper polishing may increase roughness or not contribute to a reduction in roughness while removing biofilms on tooth surfaces. The aim of this study is to examine the effects of different polishing pastes applied to the enamel of primary teeth on the surface roughness through AFM, which enables a more detailed examination of the measurements, and to evaluate the roughness changes created by the paste on the surface.

Methods

In the present study, in order to compare polishing made using Septodent Détartrine, Kerr Cleanic, Shofu Mersaage Regular under the recommendations of the companies in addition to the application of pumice with a rubber brush, a total of 88 samples with 22 samples in each group were created using 88 primary molar teeth. Before and after polishing, roughness measurements and visualizations were performed with atomic force microscopy (AFM). After polishing, Ra (average roughness) values, which express the surface roughness of the re-scanned samples, were calculated so that the samples were the same as the first scanning. For statistical analysis, Shapiro-Wilk normality test and generalized linear models tests were applied and $p < 0.05$ was considered as statistically significant

Results

In the groups; while there was no significant difference in terms of roughness values (Ra) within the group ($p > 0.05$), a statistically significant reduction in roughness (Ra) was observed on the sample surfaces after polishing in all groups compared to the baseline ($p < 0.05$). According to the data obtained; all polishing methods used in the treatment of primary tooth discoloration can reduce the plaque formation and thus the amount of recoloring by reducing the surface roughness at a similar level.

Conclusion

Accordingly, it has been observed that the current polishing pastes do not provide a significant advantage over the traditional polishing method (polishing brush with pumice) in terms of surface roughness in removing discoloration in primary teeth.

Background

Color change in primary and permanent teeth negatively affects the aesthetic appearance. Especially, the coloration of the primary teeth causes parents to consult dentists for the concern of the presence of a decay [1]. In order to eliminate this aesthetic concern caused by tooth staining, the coloration should be removed [2]. The type of coloration is important in determining the method to be used for discoloration removal. There are three types of coloration: external coloration, internal coloration and internalized [3].

While external staining lies on the tooth surface and in the acquired pellicle, internal and internalized stains are found inside the tooth tissues [4] . Therefore, internal and internalized stains cannot be easily removed and must be treated with bleaching or various restorative techniques [4].

The black stains that dentists frequently encounter in children aged 5-13 years are external staining [5, 6]. The most commonly used procedure to remove external staining is polishing with abrasive-containing pastes [7]. However, the materials to be used in the polishing process should not damage the surface and increase the roughness [3].

Surface roughness is an irregularity that occurs on the surface of materials [8]. The surface roughness detected as a result of the measurement in the studies is caused by the areas removed from the organic matrix during polishing and the empty areas left by the filler or glass particles removed from these areas [9]. The enamel surface has a natural roughness due to the presence of Retzius grooves, pits and minor defects as well as the mineral accumulation that may occur in the mouth environment. The use of pastes with high abrasive content or the use of cycle tools in improper torque, speed and time may increase the surface roughness and cause the discolorations to increase in later stages [10].

Various devices are used to measure the surface roughness. Surface roughness measurements can be performed with qualitative methods such as scanning electron microscopy (SEM) and quantitative methods such as profilometry. In addition to these, atomic force microscopy (AFM) which is a new technique that has been used in recent years was also used in the measurement of surface roughness [11]. AFM allows the mineralization amount in dental hard tissues and the mechanical properties of calcified tissues to be examined in three dimensions and at high resolution [12]. Compared to conventional techniques, AFM has advantages such as providing 3-dimensional measurement, three-dimensional measurement at nanometer resolution, and not requiring vacuum or special treatment (coating, etc.) for samples [13]. AFM provides a recording of quantitative information such as surface roughness of samples as well as providing qualitative information such as images of surfaces [14]. However, it has disadvantages such as low scanning speed, high cost, and inability to detect undercuts [14].

In the literature, studies on polishing on the enamel are based on SEM imaging of the enamel surface [15-18] or measuring surface roughness with a profilometer [19-22] . Although there is no study examining the effect of polishing applications on the roughness of enamel surface with AFM, there are a limited number of studies examining the effect on materials such as composite surfaces or brackets with this technique [23, 24] . In this context, our research is also important in that it is the first study to evaluate different polishing methods applied to primary teeth with AFM.

Moreover, many new polishing pastes have been produced claiming that it causes less damage to the enamel surface instead of pumice, which is used as classical polishing material. At this point, in the use of these materials, which are much more costly than pumice, their superiority to pumice in terms of surface roughness becomes important. For this purpose, in this study, after measuring and visualizing the initial surface roughness of the primary tooth enamel surfaces with AFM, the difference between the roughness and appearance of the enamel surfaces after polishing using three different polishing paste and pumice (Septodent Détartrine, Kerr Cleanic, Shofu Mersaage Regular) was evaluated.

Methods

The present study was conducted in accordance with the Declaration of Helsinki approved by the institutional ethics committee (2019/894). Informed consent was obtained from legal parents of pediatric patients. Our study was supported by the Scientific Research Projects Coordinator of Erciyes University within the scope of TDH-2020-10001 project.

Considering the roughness, with the G. Power ver.3.9.1.2 program, with 95% confidence (one-tailed alpha), 95% test power and 0.72 effect size, dependent groups t-test power analysis results, in a total of 88 teeth, 22 teeth in each group were included in the study [25].

