Effects of air-powder abrasives on enamel and root surface: An in-vitro micro-computed tomography study

Vecihe Merve Balta Uysal[1], Kaan Orhan[2], and Esra Güzeldemir Akçakanat[1]

[1]Kocaeli University
[2]Ankara University

March 30, 2023

Abstract

Intro: Removal of bacterial plaque and stains are a crucial part of non-surgical periodontal treatment. Following scaling, polishing by air-powdered devices is widely used. The aim of this study is to evaluate the changes caused by three different air-powder abrasives from the same company (sodium bicarbonate, glycine, and erythritol) on the enamel and exposed root surface. **Methods:** The enamel and exposed cementum surface were air polished at an instrumentation time of 5s, combinations of medium and maximum power, medium water settings, the distance of 5mm, and angulation of 60 ^{0}. Samples were scanned in a micro-computed tomography (micro-CT) at baseline and then after air-polishing powder applications, and the defect depth, defect volume, demineralization depth, and tissue mineral density (TMD) values were evaluated. **Results:** Sodium bicarbonate-based powder is more abrasive than glycine and erythritol-based powders ($p<0.05$). All powders caused more abrasion at the maximum power setting ($p<0.05$). There were statistically significant differences between the mean TMD values before and after the application in all groups ($p<0.05$). After the application, the average TMD was found to be lower. **Conclusion:** We can conclude that glycine and erythritol-based powders can be used for supragingival air polishing in patients with gingival recession, in addition, we can recommend that the power setting be set to the minimum level at which stain, and plaque can be effectively removed.

Introduction

Periodontal diseases are usually plaque-associated inflammatory diseases and are initiated by the accumulation, organization, and maturation of biofilm on teeth surfaces. Periodontitis results from polymicrobial dysbiosis. Hence, the treatment of periodontitis can be achieved by restoring homeostasis by reducing microbial load. Recently, it was reported that treatment of periodontitis comprises of a) behavioral changes, supragingival biofilm, gingival inflammation, and risk factor control; b) supra- and sub-gingival instrumentation, with and without adjunctive therapies; c) periodontal surgical interventions; d) supportive periodontal care. The success of periodontal treatment and maintaining of periodontal health relies on the removal of plaque and calculus from supra and subgingival areas.

Professional mechanical plaque removal (PMPR) is described as "the removal of the supragingival dental biofilm and calcified deposits (calculus) and is reported as an essential component of the treatment of plaque-induced periodontal diseases and both primary and secondary prevention of periodontitis.

The first step in periodontal therapy consists of behavioral changes in patients and motivation towards the removal of supragingival biofilm. Supragingival biofilm control is not only a keystone of both nonsurgical and surgical treatment but also maintaining periodontal health. Supragingival plaque control should be achieved by self-performed oral-hygiene measures by patients themselves, however, proper oral hygiene can not be obtained without removing pre-existing plaque, calculus, and other plaque-retaining factors professionally.

The first step of periodontal therapy as mentioned above includes PMPR. On the other hand, studies on oral hygiene measures performed by patients clearly showed that it is not sufficient to maintain periodontal health alone with the reasons of limited patient compliance, unable to use of dental floss or interdental brushes, irregular toothbrushing, etc. Hence, PMPR together with proper oral hygiene is an inevitable part of regular dental check-ups and follow-ups of periodontal treatments.

The purpose of PMPR does not perform careful root planing , but meticulous plaque and calculus removal. PMPR, supra- and sub-gingival calculus, and removal of remnants from supra- and sub-gingival areas can be achieved by hand instruments and, sonic and ultrasonic scalers, and air-polishing devices (power-driven devices) by professionals. There are numerous studies in the literature since 1950s have studied manual and sonic and/or ultrasonic scalers. Especially powdered air abrasive polishing systems have received considerable attention with various powders developed not only to disrupt the biofilm from teeth and lately implant surfaces but also for tooth polishing and stain removal. While traditional air abrasive systems were found to be more harmful on root surface, later systems have demonstrated better results without damaging the hard and soft tissues of the teeth. In individuals with gingival recession, polishing procedures affect dentine and cementum as well as enamel. In vitro studies have been conducted on extracted human and bovine teeth to determine the effects of materials used for polishing on dental tissues, but most of the studies were performed on the healthy root surface.

