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Wear Effect of Different Abrasive Materials on Tooth Enamel: A Comparative Study

Ahmed Alzahrani*, Ihab Moussa ,Omar Saleh , Sulaiman Alarifi
College of Dentistry, King Saud University, Riyadh, Saudi Arabia
*Corresponding author: Ahmed Alzahrani, email: ksu.alzahrani@gmail.com

ABSTRACT

Objectives: The purpose of the study was to measure and compare mean enamel loss caused by microabrasion treatment of different abrasive materials under a fixed variable**.**

Materials and methods: In this laboratory study, three commonly used abrasive materials were compared: Dental Pumice, Zircate® Prophy Paste, Opalustre® and a controlled group (distilled water). Hundred extracted human premolars were randomly allocated into four groups; each group was subjected to fixed pressure, time and rotational speed mimicking dental office setting. **Results:** Data was collected and statistically analyzed. The results of the study ($p < 0.01$) was statistically significant and showed that Opalustre® caused the highest mean difference in enamel loss. Followed by dental Pumice and Prophy paste in order with minimal difference between them. And the controlled group (distilled water) had the least mean enamel loss. **Conclusion:** microabrasion offers a great approach in treating enamel defect/staining in a minimally invasive procedure in order to achieve acceptable aesthetic results while preserving the tooth's microstructure as much as possible. As shown in the result; Combined chemical acid with mechanical abrasive particles produce most effective results.

Keyword: Enamel microabrasion, Enamel surface, Wear, hydrochloric acid (HCl), pumice, prophy.

INTRODUCTION

Patients seek and demand aesthetics in the dental office. One of the most common complaints in aesthetic demanding patient is teeth staining. Stains are divided into three categories (intrinsic, extrinsic, combination of both). management of such cases vary depending on several factors such as location, etiology of the stain and severity of the stain [(1)]. Regarding extrinsic staining, significant improvements in the past years have been achieved in less invasive, safe and conservative method such as dental bleaching and enamel microabrasion using different abrasive materials which is the focus of this research. First introduction of "mechanical application with a low-rotation micro motor was indicated in the 1970s, using a mixture of 18% hydrochloric acid, hydrogen peroxide and ether [(2)].

Enamel Microabrasion treatment has been known as a conservative, safe and relatively low cost procedure to enhance enamel surface appearance by minimal removal of staining/enamel defects in the enamel outer layer. A previous study done by **Sundfeld *et al.*** [(3)] briefly described "performing enamel microabrasion with hydrochloric acid mixed with pumice and other techniques employing a commercially available compound of hydrochloric acid and fine- grit silicon carbide particles in a water-soluble paste" result as "highly satisfactory, safe and effective procedure". Another study done by **Balan *et al.*** [(4)] demonstrated that even mild fluorosis can be treated conservatively with combinations of microabrasion with bleaching lead to acceptable results. So even with the advancements of modern day dentistry, the effectiveness and efficiency of multiple materials and techniques to produce a satisfying outcome is being studied and evaluated in laboratory investigation and in clinical setting.

Wear Effect of Different Abrasive Materials on Tooth Enamel is a true experimental comparative study aimed to identify the wear effect of different materials on teeth enamel loss in weight in order to understand furthermore different wear effect of multiple materials against enamel microstructure. The results can improve knowledge in aesthetic dentistry field.

MATERIALS AND METHODS

MATERIALS

Three different abrasive materials were used Dental Pumice (Interdent, Inc., CA, USA), Zircate® Prophy paste (Dentsply Sirona. Inc., NY, USA) and Opalustre® (Ultradent Prod. Inc., Utah, USA) in this study and a control group used distilled water. **(Table 1)** shows the manufactural, acid used, particle size of the abrasive particles.

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Table 1: Materials used in the study

Materials	Manufacturer	Acid	Abrasive	Particle size
Opalustre®	**Ultradent®**	**6.6% Hydrochloric acid**	**Silicon Carbide**	**20-160 µm**
Pumice	**Interdent®**	**-**	**Silicon Dioxid Aluminium Oxide**	**30-50 µm**
Zircate® Prophy paste	**Dentsply®**	**-**	**Zirconium Silicate**	**10-70 µm**
Controlled (water)	**-**	**-**	**-**	**-**

METHODS

Random sample of a hundred recently extracted human premolars collected from 14 orthodontic clinics were selected in this study. Every tooth carefully examined for any exclusion criteria. Inclusion criteria: Extracted permeant teeth (Premolars only) and the exclusion criteria: Crowned teeth, endodonticalliy treated teeth, buccally restored teeth, decayed teeth, primary teeth and enamel/dentin defected teeth. Sample were also randomly divided with into four groups according to each material used: 25 teeth for one material.