The primary molar teeth without cracks, calculus, restoration and caries in the coronal region were included in the study as a result of the examination performed with a magnifying glass. Freshly extracted teeth were stored in deionized water at room temperature until the moment of measurement. Preparation of the samples was performed by a single researcher. In order not to damage the enamel on the working surface in suitable teeth, it was removed from the root with the help of a water-cooling aerator (Bien Air, Black Pearl Eco, Suisse) and bur (Dimei, P.R.C.) at a distance of 2 mm from the apical point of the enamel cement border of the tooth. Afterwards, the teeth were divided into two pieces mesio-distally with a precision cutting device (Struers Inc., Minitom, USA). The vestibule surfaces of the samples were exposed and the study surfaces were buried into pink cold acrylic (Imicryl SC, Imicryl, Turkey) in the cardboard mold parallel to the ground plane.

All samples removed from the mold were cut and separated with the help of a 0.30 mm diamond separator (Sunshine Diamonds, Germany), arranged under water cooling with their acrylic surfaces parallel to each other. The samples were randomly grouped by preventing contact with each other in a container divided into compartments, and the container with the samples was divided and the group numbers and number of samples were written in each compartment. Samples were maintained in 100% humidity in an oven at 37 ° C in deionized water until the measurement day Atomic Force Microscope (Veeco Multimode 8, Mannheim, Germany) and Nanoscope 3D (Veeco, Mannheim, Germany) programme was used for the measurement of surface roughness of the samples and their three-dimensional imaging. Three-dimensional images of the samples in 20x20 µm and 256 x 256 pixels resolution and average surface roughness (Ra) values were determined. Calibration was repeated at each measurement stage, AFM measurements were made three times for each sample and Ra values were obtained by taking the average of the obtained data. Eighty-eight primary teeth were randomly divided into four main groups with 22 samples in each group. To the first group (GI) rubber brush and pumice, to the second group (GII) polishing rubber and Septodent Détartrine (Détartrine, Septodent UK. , France) with 45 g of polishing paste, to the third group (GIII) with polishing rubber (Pro-Cup Soft [ref 990/30, KerrHawe SA, Bioggio, Switzerland]) and Kerr Cleanic (Kerr Cleanic, Kerr, Switzerland), to the fourth group, polishing rubber and Shofu Mersaage Regular (Shofu Mersaage Regular, Shofu, Japan) paste were applied following the recommendations of the manufacturers(Table 1). The speed of the Shofu Mersaage Regular paste cycle device was set at a speed of less than 2000 rpm for 10 seconds, the speed of the Kerr Cleanic paste cycle device at a speed not exceeding 3000 rpm for 10 seconds, and in Septodent Détartrine and pumice paste it was applied for 10 seconds. After polishing, the samples were kept in deionized water at 37 ° C until the second measurement day.

After the polishing process, the second measurement and three-dimensional imaging of the surface roughness of all samples were carried out under the same conditions as the first measurement.

Data were analyzed with IBM SPSS V23 (IBM, Chicago, IL, USA). The suitability of the roughness values to normal distribution was examined using the Shapiro Wilk test. Data that are not normally distributed as a result of the normality test (Table 3). Normality assumption has been provided by making LN transformation. The changes of LN transformed roughness values according to group and time were analyzed by generalized linear models. In generalized linear models, the main effects of group and time on mean values and the interaction of group and time were examined. Analysis results are presented as mean ± standard deviation. The significance level was set as $p < 0.05$.

Results

Roughness mean values do not differ according to the groups ($p = 0.351$). While the average Ra value was 4.07 in Group I, it was 4.01 in Group II, 3.96 in Group III and 3.93 in Group IV (Table 4). Mean values differ by time ($p < 0.001$). While the average Ra value before the procedure was 4.1, the average value after the procedure was 3.88. Group and time interaction did not have a significant effect on measurement values ($p = 0.922$) (Table 2) (Fig 1-8).

Discussion

External tooth discoloration is caused by the adhesion of staining substances to the accumulated plaque on the teeth and chemical changes in the content of the deposits resulting from this organic combination [1]. Since the roughness of the oral hard tissues and restorative materials increases plaque retention, the surface roughness will affect the color change. Therefore, the polishing process has great importance [22]. In order to prevent recoloring after the polishing process applied to remove tooth stains, the agents to be used in the treatment process should not increase the roughness. Because a well-polished enamel surface holds less plaque than a rough surface, and thus the risk of recoloring is reduced [20]. Therefore, materials that establish smooth enamel surfaces and do not damage the enamel should be preferred.

Instead of pumice, which is used as a classical polishing material, many new polishing pastes have been produced with the claim that it causes less damage to the enamel surface. At this point, in the use of these materials, which are much more costly than pumice, their superiority to pumice in terms of surface roughness becomes important. In the study conducted by Covey et al. in 2011, they applied polishing rubber to enamel surface samples with and without polishing paste. The initial and final roughness values were measured with a profilometer. Surface roughness increased significantly in enamel samples with polishing paste applied. It has been stated that the abrasive feature of polishing pastes used during polishing is the reason for the roughness on the enamel surface [19]. In this context, in the present study, after measuring and visualizing the initial surface roughness of primary tooth enamel, the difference between the roughness and appearance of the enamel surfaces after polishing using three different polishing paste with pumice was evaluated. As a result of the research, polishing pastes produced to be used instead of pumice remove external discoloration on the surface of the primary tooth enamel, while the ones that do not increase the roughness -as it has been suggested- will prevent recoloring and plaque retention and will help clinicians in the selection of the most affordable material.