Air polishing devices remove dental biofilm from the tooth surface with the operating system of compressed air containing water, and abrasive particles. Air polishing devices can only remove biofilm, not calculus and other calcified or hard remnants from the tooth surface. Consequently, air polishing devices must be used along with hand instruments or power-driven devices in the treatment of periodontal diseases. Air polishing devices are safe and comfortable, require less operation time, and cause less discomfort and pain for the patient compared to traditional polishing methods, moreover, it is a less fatiguing method for the operator. Side or adverse effects of the use of air polishing devices are usually very rare which include painless gingival erosion, tooth sensitivity, abrasion of the root cementum, and subcutaneous emphysema, etc.

There are studies in the literature that compare the efficacy of air polishing devices vs ultrasonic instrumentation and air polishing devices vs hand instrumentation. The reports revealed that air polishing and hand or ultrasonic scaling are clinically efficient for interrupting and removing plaque. In addition, air polishing abrasives are also investigated for their potential harm to the hard and soft tissues in different ex vivo or in vitro settings. The surface modifications of the treated teeth and soft tissues by different air-polishing abrasives such as sodium bicarbonate, glycine, erythritol, calcium carbonate, and bioglass are evaluated not only for the specifications of the powders but also for air-polishing devices. In the literature, air polishing powders were evaluated with their grain size and shape; air polishing devices for angulation and distance of application, exposure time, and surface modification of hard tissues were evaluated with defect depth, defect volume, defect size, surface roughness, cleanliness and root substance removal the methods such as biopsy, the triplicate wax pattern of defect, average weight, electron microanalyzer, micro-CT, 3-D-measuring microscopy, SEM, confocal laser scanning microscope, light microscopy, superimposition, impressions, replicas, epoxy resin casts, and optical profilometer etc.

Since air-polishing devices are an inevitable part of the clinical periodontal practice for the treatment of periodontal diseases and maintenance, the present study was conducted to analyze the effects of different air-polishing powders on the enamel and exposed root surface.

Our hypothesis was that with erythritol air polishing, defect volumes, defect depth, and demineralization depth on enamel and exposed root surface would be smaller than those created with sodium bicarbonate and glycine powder. The second hypothesis was that defect depth, defect volume, and demineralization depth value at the maximum power setting would be higher than at medium power setting values in all groups. Therefore, the aim of this in vitro study to test these hypotheses is to evaluate the effect of an air-polishing device using three different air-polishing powders on enamel and exposed cementum surfaces in the oral cavity at two different power settings.

Materials and Methods

Approval from Research Ethics Committee

This study protocol was approved by the Kocaeli University Ethical Committee of Clinical Research, Non-Invasive Clinical Research Ethical Committee (KOU GOKAEK 2019/10.34) and was conducted following the Declaration of Helsinki of 1975, as revised in 2000. All participants signed an informed consent form for being included in the study. This clinical trial is registered at ClinicalTrials.gov as NCT04853745.

Sample selection and processing of teeth

The patients were recruited from individuals seeking periodontal and/or dental treatment at the Faculty of Dentistry, Kocaeli University, Kocaeli, Turkey. The teeth samples were collected from the participants who met the following criteria: being older than the age of 18, having no history of any infectious disease such as hepatitis and/or HIV (+), being willing to participate in the study, having a single-rooted tooth with a gingival recession on all surfaces and need to be extracted, the tooth must be free of caries, defects, and restorations.

All patients who met the criteria were informed about the study. Patients who gave written informed consent were included in the study.

Before the teeth extractions, root surfaces were marked all around with a bur at the gingival margin. Extractions were performed under local anesthesia with articaine hydrochloride and epinephrine 1:200,000 (Ultracain® D-S, Sanofi Aventis, Istanbul, Turkey). Following the extractions, tooth surfaces were cleaned with an ultrasonic scaler (Woodpecker® Medical Instrument Co. Ltd., Guilin, China) to remove deposits and soft tissue remnants and were inspected under 2.7X magnification (Orangedental®, Biberach, Germany). They were sectioned using a metal disc attached to the handpiece by gingival margin level. Extracted teeth were collected and were randomly divided into 3 groups as follows: sodium bicarbonate group¸glycine group, and erythritol group. The samples were stored in 1% thymol.

