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EFFECT OF DIFFERENT POLISHING STRATEGIES ON EXTRINSIC STAIN REMOVAL IN PRIMARY TEETH: AN IN-VITRO STUDY

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ABSTRACT

Objectives: This study aimed to evaluate the effects of different polishing strategies on extrinsic stain removal in primary teeth using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX)

Materials and Methods: A total of 48 primary molars with 12 samples in each group were used. External surface staining was created in all samples, and then samples were randomly divided into four groups: Group I: the teeth were polished using an ultrasonic scaler; Group II: the teeth were polished using pumice; Group III: the teeth were polished using an electric toothbrush and whitening toothpaste; and Group IV: the teeth were polished using an Aqua-care air abrasion device. Before and after polishing, teeth were examined using SEM, EDX, and visual shading. The data obtained were tabulated and subjected to statistical analysis.

Results: in group I (**Ultrasonic scaler)** after polishing the enamel surface, there was an alternation in surface smoothness and multiple irregularities, while in groups II (pumice paste) and III (electric toothbrush and whitening toothpaste), enamel showed a relatively homogenous surface and a few superficial depressions on the enamel surface. On the other hand, in group IV, after the aquacare treatment application, the enamel appeared to have a generalized smooth surface.

Conclusion: Teeth polishing using an air abrasion device seems to be the safest and most effective method for removing extrinsic dental stains in primary teeth.

KEYWORDS: Enamel, surface roughness, Extrinsic stain, teeth polishing, primary teeth.

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INTRODUCTION

Teeth discoloration is crucial to many people who care for an aesthetically satisfying look. Subjective levels of people's dissatisfaction with the color of their teeth have been reported to be as high as 53% [1]. The natural color of teeth is essentially determined by dentin color and is somewhat affected by the thickness and transparency of enamel, which happens to be the hardest structure in our body. It provides the first and most imperative line of defense against caries and shields the inner, more fragile dentin and pulp [2, 3].

Teeth staining is the product of multiple factors that could be categorized as extrinsic, intrinsic, and internalized. Intrinsic and internalized staining are those that occur during the period of tooth development or as a result of disease; they are deeply settled inside the dental tissues and thus difficult to reverse in most instances. Extrinsic staining, on the other hand, is mainly environmental and results from chromogenic bacteria, smoking, food tinctures, chlorhexidine, and metals [4, 5].

Children are also susceptible to extrinsic staining, with a prevalence as high as 20% in some populations. It is often in the form of recurrent black stains affecting mainly the buccal and lingual surfaces of both primary and permanent teeth and is hard to remove during regular tooth brushing. Such conditions negatively influence children's self-esteem, developing personalities, and psychological well-being. Most children start to notice a difference in their teeth color at around 6 years of age [6].

Extrinsic stains do not imply an underlying pathology; however, removing those stains is still required for aesthetic goals. Many clinically successful protocols are employed for this purpose. Home-brushing using special toothpaste containing abrasive grains such as hydrated silica, dicalcium phosphate dihydrate, or calcium carbonate can efficiently cleanse and remove stains from teeth surfaces. Electric toothbrushes are said to have more stain-removing potential than manual toothbrushes. Despite being simple and affordable, regular and/or violent application of such abrasive toothpaste could harm the enamel [7].

One of the most used practices is rotary rubber-cup/brush polishing with an abrasive polishing paste. In order to achieve effective stain removal using such a protocol while at the same time avoiding unfavorable effects such as increased temperature and roughness of the enamel surface, some factors should be respected, including the polishing paste abrasiveness, speed of rotation, application pressure, and application time [8].

Air polishing is another means of extrinsic stain removal that has become increasingly popular in recent years owing to its ability to remove plaque and stains in areas inaccessible by other methods. Water and abrasive powder, such as sodium bicarbonate, glycine, or calcium carbonate, are sprayed by a special device and at a specified pressure. Although effective, factors such as the distance between the device tip and the enamel, angle of application, and spraying pressure are crucial to avoid enamel damage [9].

The effects of these frequently applied polishing methods on tooth surfaces have been an area of interest for many researchers. The aesthetic, social, and psychological benefits of stain removal should be wisely weighed against the potential harms of such a procedure. Surface roughness is among the injurious effects that could result from teeth polishing—an irregularity occurring on the surface of enamel or dental materials [10].

Normally, some degree of roughness exists on the surface of enamel because of Retzius grooves, pits, and minor defects, as well as the ongoing mineral accumulation from the oral environment. The improper use of polishing pastes, torque, speed, or time compromises the enamel organic matrix, which intensifies the surface roughness and consequently leads to more future staining liability in both permanent and primary teeth. Moreover, the thickness of enamel in primary teeth is less than in permanent teeth with lower calcium and phosphorus levels [11].

From this point of view, this study aimed to assess in vitro the effect of different polishing strategies of dental extrinsic stain removal on enamel surface roughness and mineral content using a scanning electron microscope (SEM) and energy dispersive x-ray (EDX), respectively.