In the literature, it has been observed that different methods are used to evaluate the roughness of different applications on dental tissues and restorative materials. When the literature is reviewed, it was seen that there are many studies [19-22, 25] examining the surface roughness with SEM [15-18] and profilometer. SEM has some disadvantages such as its inability to display the surface properties in three dimensions, it is a qualitative method that cannot give a quantitative result, requires specific (coating, etc.) processing [11]. On the other hand, profilometers allow a two-dimensional measurement of the surface profile by going over the material surface of a diamond point [26, 27] . Mechanical profilometers have been widely used for many years to measure surface roughness [28-30]. The most important advantage is that the samples do not require a preliminary preparation stage, thus allowing repeated use and measurement of samples [31]. On the other hand, its most important disadvantages are that it cannot provide visualization of its surface and gives only a quantitative measurement [26, 27]. AFMs can make measurements in wide scales ranging from nano-size to micro size [32]. Measurements made at the nanometric level provide a much more detailed measurement of the surface topography than the profilometer. It has important advantages that it gives a three-dimensional image that cannot be obtained with SEM or profilometry and does not damage the examined tissue because it does not require a special coating process such as SEM [14]. However, it could not be used routinely in the assessment of surface roughness because it is expensive compared to profilometer and SEM and the measurements take a long time [14]. As it can be understood, there is no consensus among researchers about the method of evaluating surface roughness, as each technique has its own advantages and disadvantages. In our study, we evaluated it with AFM analysis because it gives high-resolution objective results.

Researchers have used different types of human teeth in various studies. Chowdary et al. [16] conducted a study with 60 teeth in 2018. They included each tooth extracted for periodontal reasons and showed no signs of caries, abrasions or fractures. Castanho et al. [25] , Giampaolo et al. [20] and Salami et al. [10] used a third molar tooth in their study in which they evaluated enamel roughness. Willman et al. [33] stated that they used molar teeth in their study in which they examined the roughness change created by polishing methods on the enamel. Yurdagüven et al. [22] preferred central incisors in their study. In the present study, in which we evaluated the effect of different polishing methods on primary tooth enamel, primary molar teeth were used because of their more sensitive structure than permanent teeth.

In a study performed by Chowdhary et al., the effectiveness of three different polishing systems on enamel was compared with SEM. Compared polishing methods were polishing paste application with polishing rubber, polishing paste application with bristle brush and air abrasion. All polishing tools used in this study were applied to the samples for 15 seconds. The rotation speed for the tire and brush applied with the help of a motor is between 2500 and 3000 rpm. In the present study, the application was carried out for 10 seconds with a rotation speed between 2000 and 3000 rpm in accordance with the manufacturer's instructions. According to the study results of Chowdhary et al., it has been reported that the surface of the samples treated with an air-polishing device has a more irregular surface than the surface of the samples treated with rubber and brush. It has been suggested that polishing with a rubber brush is the most effective method for obtaining smooth surfaces [16].

Castanho et al. compared the air abrasion method applied with pumice and paste and sodium bicarbonate spray applied with a rubber brush. They stated that the use of sodium bicarbonate spray results in rougher surfaces than the pumice mixture. Also, they found that the use of polishing paste did not show a statistically significant difference when compared to other methods. In their study, although the brands of polishing pastes are different from the ones we use, it was revealed that the use of polishing paste did not show a statistically significant difference compared to pumice similar to our study [25].

Salami et al. [10] investigated the effects of sodium bicarbonate jet, pumice and a whitening paste on enamel using SEM. According to the results, pumice caused the enamel to wear, resulting in a smoother surface than natural enamel. However, the surface formed as a result of polishing with pumice was found to be rougher than the enamel surface which was polished with sodium bicarbonate and paste. However, statistical analysis and SEM images showed that the erosion power of pumice can change the enamel and create a more homogeneous surface than the natural one. In parallel with the results of our study, all methods are statistically significant in reducing enamel roughness. And the roughness measurement values of the pumice group gave mathematically higher results than the other groups.

In the study conducted by Yurdagüven et al. [22], the effects of polishing paste (Septodont-Detartrine, France) on enamel, dentin, porcelain and various composite types were investigated. The researchers first smoothed the surfaces with discs and then polished them with pumice and distilled water. After this process, the initial roughness value was measured. Then the paste was applied and the final roughness values were measured. As a result, they found that the prophylaxis paste increased the surface roughness of all groups. We think that this result, which is different from our result, is since Yurdagüven et al. tried to obtain an initial roughness value close to the strip band surface roughness by flattening the surface of all samples with a disk in order to establish standardization before the first roughness value measurement. In this study examined [22] , the evaluation was made by SEM imaging, and since the coating process was applied to the sample used, the initial and final measurements could not be made on the same sample, so a standardization process was performed. In our study, there was no need for such a procedure since the examination was performed with AFM. On the other hand, although our study is an in vitro study, we aim to try to obtain results that can be integrated into clinical conditions. For this reason, this application was not performed in our study since there is no possibility to polish the surface of the tooth of a child patient during clinical practice after flattening with a disc.