Evaluation with Micro-CT scanning

Samples were scanned before and after polishing powder application with a high-resolution micro-CT device (Bruker SkyScan 1275, Kontich, Belgium). The scanning conditions were 100 kVp; 100-mA, 0.5-mm Al/Cu filter; 13.1-μm pixel size; and rotation at 0.2 steps. According to the manufacturer's instructions, each sample was rotated 360°. The mean scanning time was around 1h. Also, to measure tissue mineral density (TMD), two different mineral concentrations of conical MD phantoms (rods) of 0.25 and 0.75 gHAp cm^3 were placed next to the samples, and the scan was repeated at the same conditions at baseline and after the polishing procedure.

Tooth surfaces instrumentation

The same air-polishing device (AIR-FLOW® Master Piezon, EMS SA, Nyon, Switzerland) was used for all powder instrumentations. Three types of air-polishing powders were used: sodium bicarbonate-based particles (CLASSIC®, EMS SA, Nyon, Switzerland), glycine-based particles (PERIO®, EMS SA, Nyon, Switzerland), and erythritol-based particles (PLUS®, EMS SA, Nyon, Switzerland). All surfaces were numbered, and application was made to the mesial and distal surfaces of the root, buccal and lingual surfaces of the crown to avoid repeated instrumentations. After the device and samples were fixed, a metal plate with a 5 mm diameter hole was placed on the sample to limit the application area. Surfaces one and three were air-polished at medium power setting (9 LED power setting) and surfaces two and four were air-polished at maximum power setting (17 LED power setting). The distance between the handpiece and the tooth surface was kept constant at 5 mm, and the treatment angulation was adjusted to 60^0. In all applications, the application time was 5 seconds, and the water setting was medium (6 LED). The powder chambers of the device were filled to the maximum level in each application.

Micro-CT image analysis

The special software (NRecon ver. 1.7.4.2, Skyscan, Kontich, Belgium) was used for reconstructions. For the reconstruction parameters, ring artifact correction and smoothing were fixed at 7 and 3 in the order, and the beam artifact correction was set at 40%. 16-bit gray-value images were obtained. Reconstructed images were superimposed using another software (DataViewer ver. 1.5.6.2, Skyscan, Kontich, Belgium). The pre-application images and the incisal edges and buccal cusps of the teeth in this image were chosen as a landmark to align the pre-application and post-application images. The reference and target images were superimposed, and a different image was obtained from the different areas of the two images. This image represented the change in the area after the air-polishing. After reconstruction, the interpolated regions of interest (ROI) were drawn using the software (CTAn ver. 1.16.1.0, Skyscan, Aartselaar, Belgium). Using these ROIs, defect depth, defect volume, and demineralization depth were measured. Thresholding was applied to each of the images. The threshold was set as follows: the lower limit was set between 20 and 255 (in grayscale values), and the upper limit was set at the top end of the brightness spectrum. A multilevel Otsu threshold was used.

To evaluate TMD, ROIs were manually drawn to include the enamel and exposed root surface which is cementum. Other regions were excluded from the ROI selection. The ROIs were subtracted from the original image by software (CTAn ver. 1.16.1.0, Skyscan, Aartselaar, Belgium) to allow average gray value and density analysis, and TMD was calculated. To aid TMD calculations, grayscale values were converted into MD values (gHAp cm^3) with a linear calibration curve based on grayscale values obtained from two mineral concentration conical phantoms of 0.25 and 0.75 gHAp cm^3.

Statistical analysis

Power analysis was performed using software (G*Power Software version 3.1.9.2, Düsseldorf, Germany) to estimate the minimum required sample size. Sample counts were calculated at 12 for each group. Type I error and test power was set to 5% and 90% respectively. Considering the losses that may arise during sample preparation, the sample size was determined to be 48.