MATERIALS & METHODS

The present investigation was conducted in adherence to the protocols established by the Research Ethics Committee of the Faculty of Pharmacy, Pharos University, under ethical code # (PUA-UREAC 079/2023). Parents received an explanation of the purpose of this study and were asked to sign an informed consent stating that they were willing to donate their children's extracted teeth for research purposes.

Eligible participants were those aged 4–12 years, scheduled for extraction of primary teeth for therapeutic purposes.

Eligible teeth were those having buccal enamel surfaces free from cracks; developmental defects; caries; erosion; and fillings.

Sample size calculation:

The minimum required sample size was calculated to be 10 primary molars per group. Also, for each group, 2 more teeth were added for qualitative evaluation of surface roughness. Having four groups in the study, the entire sample size was 48 molars. This calculation was based on a 95% confidence level and was performed using MedCalc Statistical Software version 19.0.5. Teeth were arbitrarily and equally allocated to the 4 groups using a digital list of random numbers with the aid of RAND and RANK, Excel (MS Office 365). (BAG45S5)

Sample preparation:

Extracted teeth were scrubbed with a hard toothbrush and deionized water to detach any soft tissue or debris; autoclaved at 121°C for 30 minutes; and stored in phosphate-buffered saline to avoid bacterial growth. Teeth were immersed in sterile, filtered artificial saliva for 24 hours prior to the study as well as throughout the whole study period, except for the treatment and measurement periods. Teeth were embedded in acrylic resin, exposing the buccal surface of the crown.

Staining procedure [12]:

The staining solution was prepared by adding 5 grams of tea leaves (Dilmah) to 500 ml of boiling water and letting it set for 3 minutes. The tea was then filtered through a fine mesh and allowed to cool down to 50 °C. Specimens were left to soak for 6 hours/day in a freshly prepared tea solution for five consecutive days. Rinsing with running water was done after each staining cycle before restoring the teeth in artificial saliva. A total of 5 tea cycling steps were carried out within a 5-day period. Following the staining procedure, the samples were rinsed under running water and then kept in water at 37 °C for a week. Each specimen's color was measured.

Color measurement [13]:

Color measurement was done using Visual shading is predominant in clinical dentistry. It is an easy method for assessment of shade differences. We used the Classical Vita shade guide, which is one of the most used shade guides nowadays. The VITA classical A1-D4 shade guide serves to accurately determine tooth shade. The arrangement of the shades in the VITA classical family of shades is as follows: A1-A4 (reddish-brownish); B1-B4 (reddish-yellowish); C1-C4 (greyish shades).

Initial color measurements were performed first. This process was done after the samples were prepared and before staining and applying selected polishing. The second color measurement (before) was performed after applying the staining procedure to the samples. The third color measurement (after) was carried out for each test surface after the determined polishing process was complete.

Grouping:

After staining teeth were classified into 4 groups.

Group I: Ultrasonic scaler

Twelve specimens were subjected to ultrasonic scaler polishing (Woodpecker UDS-K) to remove teeth stains. The apparatus vibrates at an extremely high frequency of roughly 15,000 oscillations per second, producing waves that are audible to humans. These potent tiny vibrations remove tartar, plaque, and stains [14].

Group II: Pumice paste

Twelve specimens were subjected to pumice paste (i-Faste polishing paste) using a low-speed handpiece. It is a strong siliceous, light-gray substance that is created by volcanic activity. The very finely powdered derivative known as pumice flour is used to polish acrylic resins, gold foil, and tooth enamel. It involves smoothing the tooth surfaces to give them a glossy, lustrous appearance. Stains were removed with i-Faste teeth surface polishing paste [15].

Group III: Electric toothbrush and whitening toothpaste

Twelve specimens were subjected to The Oral-B Pro-Expert Pulsar **manual** medium toothbrush was utilized because it cleans more effectively than a typical manual toothbrush by simultaneously pivoting and pulsating with micropulse vibrating bristles. The toothbrush's vibrating bristles spread deep between teeth to clean more thoroughly than a typical manual brush, and it has separately flexible sides. The toothbrush is battery-operated. The toothbrush was used in conjunction with Signal whitening toothpaste [16].

Group IV: Aqua-care air abrasion device

Twelve specimens were subjected to Sodium bicarbonate was used to treat extracted teeth. About 65 m-sized particles made up the powder. As instructed by the manufacturer, each group's teeth received the appropriate powder treatment by airflow for approximately 10 s at a distance of about 1 cm while moving horizontally and perpendicular to the tooth surface. The producer's suggested pressure ranges (air pressure: 2.7-3.5 bar; water pressure: 1.0-2.2 bar) were used [17].

Study outcomes:

Surface roughness:

For each group, two teeth were evaluated for surface roughness. Each tooth was sectioned into two halves; where one half was used for pre-polishing evaluation and the other half for post-polishing using scanning electron microscopy (SEM) (JSM-IT200 InTouchScope™ Scanning Electron Microscope (JSM-IT200 Series, JEOL; Tokyo, Japan))

Teeth Preparation for SEM [18]

Specimens were fixed in 4% formaldehyde with 1% glutaraldehyde and then rinsed in phosphate buffer for 10 minutes. Then, specimen dehydration through immersion in a series of 50%, 70%, and 95% ethyl alcohol for 10 minutes each and then for one hour twice in absolute alcohol. Specimens were then dried using the air-drying method in a vacuum desiccator for another hour. Specimens were mounted using silver paint on the specimen holder, followed by a gold coating using an ion-sputtering device.