In the study conducted by Camboni et al. in 2016, the effects of different polishing pastes (Prophy Paste CCS®, Proxyt®, Cleanic®, Super Polish) applied with rubber on enamels were compared with SEM imaging. It was observed that there was an increase in roughness on the surfaces where the polishing paste applied with a rubber brush was applied compared to the control surface [15] . The reason for this result, which is different from our findings, might be due to the fact that the evaluation with SEM does not provide quantitative data and cannot display the three-dimensional surface profile. On the other hand, the evaluation with AFM, which we used in our study, provided quantitative results and the opportunity to examine with high resolution.

Conclusion

In the present study, it was concluded that the polishing process performed to remove external discoloration in primary teeth is a useful application, it will reduce the plaque formation and recoloring by removing surface irregularities. However, the effectiveness of the pastes to be used in this process is similar. The roughness values created by all the materials we applied to the enamel surface were found below 200 nm [34] , which is the highest clinically acceptable surface roughness value. However, considering the cost, accessibility and benefit criteria, pumice still maintains its feature of being a sufficient material in polishing materials.

Declarations

Ethics approval and consent to participate

This study was approved by Erciyes University Clinical Research Ethics Committee (2019/894). Informed consent was obtained from legal parents of pediatric patients.

Consent for publication

Not Applicable.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

All authors contributed to the study conception and design. BD and SD prepared the material, collected the data. BD wrote the first draft of the manuscript. BD and SD have been involved in drafting the manuscript or revising it critically for important intellectual content. All authors approved the final manuscript.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1 Groups included in the study and their content

Group Name	Polishing Paste	Included Abraziv	Manufacturer	Ingredients
Group I (GI)	Imıpomza	Pumice	Imıcryl,Turkey	Pumice
Group II (GII)	Septodent Détartrine	Silica	Saint-Maur-des-Fosses Cedex France, 94107	Silicon oxide, natural volatile oils, additives
Group III (GIII)	Kerr Cleanic	Perlite	Via Strece 4, Bioggio Switzerland, 6934	Titanium dioxide, menthol, perlite
Group IV (GIV)	Shofu Mersaage Regular	Pumice	Kyoto 605-0983, Japon	Pumice, binders, surfactant, flavorings, colorants, sodium monofluorophosphate (0.34%)

Table 2 Comparison of roughness values by group and time

	Test Statistics	Degree of Freedom	p*
Group	3,277	3	0,351
Time	14,774	1	**<0,001**
Group*Time	0,487	3	0,922

*Results of Generalized Linear Models

Table 3 Descriptive statistics of roughness values (mean ± standard deviation) (original)

	GI (n=22)	GII (n=22)	GIII (n=22)	GIV (n=22)	Total
Before	67,28 ± 1,59	60,10 ± 1,74	58,59 ± 1,63	57,44 ± 1,52	60,74 ± 1,62
After	50,96 ± 1,29	50,96 ± 1,31	47,14 ± 1,36	45,13 ± 1,36	48,48 ± 1,33
Total	58,55 ± 1,49	55,34 ± 1,55	52,55 ± 1,52	50,91 ± 1,46	54,26 ± 1,51

Table 4 Descriptive statistics of roughness values (mean ± standard deviation) (LN transformation

	GI (n=22)	GII (n=22)	GIII (n=22)	GIV (n=22)	Total
Before	4,21 ± 0,46	4,09 ± 0,55	4,07 ± 0,49	4,05 ± 0,42	4,10 ± 0,48
After	3,93 ± 0,26	3,93 ± 0,27	3,85 ± 0,31	3,81 ± 0,31	3,88 ± 0,29
Total	4,07 ± 0,4	4,01 ± 0,44	3,96 ± 0,42	3,93 ± 0,38	3,99 ± 0,41