The data were analyzed using commercially available statistical analysis software (MedCalc Statistical Software version 12.7.7, MedCalc Software bvba, Ostend, Belgium).

Descriptive statistics that were used to analyze the results included the mean, standard deviation, median, minimum, and maximum. Kruskal Wallis test was used to compare differences in more than two independent variables. Mann-Whitney U test was performed to compare differences between two independent variables. Wilcoxon test was used to compare differences between two dependent variables. P -values less than 0.05 were considered statistically significant.

Results

A total of 48 samples were prepared. Samples found to have defects in the pre-application scanning images during micro-CT analysis were excluded from the study. The number of samples in the sodium bicarbonate group decreased to 15, in the glycine group to 12, and in the erythritol group to 14.

Defect depth

The mean defect depth values of sodium bicarbonate, glycine, and erythritol groups on enamel and cementum surfaces were shown in Table 1. The mean defect depth on enamel and cementum surfaces in the sodium bicarbonate group was observed significantly greater than the erythritol and glycine groups at both power settings (p <0.05, Table 1). There were statistically significant differences between the erythritol and glycine groups on enamel surfaces (p <0.016). The mean defect depth in the glycine group was greater than the erythritol group. At a medium power setting, the mean defect depth in the erythritol group on the cementum surfaces was observed significantly greater than a glycine group (p <0.016). At maximum power setting, on cementum surfaces, no statistically significant difference was observed between the glycine and erythritol groups (p >0.016). The mean defect depth at the maximum power setting was significantly higher than at the medium power setting in all groups (p <0.05, Table 1). There were no statistically significant differences between the mean defect depth on enamel and cementum surfaces in the glycine group (p >0.05).

Defect volume

The mean defect volume values of sodium bicarbonate, glycine, and erythritol groups on enamel and cementum surfaces were shown in Table 2. At both power settings, there were no statistically significant differences between the mean defect volume on enamel surfaces in the erythritol and glycine groups and the erythritol and sodium bicarbonate groups (p >0.016). The glycine group had significantly less mean defect volume than the sodium bicarbonate group (p <0.016). The mean defect volume at the maximum power setting was significantly higher than at the medium power setting in all powder groups (p <0.05, Table 2) whereas the erythritol group had significantly less mean defect volume than the sodium bicarbonate group (p <0.016). At maximum power settings, the mean defect volume on enamel surfaces was significantly lower than the mean defect volume on cementum surfaces in all groups (p <0.05)

Demineralization depth

The mean demineralization depth values of sodium bicarbonate, glycine, and erythritol groups on enamel and cementum surfaces were shown in Table 3. At both power settings, no statistically significant differences were observed between the mean demineralization depth on enamel surfaces in all groups (p >0.05, Table 3). Also, at a medium power setting, no statistically significant differences were observed between the mean demineralization depth on cementum surfaces in all groups (p >0.05, Table 3). The mean demineralization depth at the maximum power setting was significantly higher than at the medium power setting in all powder groups (p <0.05, Table 3).

Tissue mineral density (TMD)

The mean TMD values of sodium bicarbonate, glycine, and erythritol groups on enamel and cementum surfaces were shown in Table 4. No statistically significant differences were observed between the mean TMD values of the samples in all groups before the application (p >0.05, Table 4) while the mean TMD in the sodium bicarbonate group had significantly greater than the mean TMD in the erythritol and glycine groups after the application (p <0.05, Table 4). In all groups, the mean TMD after the application was significantly less than the mean TMD before the application (p <0.05, Table 4).

Discussion

This in-vitro micro-computed tomography study was designed to assess the effect of an air-polishing device using three different powders on the enamel and root surface at two different power settings. Defect depth, defect volume, demineralization depth, and TMD were also evaluated. To our knowledge, this is the first study in the literature that has assessed demineralization depth and TMD change after air polishing and evaluate the effect of erythritol air polishing on the root surface.

The first hypothesis for defect depth was supported by results on the enamel surface at two different power settings. It was found that all powders caused defects on the enamel surface at both power settings. There was a statistically significant difference between the mean defect depths of the three powders. The sodium bicarbonate group had significantly the greatest mean defect depth.