Mineral composition change

For quantitative elemental analysis, changes in mineral content were detected using energy-dispersive X-ray spectroscopy (EDX). This was carried out at two points: baseline and after polishing [19].

Statistical analysis [20]

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp.) and statistically evaluated. Quantitative data were described using mean and standard deviation. Significance was judged at the 5% level. Student t-test for normally distributed quantitative variables, to compare between two groups; F-test (ANOVA) for normally distributed quantitative variables, to compare between more than two groups; and Post Hoc test (Tukey) for pairwise comparisons. Bar charts were used for the graphical representation of EDX analysis.

RESULTS

Color measurement result (Table 1):

The color measurement of the teeth was done at three different observation stages (initial, before, and after). In Group I: Ultrasonic Scaler (Cavitron) and Group IV: Aqua Care Air Abrasion, the color measurement findings from the visual shading showed an obvious change in color between the initial measurement and the before and after results for each tooth. While in both Group II: pumice paste and Group III: electric toothbrush, the color of the specimen didn't show any obvious difference before and after the polishing procedure.

TABLE (1) Visual shading [Vita Easy Shade]

Sample	Initial color measurements	Before	After
1	A2	A3	A1
2	B2	B3	B3
3	C2	C4	C4
4	C1	C4	C1
5	A1	A4	A1
6	C1	C4	C4
7	B1	B3	B1
8	C2	C4	C4

Samples 1.7 were treated by cavitron
Samples 2.8 were treated by pumice
Samples 3.6 were treated with toothbrush
Samples 4.5 were treated by air abrasion

Scanning electron microscopic results

Group I:

Before polishing, generalized surface craters over the enamel surface along with depressions, projections, and irregularities covered with plaque were clearly seen. (Fig. 1. a). After polishing, intact smooth surface topography and low surface roughness with generalized smooth surface architecture were observed. (Fig. 1.b.)

Group II:

Enamel surface examination before pumice paste application demonstrated generalized surface depressions and craters. (Fig. 1. c). While, after pumice paste application, a relatively homogenous surface with few superficial depressions and irregularities was noted. (Fig. 1. d).

Group III:

Before brushing with whitening toothpaste, generalized surface irregularities, depressions, and craters over the enamel surface were seen (Fig.1.e). After brushing, the enamel surface showed some microscopic roughness and irregularities along with multiple grooves and scratches alternating with other scattered areas of smooth regular enamel surface. (Fig. 1. f).

Group IV:

Before ultrasonic scaling: alternating areas of smooth & irregular surfaces with accumulation of plaque (Fig.1.j). After ultrasonic scaling: generalized irregular surface architecture of the enamel surface. (Fig. 1. k).