Figures

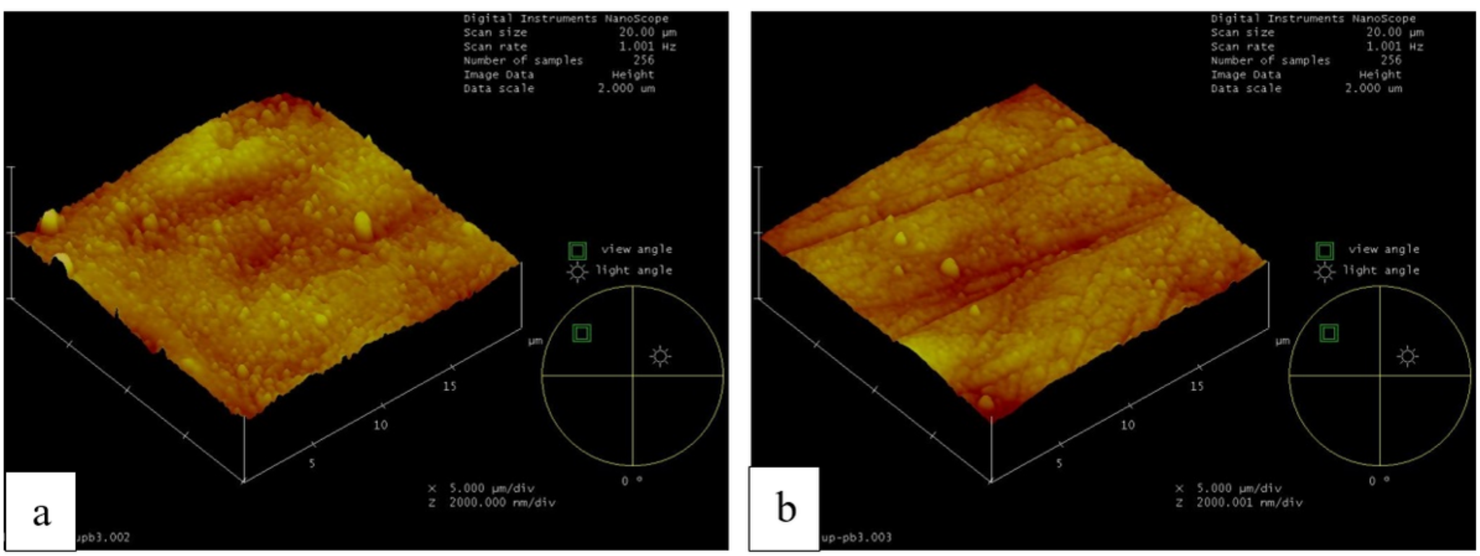

Figure 1

AFM images of samples in Group I (a- pre-polishing, b-after polishing)

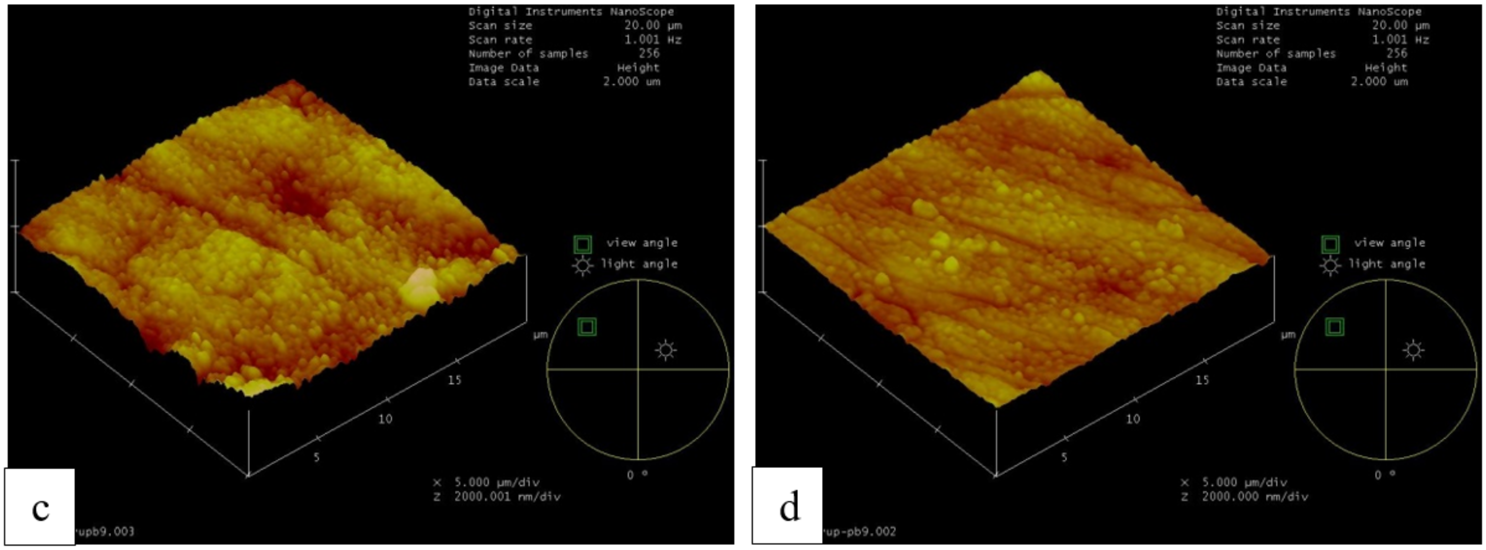

Figure 2

AFM images of samples in Group I (c- pre-polishing, d-after polishing)