- Group A (controlled group) subjected to distilled water.
- Group B subjected to Dental Pumice.
- Group C subjected to Prophy paste.
- Group D subjected to Opalustre®.

Each material was applied on the buccal surface under four fixed variables: pressure, rotational speed, time and number of applications to simulate the commonly procedure performed in the dental office micro-motor. All samples were preserved in 0.4% Thymol liquid within 37c incubator.

First, each tooth was individually washed and dried for 10 seconds. Secondly, the samples weight was measured using a calibrated scale in milligrams, and recorded it in a labelled sample bag and a spread sheet.

Then, the sample were mounted in a containing cell with manipulated Putty index. Next, the tooth in the containing cell was subjected to fixed pressure (load) of 30 Gram, Rotational speed 1000 RPM for 30 second 4 applications.

After that, the tooth was removed from the containing cell, then washed and dried for 10 seconds. And finally, the weight was measured post applications in milligrams and recorded it in the same labelled sample bag and spread sheet. The brush was changed every 5 samples.

Data analyzed using SPSS Statistics for Windows, version V22.0 (Chicago, IL, USA) and selected one-way ANOVA statistical test to find any significant difference between groups.

The study was done after approval of ethical board of King Saud university.

RESULTS

The results presented in **(Table 2)** and **(Table 3)** shows the extent of enamel loss by weight difference in milligrams. Three materials were chosen and one controlled group with 25 samples each. The result of the statistical analysis in each material being statistically significant by itself except the controlled group ($p < 0.01$). Under fixed pressure, time, number of applications and rotation speeds, the variable factor that was focused on is the type of abrasive material.

The comparison between the four groups were significant, indicating that the materials components were effective in enamel microabrasion. As an example, the controlled group results, as prescribed in the **(Figure 1)** and **(Figure 2)**, showed non-significant difference due to absence of abrasive particles, unlike the other groups. And the most significant enamel loss was observed with group D (HCL 6.6% with silica carbide) followed by group C (Dental Pumice) and lastly, Group B (Prophy Paste).

Table 2: Statistical analysis

Material	N	Mean (mg)	Std. Deviation	Std. Error	5% Confidence Interval for Mean	
					Lower Bond	Upper Bond
Control	25	7.016	4.76582	0.95316	5.0488	8.9832
Pumice	25	21.112	7.49474	1.49895	18.0183	24.2057
Prophy	25	19.188	9.88974	1.97795	15.1057	23.2703
Opalustre®	25	31.56	15.70727	3.14145	25.0764	38.0436
Total	100	19.719	13.39259	1.33926	17.0616	22.3764

Table 3: Mean and P-value of the different abrasive materials

Material		Mean	Std. Error	95% Confidence Interval		P-value
				Lower Bond	Upper Bond	
Control	1	1131.788	35.425	1061.469	1202.107	0.01
	2	1124.772	35.047	1055.205	1194.339	0.01
Pumice	1	1069.18	35.425	998.861	1139.499	0.01
	2	1048.068	35.047	978.501	1117.635	0.01
Prophy	1	1116.296	35.425	1045.977	1186.615	0.01
	2	1097.108	35.047	1027.541	1166.675	0.01
Opalustre®	1	970.596	35.425	900.277	1040.915	0.01
	2	939.036	35.047	869.469	1008.603	0.01