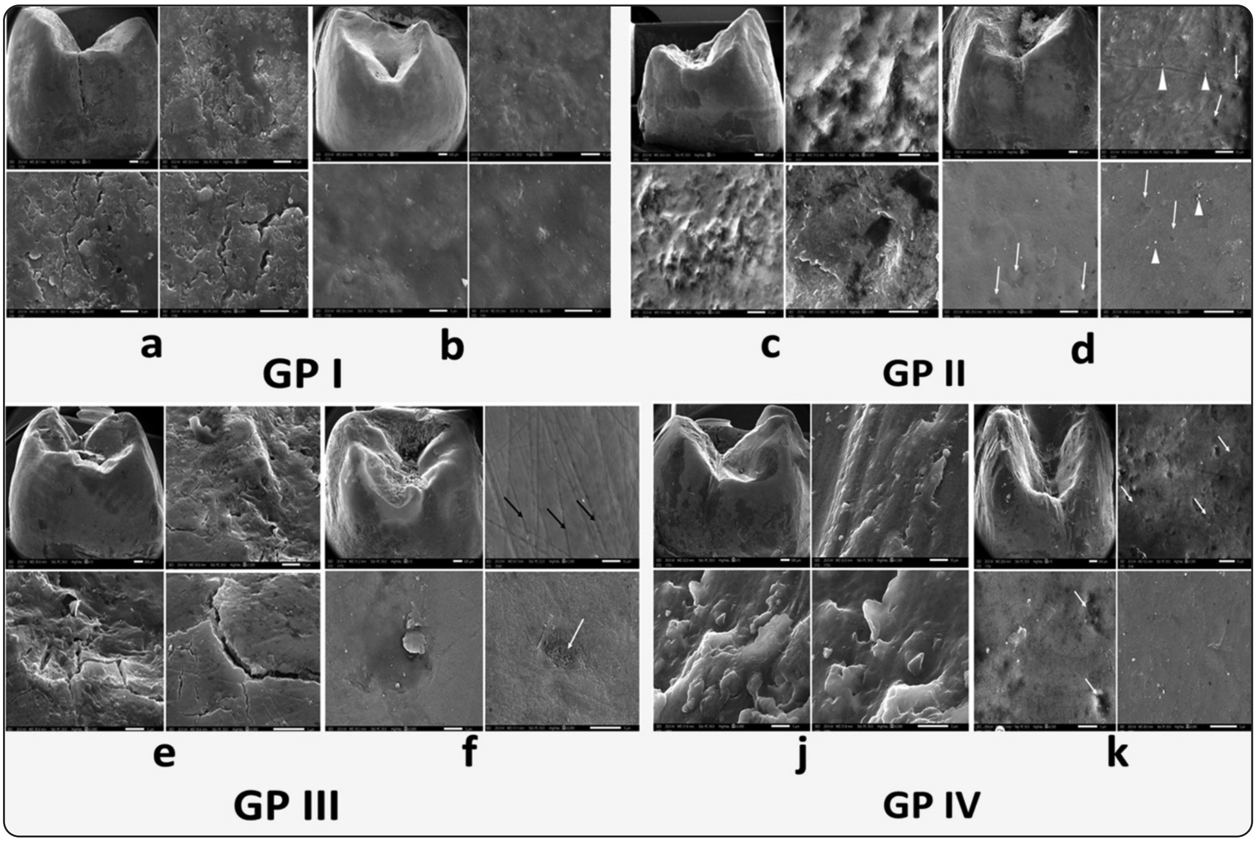

Fig. (1) Group I (a) Before air abrasion: enamel surface projections and irregularities covered with p1laque. (b) After air abrasion: homogenous surface, generalized smoothening, and reduction of surface irregularities. Group II: (c) Before pumice, surface irregularities embedding long filamentous microbes, accumulated plaque, and calculus. (d) After pumice: relatively homogenous surface with few irregularities, and superficial depressions (arrows). Remnants of pumice paste can be seen (arrowheads) . Group III (e) Before brushing: rough enamel surface with grooves covered with smear layer and plaque. (f) After brushing: multiple deep grooves and scratches (black arrows), A deep crater on the enamel surface is observed. (White arrow) . Group IV (j) Before ultrasonic scaling: rough enamel surface. (k) After ultrasonic scaling: Alternating smooth and irregular areas are observed with a footprint of a scaler blade on the enamel surface (arrows). SEM magnification (15xX1500X,3000X,5000X respectively).

Energy Dispersive X-ray Analysis (EDX): (Table 2& 3)(Fig .2)

The energy-dispersive X-ray revealed differences in the surface elemental composition among different groups. Table (2) Comparison between the studied groups according to different parameters, before and after teeth polishing.

Group I:

The (mean±SD) was at before polishing for calcium (Ca) and phosphorus (P)= 19.14±5.48 and 10.37±3.68 respectively which increased after polishing to = 30.13±2.38 and 16.19±1.69 for Ca and P, respectively. This was statistically significant in Ca ($p < 0.033$) while not significant in (P) ($p < 0.068$). Carbon (C) (mean±SD) showed a decrease after polishing = 15.25±2.52 than before = 31.66±9.14 which was statistically significant ($p < 0.040$). Oxygen (O_2) (mean±SD) showed a minor increase after polishing = 39.42±1.81than before = 38.53±2.24 which was statistically non-significant ($p < 0.623$). Fluoride (F) (mean±SD) showed a negligible amount before and after with no significant difference ($p = 0.446$).