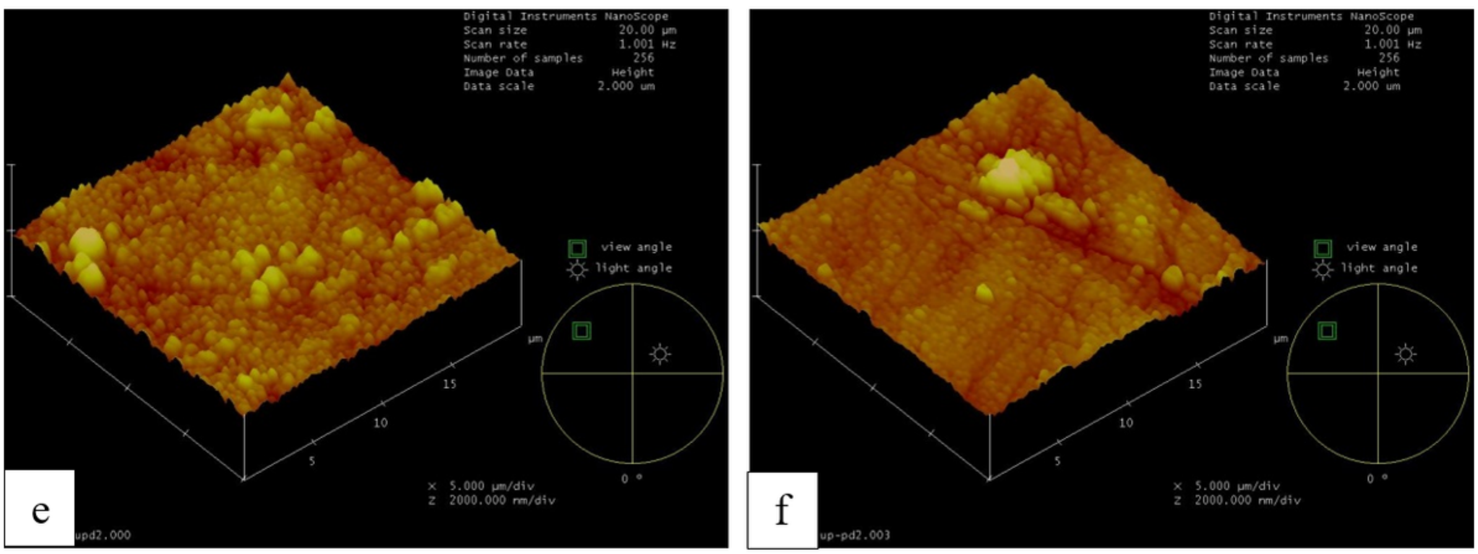

Figure 3

AFM images of samples in Group II (e- pre-polishing, f-after polishing)

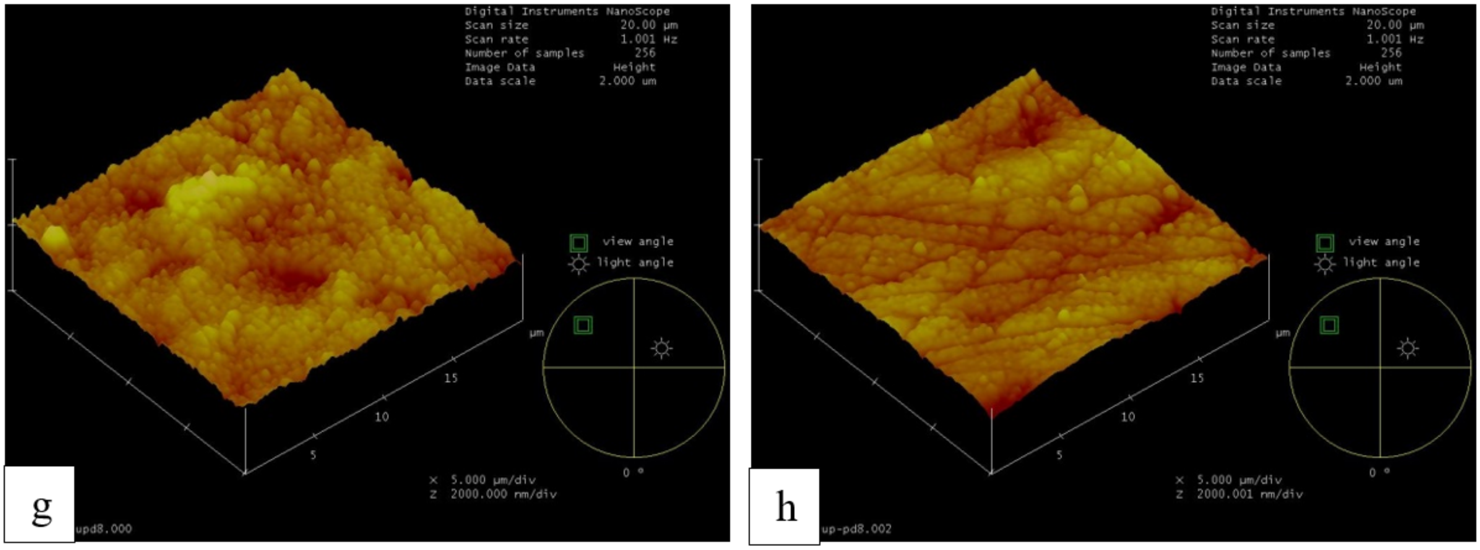

Figure 4

AFM images of samples in Group II (g- pre-polishing, h-after polishing)