The abrasive property of the powder is determined by particle diameter, shape, and hardness. Particle shape and hardness are the main factors affecting the abrasive property. Data on particle sizes are contradictory. Some studies reported that abrasive powders with small particle sizes cause more abrasion, as well as studies showing the opposite. According to the results of the present study, the fact that sodium bicarbonate powder had the highest mean defect depth can be explained by having a greater Mohs hadness value and particle size than erythritol and glycine powders. It was thought that the difference between the mean defect depths is less because the Mohs hardness values of the erythritol and glycine powders are the same and their particle sizes are close to each other.

Some of the studies reported that sodium bicarbonate air polishing causes abrasion and roughness on the enamel surface, while others reported that it does not cause changes on the intact enamel surface and is safe and efficient to remove stains. In the present study, in line with other previous studies, it has been also

shown that sodium bicarbonate-based powder cause defects on the enamel surface. Barnes et al. reported that sodium bicarbonate and glycine-based abrasive powders showed statistically significant abrasive properties on the enamel surface, however, no difference between their abrasive properties was seen. In the present study, it was observed that the defect depth and defect volume caused by sodium bicarbonate powder on the enamel surface were significantly higher than the defect depth and defect volume created by glycine powder. The sodium bicarbonate powder used in the study by Barnes et al. has the same particle size as the powder used in our study, however, the particle size of the glycine-based powder is larger than the glycine powder used in our study. Barnes et al. evaluated the roughness caused by polishing with profilometry. Our study evaluated defect depth, defect volume, and demineralization depth using a micro-CT device. The different materials and methods of the studies may have caused differences between the results.

Camboni and Donnet evaluated the effect of erythritol air polishing on the enamel surface by SEM and reported that erythritol air polishing did not create a microscopically visible defect on the enamel surface. Considering the results of our study, erythritol-based abrasive powder causes defects and demineralization on the enamel surface. Camboni and Donnet made an application with a water setting of 11 LED and a power setting of 6 LED for 10 seconds. In our study, the applications were made for 5 seconds with a power setting of 9 and 17 LED and a water setting of 6 LED. As the air pressure increases, the efficacy of the instrument increases. The higher power settings in our study may have caused defects on the enamel surface.

The results regarding the mean defect depth and defect volume on the cementum surface did not support our first hypothesis. The findings in the present study showed that sodium bicarbonate air polishing caused the highest mean defect depth on cementum as caused by enamel at both power settings. At the maximum power setting, no significant differences were found between the mean defect depth of erythritol and glycine groups on the cementum. At both power settings, no significant differences were detected between the mean defect volume on cementum surfaces in the erythritol and glycine groups and the glycine and sodium bicarbonate groups. The erythritol group had significantly less mean defect volume than the sodium bicarbonate group.

Although many studies in the literature evaluating the effect of sodium bicarbonate and glycine air polishing on the root surface there are no studies evaluate the changes caused by erythritol air polishing on the root surface. Studies have reported that sodium bicarbonate air polishing causes severe defects and is not safe to use on the root surface. Some studies reported that glycine powder shows less abrasive properties on the root surface compared to sodium bicarbonate, while other studies reported that there is no statistically significant difference between the mean defect depths and defect volumes of glycine powder and sodium bicarbonate. It is thought that there may be differences in the particle size and shape of the powders used in the studies, the manufacturers of the powders and devices, the application time, angle, application method, and the analysis method of the post-instrumentation defect may be revealed differences between the studies.