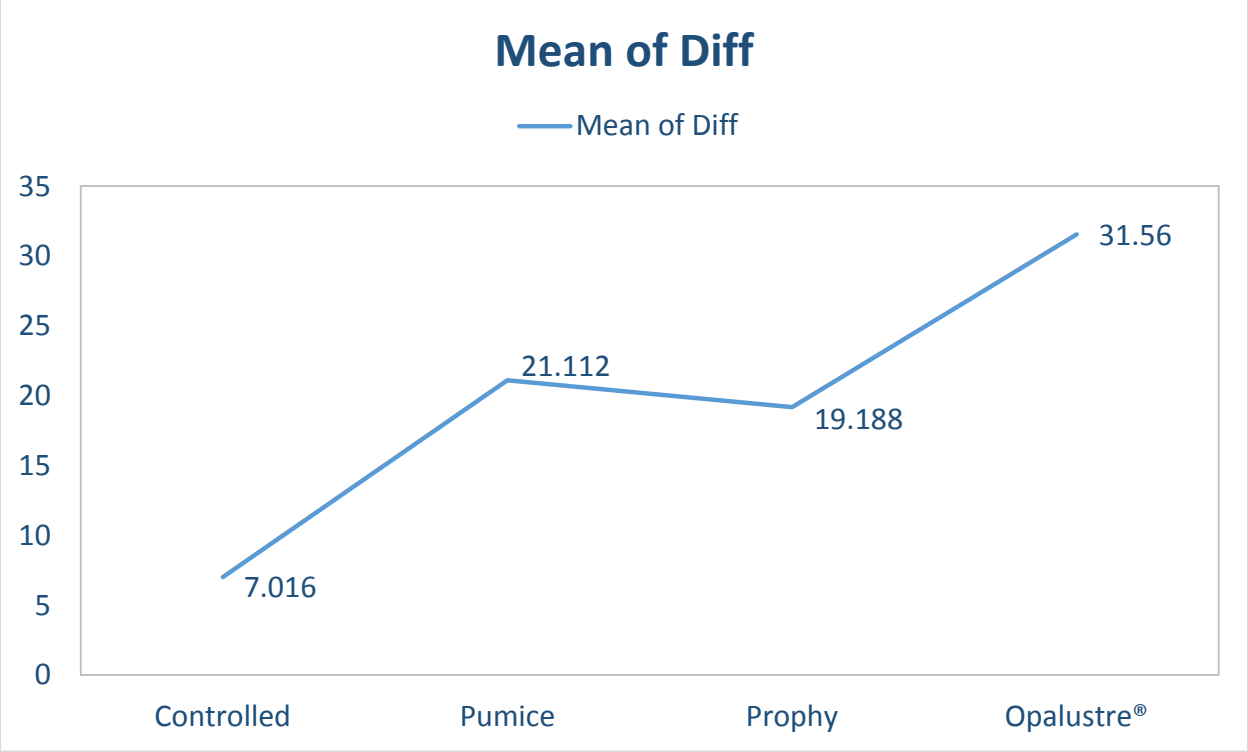

Figure 1: Mean weight loss of enamel

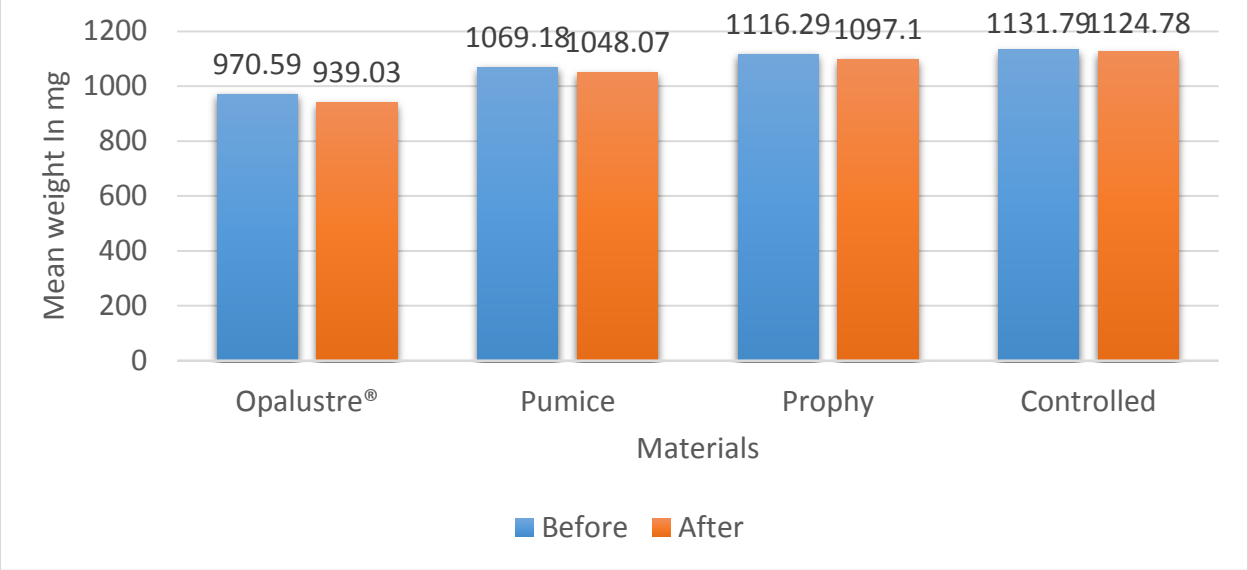

Figure-2: Histogram showing the mean of pre and post wear values of samples

DISCUSSION

The study shows that application of Opalustre®, Prophy paste and Pumice on tooth enamel under fixed rotational speed, time, number of applications and pressure caused different enamel loss ranged from (19.188mg to 31.5600 mg) As presented in table 2, Hydrochloric acid with silica carbide had the most abrasion effect of all materials used, similar to laboratory study done by **Paic *et al.*** [5] "Opalustre® caused the highest tooth substance loss followed by the Prema® compound and pumice" and in a study carried by **Meireles *et al.*** [6] concluded that " The increased roughness observed with 37% phosphoric acid could be attributed to a less aggressive decalcification, producing a selective conditioning pattern on the enamel surface" compared to 18% HCL which they considered more aggressive and have significantly higher enamel loss, but Opalustre® used in this study have less HCL concentration , 6.6% Hydrochloric acid, and Silica carbide as abrasive particle with a size range 20-160 mm, and had a mean difference in weight 31.56 mg which is explained by the material combination of chemical and mechanical abrasion [7].

A recent study carried by **Rodrigues *et al.*** [8] showed that 120 seconds of microabrasive treatment reduces about 10% of the enamel thickness, and it had 3.252% weight loss from the overall tooth weight in the application of Opalustre® which reflects how minimally invasive this procedure is. Controlled group with only distilled water had the least abrasion effect with mean difference in weight (7.0160 mg) which could be explained by the absent of abrasive particles and caused by Weight, pressure and friction of the brush's bristles as suggested in **Dalzell *et al.*** [9] study which showed that increasing pressure resulted in increased enamel loss.

On the other hand, there was minimal or no significant difference between the mean difference in weight loss between the Pumice with (21.1120 mg) mean weight loss and Prophy with (19.1880 mg) mean weight loss which could be explained by the relatively similar size in abrasive particle. The application of this study in a clinical setting must not be absolute. Each case varies in the severity of the staining or defects. Therefore, choosing the appropriate materials depend on each case separately, even though enamel loss cannot be accurately measured clinically, clinician must be concerned of how much enamel loss occurred after the procedure whether sufficient enamel thickness remains for function and appearance. As mentioned in an article by **Mittal *et al.*** [10] that microabrasion considered "a conservative first treatment of choice for removing superficial stains in the enamel before proceeding to a less-conservative treatment".