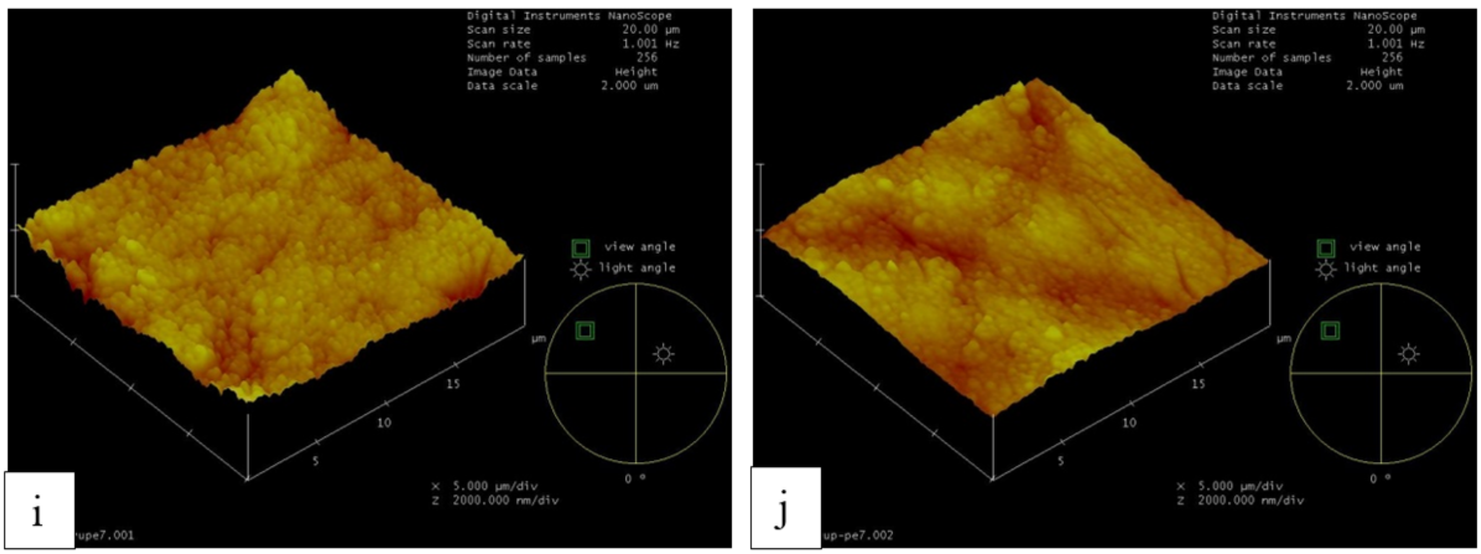

Figure 5

AFM images of samples in Group III (i- pre-polishing, j-after polishing)

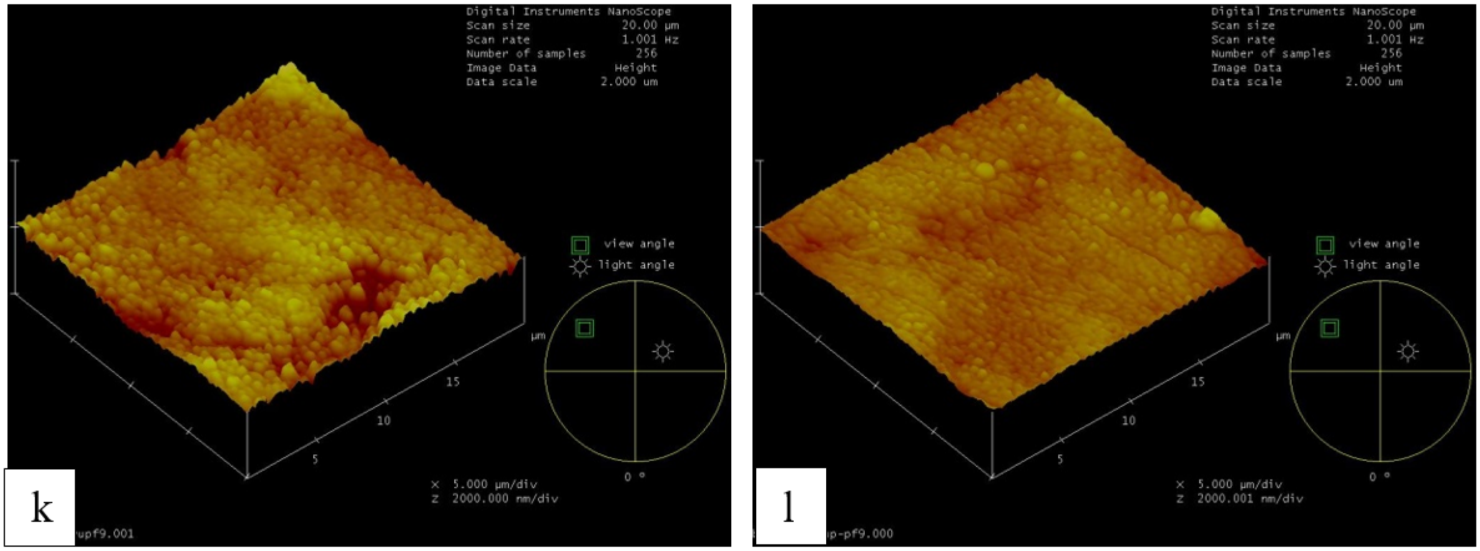

Figure 6

AFM images of samples in Group III (k- pre-polishing, l-after polishing)