The first hypothesis could not be confirmed. At both power settings, no significant differences were observed between the mean demineralization depth on enamel surfaces in between the powders. At a medium power setting, no significant differences were seen between the mean demineralization depth on cementum surfaces in between the powders. At the maximum power setting, the mean demineralization depth on the cementum surface in the sodium bicarbonate group was greater than the other two groups. The similarity of demineralization depth averages can be explained by the close pH values to each other. pH values of sodium bicarbonate, glycine, and erythritol-based powders are 8.1, 6, and 7, respectively. The second hypothesis could not be confirmed too. There were statistically significant differences between the mean TMD values before and after the application in all groups. After the application, the average TMD was found to be lower. Berkstein et al. reported that the meantime to remove the stain by the air-polishing device was 3.23 seconds per root surface. Petersilka et al. assumed that the time required to clean the surface is 2.5 seconds since the device is in a stationary position in vitro study. They reported that a time of 20 seconds would represent approximately the time spent on root surface instrumentation within 2 years. In our study, a total of 10 seconds was air polishing to the enamel and cementum surface. This represents the time spent during 1-year supportive periodontal treatment, and 4 times in a year. During the time required for one-year supportive treatment, all powders caused a reduction in tooth mineral density.

The third hypothesis was confirmed. Power setting has been shown to high impact on substance removal. An increase in power setting will cause an increase in instrument efficacy. The results of our study also support this information. At the maximum power settings, defect depth, defect volume, and demineralization depth were found significantly higher than at medium power settings in all groups.

The higher the hardness of the surface to be instrumented, the smaller the amount of substance removed from the surface. Enamel is the hardest tissue in the body of a vertebrate. Enamel has a Mohs hardness value of 5, while cementum has a Mohs hardness value of 2.5 - 3. The results of our study are also parallel to those reported results. All powders showed more abrasive properties on exposed cementum surfaces, especially at the maximum power setting.

One of the strengths of the present in vitro study is, the tooth surfaces were evaluated with a micro-CT device and the measurements were made by superimposing 3-D images before and after the examination. The biggest advantage of micro-CT examinations on the tooth surface is that high-resolution images can be obtained directly by scanning the tooth surface without requiring any surface preparation or invasive processing before imaging.

Atkinson et al. reported that due to the tendency of the exposed root surface to be hypermineralized, the amount of tissue removed by air polishing may be less than the root surface that was not exposed to the oral cavity. The differences in the cementum structure, which is not exposed to the oral environment, and which has become exposed because of periodontal pathologies, suggest that the effects of applications with air-polishing systems may also differ. For this reason, in our study, we attempted to imitate the clinical situation by air polishing the root surface exposed to the oral cavity.

It is recommended to move the handpiece during clinical use of air-polishing systems. In in vitro studies, it is difficult to imitate clinical practice by moving the handpiece and standardizing this mobility. Although the application angle and distance in our study were determined by the manufacturer's recommendations, the handpiece and the sample were fixed to ensure standardization and comparison. This may have prevented the results of our study from fully demonstrating clinical effects and this may assume as one of the limitations.

Conclusion

All powders caused abrasion on both the enamel and exposed root surfaces in the present study. Sodium bicarbonate-based powder is more abrasive than glycine and erythritol-based powders and may not be recommended use for supragingival air-polishing in patients with gingival recessions. Glycine and erythritol-based powders can be used for supragingival air polishing in patients with gingival recession, however, it should be kept in mind that these powders cause less abrasion on the enamel and root surfaces. All powders caused more abrasion at the maximum power setting than the lower setting. For this reason, it is recommended that the power setting be set to the minimum level at which stain, and plaque can be removed effectively.

References

Tables

Table 1- Defect depth of enamel and exposed root surfaces after air polishing (μm)

Power Setting Levels	Sodium Bicarbonate Group (n =15)	Glycine Group (n =12)	Erythritol Group (n =14)	P^*
Enamel (medium power)$^+$	69.09±9.86 72.6 (53.16-87.47)	46.84±3.85 46.9 (41.12-53.17)	35.26±4.39 33.59 (30.34-43.23)	**<0.001**
Enamel (maximum power) $^+$	97.75±10.82 98.83 (75.92-115.93)	70.23±7.05 69.2 (62.02-84.47)	50.93±7.26 47.48 (42.61-66.83)	**<0.001**
P^{**}	**0.001**	**0.002**	**0.001**	