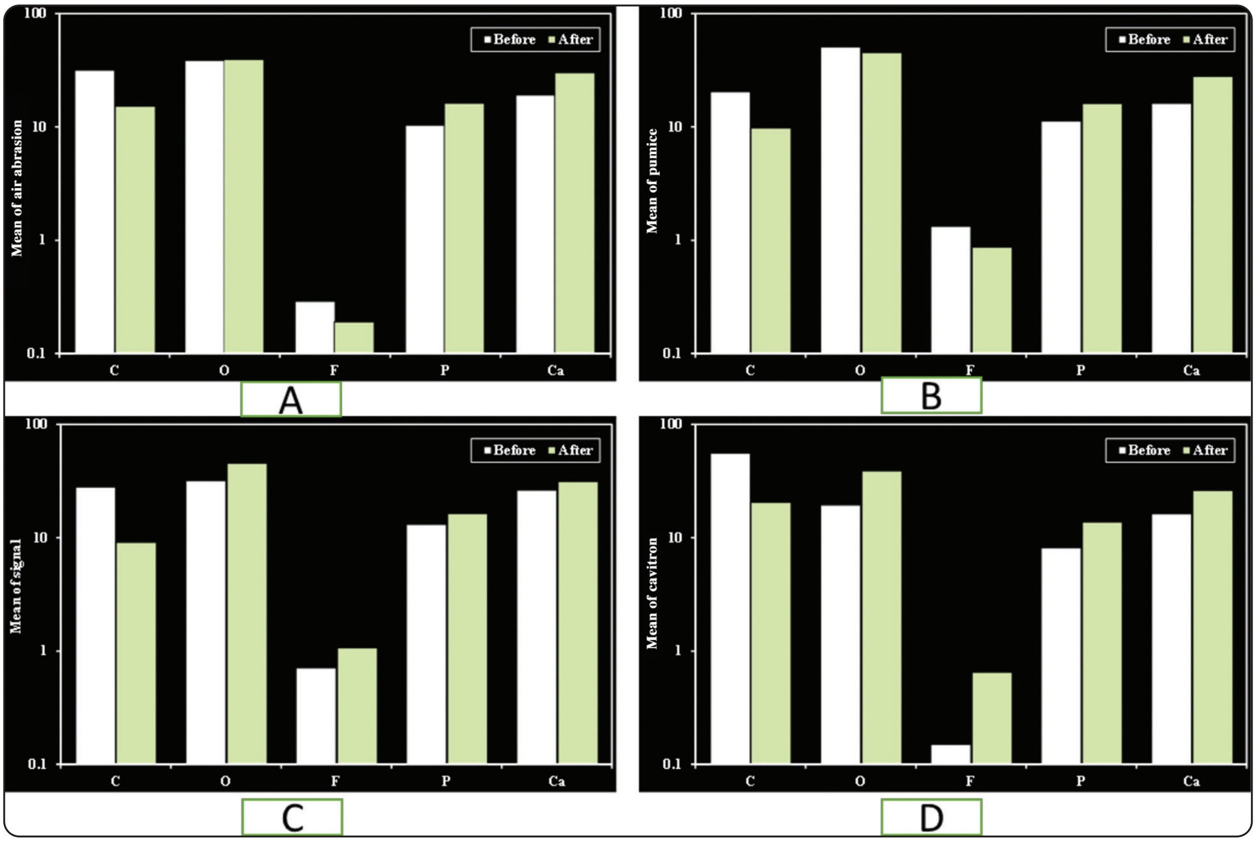

Fig. 2 (A) Comparison between before &after measurement in group 2 (ultrasonic scaler) (B) Comparison between before &after measurement in group 2 (pumice) (C) Comparison between before &after measurement in group 3 (toothbrush) (D) Comparison between before and after measurement in group 1(cavitron)

Group II:

The (mean ± SD) was comparable for Ca between before and after polishing = 16.15 ± 3.83 and 27.95±0.29, respectively. This was significant (p = 0.033). Also, for P, (mean ± SD) was comparable between before and after polishing = 11.25±2.30 and 16.11±0.27, respectively. This was non-significant (p = 0.066). C (mean ± SD) showed a decrease after polishing = 9.76±1.46 than before = 20.47 ± 9.03 which was non-significant (p = 0.112). O2 (mean ± SD) showed an decrease after polishing = 45.32±1.25 than before = 50.80 ± 3.90 which was non-significant (p = 0.082). as well as F (mean ± SD) that showed decrease after = 0.87±0.11 than before = 1.32 ± 0.66 with no-significant (p = 0.307).

Group III:

The (mean ± SD) before polishing for Ca and P was = 26.31±1.02 and 13.10±0.48 respectively which increased after to = 31.34±4.03 and 16.37±0.66 for Ca and P, respectively. This was statistically significant in P (p<0.002) while not significant in Ca (p < 0.104). C (mean ± SD) showed significant decrease after polishing = 9.09±1.30 than before = 28.0±4.06, (p = 0.002). O2 (mean ±SD) showed an increase after = 45.46±1.26 than before =31.89±2.96 which was statistically significant (p<0.002). while Fluoride (F) (mean ± SD) showed a negligible amount before and after polishing with no significant difference (p = 0.369)

Group IV:

In this group before the teeth polishing the measurements of calcium (Ca) and phosphorus (P)= 16.31±2.70 and 8.16 ± 1.32 respectively which increased after teeth polishing to = 26.15±1.41 and 13.75±0.97 for Ca and P, respectively. This was statistically significant ($p<0.005$) & ($p<0.004$). Carbon (C) (mean±SD) showed a decrease after polishing = 20.57±6.23 than before = 55.73 ± 8.81 which was statistically significant ($p < 0.005$). Oxygen (O2) (mean ± SD) showed an increase after polishing = 38.81 ± 5.78 than before = 19.48 ± 5.65 which was statistically significant ($p < 0.014$). Fluoride (F) (mean ± SD) showed a negligible amount before and after polishing with no significant difference ($p = 0.219$). (Table 2, Fig 8)

EDXA All Groups After Teeth Polishing:

Table (3) show a Comparison between the different studied groups according to different parameters after teeth polishing.

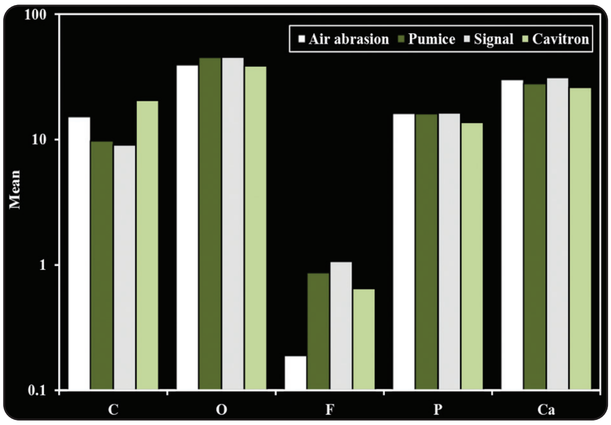

Fig. (4) Comparison between the different studied groups according to different parameters after teeth polishing