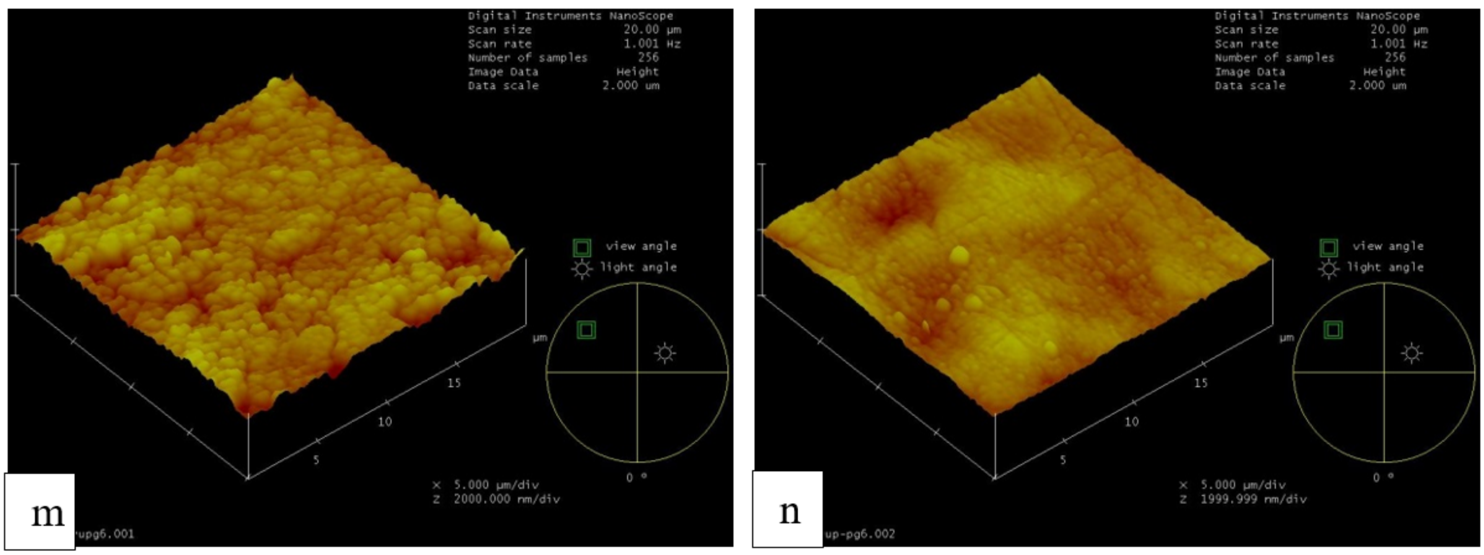

Figure 7

AFM images of samples in Group IV (m- pre-polishing, n-after polishing)

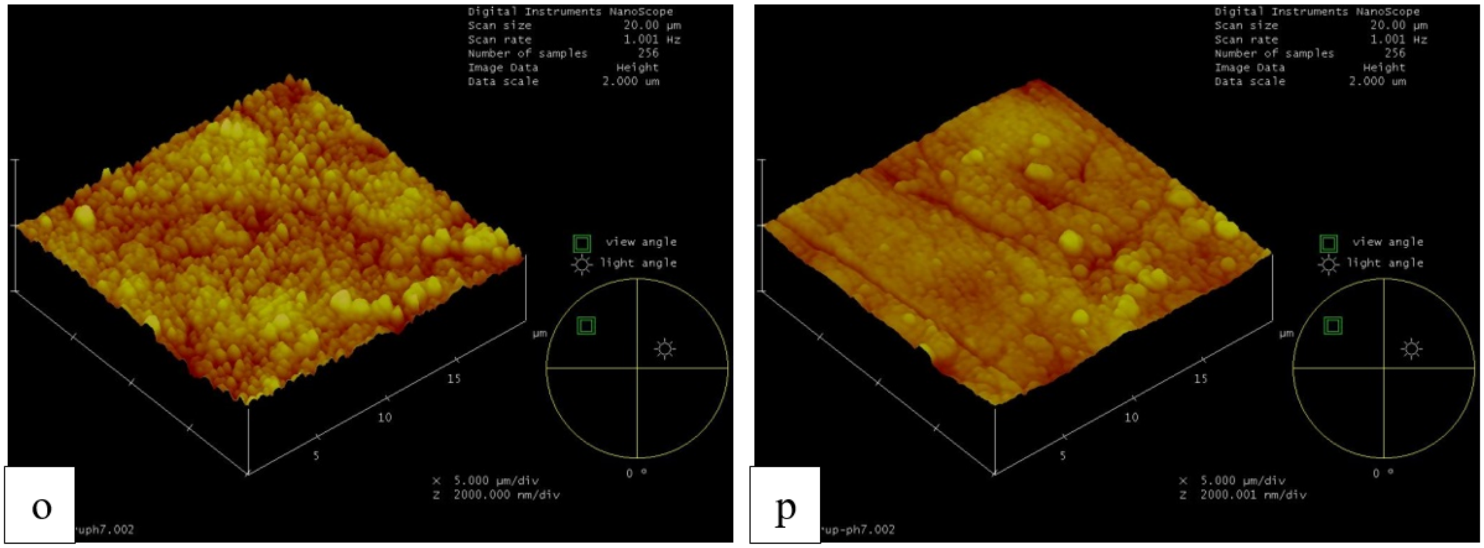

Figure 8

AFM images of samples in Group IV (o- pre-polishing, p-after polishing)