Concluding that diagnosis is the key to determine the favorable approach. Ideally, using an

automatically timed micro-motor would result in more accurate timing. However, that was unavailable in our laboratory. The use of an external stopwatch was our only option. Therefore, chance of +/-1 second Human error in each application was observed. Also, there was a small variation in surface area of enamel tooth structure exposed to the brush correlate to the tooth size.

The microabrasion technique in this study was used to simulate the commonly used method in a clinical set up. All samples prior testing were weight-measured in milligrams. Testing every sample once with four applications for thirty seconds each application, then cleaned, dried and weight measured for comparison.

Compared to previous article titled Microabrasion : effect of time , number of applications, and pressure on enamel loss by **Dalzell** [(9)] stated that "Enamel loss increased as variables of time, number of applications, and pressure increased separately", Similar time, number of application, but with fixed pressure and speed used on our study concluded that present of abrasive particles increased enamel loss, and combination of chemical and mechanical agents provided an effective enamel microabrasion results as provided in a study by **Pavesi *et al.*** [(11)] stated that Hydrochloric acid "resulted in significantly greater reductions in the microhardness results in the deeper enamel layers" and "The use of microabrasive systems containing acid and abrasive compounds combined with mechanical application can allow the efficient reduction of enamel damage in the superficial and deeper layers".

CONCLUSION

In the end, enamel microabrasion treatment is considered a safe, minimally invasive and excellent approach without great loss of tooth substance. It was found that combining chemical acid with mechanical abrasive particles produce more effective method with minimal enamel loss to enhance esthetic and eliminate enamel defect/staining with case severity in mind. This laboratory results support clinical studies in the use of microabrasion procedure as a first option in enamel staining/defects management. In sever enamel defect/staining it is useless to consider microabrasion as a treatment.

In this research it did not include color change or sensitivity that may appear after microabrasion. Therefore, Clinician's evaluation of the case and following the protocol of the microabrasion material used is a must.

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