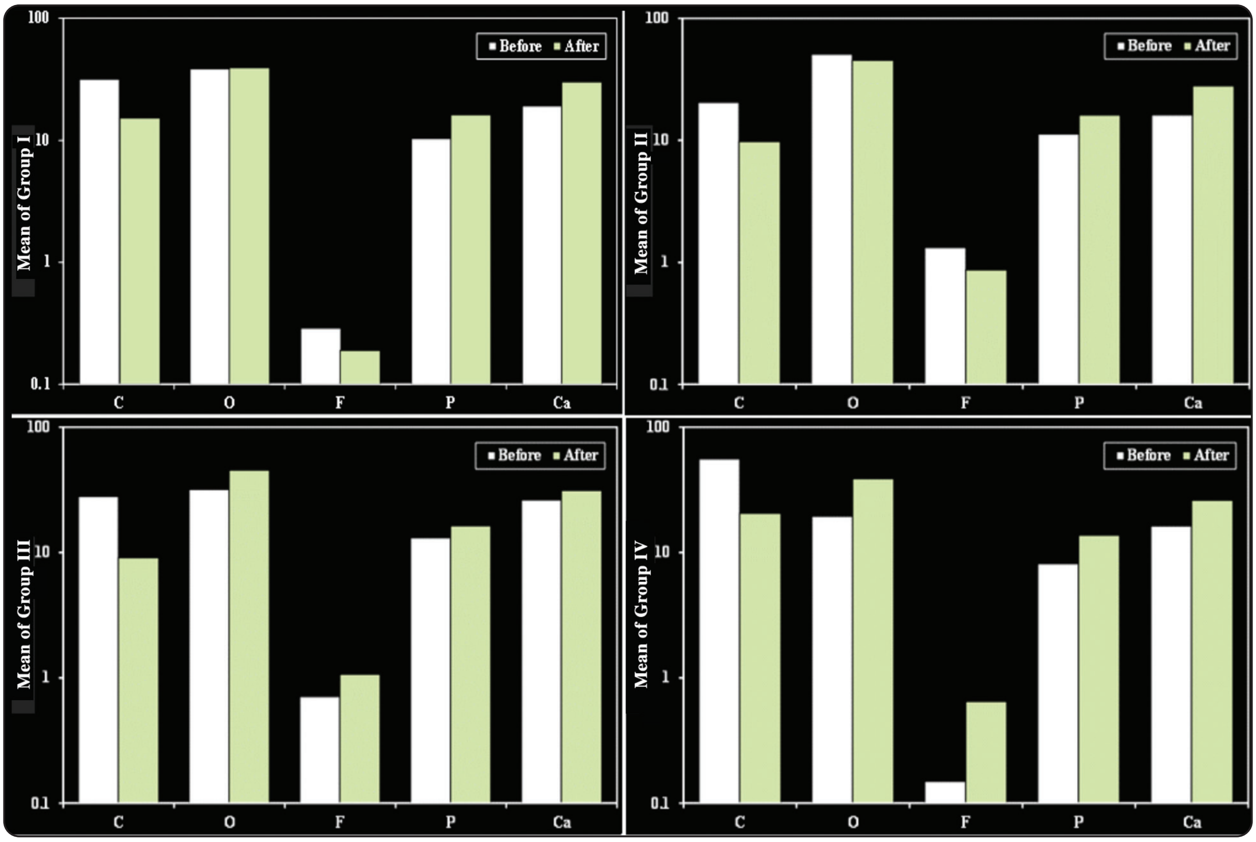

Fig. 3 (ALL previous tables, collectively)

After polishing, the (mean ± SD) of Ca content change decreased in Group I (Cavitron) than that of Group II (Pumice paste), Group III (toothbrush), and Group IV (air abrasion) = 26.15 ± 1.41, 27.95 ± 0.29, 31.34 ± 4.03 and 30.13 ± 2.38 respectively. This change was non-significant (p = 0.120). The (mean ± SD) of P content change decreased in decreased in Group I (Cavitron) 13.75 ± 0.97 than that of Group II (Pumice paste) $16.11^{\#}$ ± 0.27, Group III (toothbrush) $16.37^{\#}$ ± 0.66 and Group IV (air abrasion) = $16.19^{\#}$ ± 1.69. This change was significant (p = 0.044). The (mean ± SD) of O2 content change showed a comparable change that increased in Group II (Pumice paste), and Group III (toothbrush) = 45.32 ± 1.25 and 45.46 ± 1.26, respectively. Also in Group I (Cavitron) and Group IV (air abrasion) = 38.81 ± 5.78 and 39.42 ± 1.81, respectively This change was non-significant (p = 0.053).

The (mean ± SD) of F content in the test groups in Group I, Group II, Group III, and Group IV was = 0.65 ± 0.5, 0.87 ± 0.11, 1.07 ± 0.61 and 0.19 ± 0.17, respectively. This change was non-significant (p = 0.158). The (mean ± SD) of C content change increased in Group I (Cavitron) than that of Group II (Pumice paste), Group III (toothbrush), and Group IV (air abrasion) = 20.57 ± 6.23 $9.76^{\#}$ ± 1.46, $9.09^{\#}$ ± 1.30 and 15.25 ± 2.52 respectively. This change was significant (p = 0.012).