Power Setting Levels	Sodium Bicarbonate Group (n =15)	Glycine Group (n =12)	Erythritol Group (n =14)	P^*
Exposed root surface (medium power) $^+$	102.9±18.95 100.02 (79.61-139.75)	51.48±5.14 53.01 (42.05-59.73)	65.37±10.54 65.3 (38.4-79.41)	**<0.001**
Exposed root surface (maximum power) $^+$	134.55±24.03 140.12 (85.48-168)	72.32±5.51 71.88 (61.9-80.96)	70.67±12.47 71.92 (42.32-87.04)	**<0.001**
P^{**}	**0.001**	**0.002**	**0.021**	

*Kruskal Wallis test $p< 0.05$, ** Wilcoxon test $p< 0.05$, $^+$ mean ± SD, median, (min-max)

Table 2- Defect volumes of enamel and exposed root surfaces after air polishing (mm^3)

Power Setting Levels	Sodium Bicarbonate Group (n = 15)	Glycine Group (n = 12)	Erythritol Group (n = 14)	p^*
Enamel (medium power)$^+$	0.026 ± 0.00 0.02 (0.02-0.03)	0.019 ± 0.00 0.02 (0.02-0.03)	0.023 ± 0.01 0.02 (0.01-0.04)	**0.011**
Enamel (maximum power)$^+$	0.05 ± 0.01 0.05 (0.03-0.08)	0.03 ± 0.01 0.03 (0.01-0.04)	0.04 ± 0.01 0.03 (0.01-0.05)	**0.008**
p^{**}	**0.001**	**0.002**	**0.001**	
Exposed root surface (medium power)$^+$	0.026 ± 0.01 0.03 (0.01-0.04)	0.021 ± 0.01 0.02 (0.01-0.04)	0.017 ± 0.01 0.02 (0.01-0.04)	**0.007**
Exposed root surface (maximum power)$^+$	0.09±0.12 0.06 (0.03-0.51)	0.08±0.13 0.05 (0.03-0.5)	0.05±0.02 0.05 (0.02-0.08)	**0.006**
p^{**}	**0.001**	**0.002**	**0.001**	

*Kruskal Wallis test $p< 0.05$, ** Wilcoxon test $p< 0.05$, $^+$: mean ± SD, median, (min-max)

Table 3- Demineralization depth of enamel and cementum surfaces after air polishing (μm)

Power Setting Levels	Sodium Bicarbonate Group (n = 15)	Glycine Group (n =12)	Erythritol Group (n =14)	P^*
Enamel (medium power)$^+$	21.17±20.52 16.96 (0-61.26)	24.28±37.33 14.21 (0-126.06)	19.25±11.48 19.28 (0-38.62)	0.762
Enamel (maximum power)$^+$	33.31±19.28 36.25 (0-62.18)	29.77±38.59 18.61 (0-130.26)	24.34±13.99 25.37 (0-43.38)	0.325
p^{**}	**0.002**	**0.017**	**0.002**	
Root surface (medium power)$^+$	30.14±21.63 29.6 (0-58.02)	14.15±20.28 10.75 (0-70.66)	22.01±14.7 24.61 (0-47.63)	0.091
Root surface (maximum power)$^+$	43.71±22.16 44.18 (12.18-100.08)	25.65±23.44 20.83 (0-80.26)	28.04±16.67 31.58 (0-53.26)	**0.035**
p^{**}	**0.011**	**0.008**	**0.003**	

*Kruskal Wallis test $p< 0.05$, ** Wilcoxon test $p< 0.05$, $^+$ mean ± SD, median, (min-max)

Table 4- TMD of samples before and after air polishing (g/cm^3)

Air polishing	Sodium Bicarbonate Group (n =15)	Glycine Group (n = 12)	Erythritol Group (n = 14)	p^*
Before $^+$	2.85±0.03 2.85 (2.8-2.89)	2.87±0.05 2.85 (2.82-2.99)	2.85±0.04 2.84 (2.8-2.93)	0.632
After$^+$	2.36±0.06 2.37 (2.23-2.44)	2.65±0.05 2.64 (2.56-2.75)	2.66±0.02 2.66 (2.64-2.7)	**<0.001**
p^{**}	**0.001**	**0.02**	**0.001**	

*Kruskal Wallis test $p< 0.05$,** Wilcoxon test $p< 0.05$,$^+$ mean ± SD, median, (min-max)