TABLE (2) Comparison between the studied groups according to different parameters before & after teeth polishing

		Before	After	t	p
Group I	C	31.66 ± 9.14	15.25 ± 2.52	2.998*	0.040*
	O	38.53 ± 2.24	39.42 ± 1.81	0.532	0.623
	F	0.29 ± 0.12	0.19 ± 0.17	0.843	0.446
	P	10.37 ± 3.68	16.19 ± 1.69	2.488	0.068
	Ca	19.14 ± 5.48	30.13 ± 2.38	3.184*	0.033*
Group II	C	20.47 ± 9.03	9.76 ± 1.46	2.029	0.112
	O	50.80 ± 3.90	45.32 ± 1.25	2.314	0.082
	F	1.32 ± 0.66	0.87 ± 0.11	1.171	0.307
	P	11.25 ± 2.30	16.11 ± 0.27	3.626	0.066
	Ca	16.15 ± 3.83	27.95 ± 0.29	5.328*	0.033*
Group III	C	28.0 ± 4.06	9.09 ± 1.30	7.686*	0.002*
	O	31.89 ± 2.96	45.46 ± 1.26	7.306*	0.002*
	F	0.71 ± 0.11	1.07 ± 0.61	1.012	0.369
	P	13.10 ± 0.48	16.37 ± 0.66	6.956*	0.002*
	Ca	26.31 ± 1.02	31.34 ± 4.03	2.096	0.104
Group IV	C	55.73 ± 8.81	20.57 ± 6.23	5.643*	0.005*
	O	19.48 ± 5.65	38.81 ± 5.78	4.141*	0.014*
	F	0.15 ± 0.17	0.65 ± 0.58	1.457	0.219
	P	8.16 ± 1.32	13.75 ± 0.97	5.891*	0.004*
	Ca	16.31 ± 2.70	26.15 ± 1.41	5.599*	0.005*

Data was expressed using Mean ± SD. **t: Student t-test** ***p: p-value for comparing between the studied groups***

****: Statistically significant at p ≤ 0.05***

TABLE (3) Comparison between the different studied groups according to different parameters after teeth polishing

	Cavitron	Pumice	Toothbrush	Air abrasion	F	P
C	20.57 ± 6.23	9.76# ± 1.46	9.09# ± 1.30	15.25 ± 2.52	7.047*	0.012*
O	38.81 ± 5.78	45.32 ± 1.25	45.46 ± 1.26	39.42 ± 1.81	3.979	0.053
F	0.65 ± 0.58	0.87 ± 0.11	1.07 ± 0.61	0.19 ± 0.17	2.263	0.158
P	13.75 ± 0.97	16.11# ± 0.27	16.37# ± 0.66	16.19# ± 1.69	4.285*	0.044*
Ca	26.15 ± 1.41	27.95 ± 0.29	31.34 ± 4.03	30.13 ± 2.38	2.656	0.120

Data was expressed using Mean ± SD.

F: F for One-way ANOVA test, Pairwise comparison bet. each 2 groups was done using a Post Hoc Test (Tukey)

p: p-value for comparing between the studied groups *: Statistically significant at p ≤ 0.05#: Significant with Cavitron

DISCUSSION

The objective of this study was to evaluate the effect of different polishing strategies on extrinsic stain removal in primary teeth.

Esthetic dentistry has become a worldwide demand. One approach to achieving high aesthetic results is teeth polishing, which is considered an effective and noninvasive method [9]. Although teeth polishing is generally safe, some adverse effects may develop following polishing procedures, such as increased enamel surface roughness [21]. From this perspective, this study aimed to evaluate the effect of different polishing strategies on the surface roughness of enamel.

When assessing the whitening of stained teeth in vitro, researchers frequently employ aqueous solutions like tea or instant coffee as a synthetic staining solution [22]. In this investigation, we used a tannic acid aqueous solution to produce an extrinsic artificial stain for the enamel surface and a 10% citric acid/3% ferric chloride aqueous solution. This approach, as demonstrated in earlier research, can only stain the enamel surface; the dentin's interior is left unaffected [23, 24].

In our study teeth were used from human dentitions instead of bovine teeth for more favorable clinically applicable results. This was in the same line with Suriyasangpetch et al. 2022 [25].

Regarding diagnostic tools, SEM and EDXA were used as diagnostic tools in the current study; Most commonly the studies on polishing strategies put teeth color as the 1st concern and almost there were no studies regarding mineral contents and surface topography Changes which is why we decided using SEM and EDX in our examinations.

SEM was used to evaluate enamel surface changes and assess surface topography, while EDXA aimed to assess the elemental analysis of teeth and pointed up Ca and P, which are the main constituents of hydroxyapatite crystals that represent the main component of the inorganic part of the enamel.

This was in accordance with Ellingham et al. (2023) [26], who used scanning electron microscopy-energy-dispersive X-ray (SEM/EDX) as a rapid diagnostic tool to help in the identification of burnt enamel in forensic dentistry.

Many studies were found to test the enamel surface after teeth polishing based on SEM imaging of the enamel or measuring surface roughness [10, 27]. However, there is no study examining the effect of polishing applications on the roughness of enamel surfaces with EDX. In this context, our research is also important in that it is the almost 1st study to evaluate the effect of different polishing methods applied to enamel with EDX.

Regarding our SEM results for group I (ultrasonic scaller), By comparing the before and after images, it is possible to clearly see the scaller blade's imprints on the surface of the enamel, determining its aggressive effect on the enamel surface. While in group II (pumice), some tiny imperfections are seen in the after specimen. This finding was in agreement with Bora et al. [28], who compared the enamel surface wear and roughness resulting from different ultrasonic scalers and polishing devices.

SEM findings in group III (toothbrush) revealed widespread surface roughness along with deep, numerous scratches and grooves caused by brushstrokes due to the abrasive toothpaste effect with the hardness of the brush. This discrepancy may be elucidated by the fact that, in order to replicate a clinical setting, more pressure is typically applied to hand instrumentation. As a result, the brush group develops deep scratches as well as striae. In earlier studies, similar findings were discovered by Nima 2021 [29]. On the other hand, in the air abrasion-treated group, the surface after treatment showed an almost intact smooth regular surface.

This result was confirmed by the results of EDX, which revealed differences in the surface elemental composition among different groups. After polishing, the cavitron group showed a significant loss of Ca and P ions and an increase of C ions post-treatment, confirming greater mineral loss and surface distortion and lowering the enamel's degree of crystallinity.

The results of the toothbrush group showed an increase in F ion content due to the presence of an amount of F in the toothpaste used in polishing. On the contrary, enamel surfaces in the air abrasion group showed an increased level of Ca and P when compared to other groups. Air abrasion was suggested to be able to eliminate enamel stain with no loss of hydroxyapatite crystal content. The air abrasion appears to be the least abrasive equipment, according to the study's findings, while the ultrasonic scaler appears to be the most abrasive.

According to Janiszewska-Olszowska et al. (2020), [30] the optimum abrasive should remove stains without significantly wearing down the teeth. Our findings showed that sodium bicarbonate air abrasion had a respectable stain removal capacity. In comparison to abrasives with practically identical or higher hardness values, sodium bicarbonate—a well-known abrasive and whitening ingredient used in many commercial dentifrices—displays a superior cleaning power. The great cleansing power and low tooth structure removal of sodium bicarbonate are explained by its good water solubility and ability to prevent plaque by reducing the amount of pathogenic oral flora and lowering the critical pH. Because sodium bicarbonate has both mechanical and biological modes of action, it is more effective than other abrasives like silica and aluminum oxide, which are chemically inert and solely perform mechanical debridement. Sodium bicarbonate is also bacteriostatic, which may help to reduce tooth decay and discolorations brought on by cariogenic and chromogenic oral bacteria.

Polishing has some harmful effects on dental tissues, restorations, and gingiva. For this reason, the balance between benefit and harm should be considered before the procedure. With the idea that whiter teeth contribute to a pleasant smile and wonderful physical appearance, there is currently a greater interest and awareness among people in this area. The correlation between dental health and social acceptance and teeth whitening has been demonstrated to be beneficial. The demand for tooth-whitening solutions is a result of the social and aesthetic advantages of having whiter teeth.

By boosting the number of cycles and examining the long-term consequences, additional study is required to ensure these outcomes.

CONCLUSION

After these experiments and from comparing results of SEM and EDX for the four groups, we concluded that the use of air abrasion was the best at increasing Ca and P levels, followed by the use of toothbrushes, then pumice, and finally the use of cavitron. Regarding fluoride levels, the use of toothpaste and toothbrush was the best at increasing fluoride levels, followed by pumice, then cavitron, and finally air abrasion.

Our results show that polishing the enamel surface may cause changes in the surface's topography of enamel and increase surface roughness. Therefore, except for clinically mandatory reasons, it seems important not to apply polishing to avoid its traumatic effects. If polishing is required, air polishing should be preferred whenever possible.

Study limitations

Being dependent on collecting human teeth, difficulty was encountered in collecting the required number of teeth, which led to compensating this through tooth sectioning.

Declarations

Ethical approval and consent to participate.

The ethical committee of the faculty of pharmacy at Pharos University approved the study under the code (#079).

Consent for publication: Not applicable

Availability of Data and Materials

On reasonable request, the datasets utilized and analyzed during the present study are accessible from the corresponding author.

Competing interests

The authors declared no conflict of interest relevant to this article.

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Author contributions

E.M.S. Responsible for study conception and design. Participated in performing all required data analysis, revising histological results and analysis, and editing and reviewing the final manuscript. **R.S.S** Study conception and design, data collection, sharing in writing, and revising the manuscript**. R.k.E.** Responsible for study conception and design. Participated in performing all required data analysis, editing, and reviewing the final manuscript. **O.MA.** Study conception and design, histological analysis, data collection, shared in writing and revising the manuscript. All authors reviewed the results and approved the final version of the manuscript.

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