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Original Article

Clinical comparison of the stain removal efficacy of two air polishing powders

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ABSTRACT

Objectives: Air polishing with sodium bicarbonate powders with a grain size of 40 μm is recommended for patient comfort. However, the efficacy of small grain size on stain removal has not been adequately studied. This study aimed to compare the stain removal efficacy of sodium bicarbonate powders with grain sizes of 65 and 40 μm and to evaluate patient acceptance and operator opinion after using both air polishing powders. **Materials and Methods:** A double-blind, randomized, split-mouth study was conducted with 35 participants with moderate to heavy dental staining on both sides of the upper teeth. Removal of dental stains on the index teeth was performed using sodium bicarbonate powders with a grain size of either 65 or 40 μm. The time taken to completely remove all dental stains was recorded. After treatment, a questionnaire was used to evaluate patient acceptance and the operator's opinion. **Results:** The average time for the removal of all stains by powder was 4.5 ± 3.6 min with a grain size of 65 μm and 4.4 ± 3.8 min with a grain size of 40 μm. The difference in the average time between the two groups was not significant ($P = 0.461$). The operator's opinions of the two powders were identical, and patient acceptance did not differ significantly between the two types of powders. **Conclusions:** The 40 μm sodium bicarbonate powder removed dental stains as efficiently as the 65-μm powder. Powder handling and patient acceptance were comparable between grain sizes of 65 and 40 μm.

Key words: Air polishing, dental stain, grain size, sodium bicarbonate, stain removal efficacy

INTRODUCTION

By providing a satisfactory esthetic condition to patients, esthetic dental treatment is capable of restoring self-esteem and self-confidence, culminating in greater socialization.[1] Certain beverages may cause discoloration of the tooth surface over a short period. After immersion of teeth in tea, red wine, and cola for 6 h and after immersion in coffee for 1 week, a clinically relevant difference in tooth color can be observed.[2] Dental staining is one of the most common problems in esthetic dental appearance. The use of a rubber cup and pumice is a widely known method among professionals to remove dental stains and plaque.[3] However, this method has limitations because stains in grooves and malaligned teeth cannot be accessed. To overcome these limitations, air polishing has been introduced for stain removal.[3] The stain removal efficacies of a rubber cup with pumice and air polishing are similar, but the time required to remove all stains is longer for a rubber cup and pumice than for air polishing.[3] In addition, air polishing can remove stains more efficiently than a curette.[4]

One of the main concerns regarding the use of any device for treatment is patient comfort. Sodium bicarbonate powder with a grain size of approximately 65 μm causes gingival trauma when used in the cervical

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part of the crown, thus causing patient discomfort. Manufacturer recommendations and the literature discourage the use of sodium bicarbonate toward the gingival margin. A smaller grain size (40 μm) is more comfortable for patients, but the efficacy of this grain size in patients has not been fully studied.

Therefore, this study aimed to compare the stain removal efficacies of sodium bicarbonate powders with grain sizes of 65 and 40 μm. This study also evaluated patient acceptance after treatment and the operator's opinion after using both air polishing powders.

MATERIALS AND METHODS

The study was approved by the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University, Institutional Review Board (COA. No. MU-DT/PY-IRB 2015/034.0608) and registered on ClinicalTrials.gov (NCT03140436). Thirty-five patients were invited to enroll in the study. These patients were all older than 18 years of age, had no systemic disease, and for female patients, were not pregnant or currently breastfeeding. All patients had healthy gingiva or only gingivitis. These patients had at least three upper teeth (anterior, premolar, and molar) present on both sides (right and left side), referred to as index teeth that did not have any intrinsic stain, gingival recession, cervical abrasion, and/or abfraction, caries, restoration, or orthodontic appliance. Patients who showed any sign of allergy to sodium bicarbonate or the aroma of the powder were excluded from this study. Patients presented with index teeth with extrinsic stains with individual Lobene scores[5] of two or greater. Patients who met the above criteria were informed about the study, and those who decided to enroll in the study voluntarily signed informed consent.

Sample size calculation

This study used a split-mouth design to compare the time required to remove all extrinsic dental stains using two air polishing powders. Sample size was calculated according to the standard deviation of the time to remove all extrinsic dental stains obtained in a previous study that reported a mean ± standard deviation (SD) of 5.5 ± 3.6.[3] Using a two-sided Type I error of 0.05, 90% power of detection, difference in mean time between 2 powders of 2 min, and an SD of 3.6, a sample of 35 patients was required.

Outcome measurement

The time required for the complete removal of extrinsic stains by sodium bicarbonate powders with a grain size of 65 and 40 μm (AIR-FLOW®, EMS SA, Switzerland) was the primary outcome, and answers from the questionnaires about the clinical impressions of both patients and operators about the two powders were the secondary outcomes.

Interventions

This study was designed as a double-blind, randomized split-mouth design. The allocation was performed by one researcher (Rosalin H) who divided all participants into five groups with equal numbers of patients ($n = 7$). The Lobene score[5] of each group was recorded and compared to confirm the similarity of the groups. The area recorded was from line angle to line angle. The stain index was calculated by multiplying the stain intensity by the stain extent at each site.

For intensity, the following scores were recorded:
- 0 = no stain
- 1 = light stain
- 2 = moderate stain
- 3 = heavy stain.

For extent, the following score scores were recorded:
- 0 = no stain detected
- 1 = stain over one-third of the region
- 2 = stain over two-third of the region
- 3 = stain over more than two-third of the region.

Each group received treatment from a different operator (one operator per group). Each patient was randomized using sealed envelopes according to treatment side (right or left) to powder grain size of 65 or 40 μm. The patients and operators were blinded to the type of the powder. The numbers of sites that received treatment using a powder grain size of 65 or 40 μm were equal to eliminate bias due to differences in accessibility between the right and left sides. The index teeth used in this study were three upper teeth on the same side, in which each tooth represented anterior teeth, premolar, and molar. The index teeth were the teeth with the maximum Lobene score[5] for each type of tooth. The stain index for the index teeth was recorded as the pretreatment stain index. The stain indexes of the left and right sides were compared to confirm similarity. The stain index was examined by a blinded researcher, and the intra-examiner reproducibility of the examiner (κ) exceeded 0.8.

Air polishing with powder with a grain size of either 65 or 40 μm was performed using an AFM (AIR-FLOW® Master, EMS SA, Switzerland) at medium power (8–9 light emitting diodes) and maximum water.

The handpiece was moved using mesial to distal movements supragingivally as recommended. Each side received treatment with a 30°–60° angle of the spray nozzle to the tooth surface at a distance of 3–5 mm from the tooth surface. Each patient received treatment with both powders to remove extrinsic stains until complete removal of stains on the index teeth was accomplished. A rubber dam was used to eliminate possible contact of one powder with the area preassigned to the other type of air polishing powder. The time required for complete removal of extrinsic stains on all index teeth was recorded. Each participant received full mouth scaling and polishing to remove any calculus after total removal of extrinsic stain.

Questionnaire

Both patients and operators received questionnaires. The patient questionnaire asked the patients to assess their acceptance after treatment with each powder. The operator questionnaire sought the operators' opinions of each powder after the first use. The questionnaire was applied separately for powders with grain sizes of 65 and 40 μm.

Statistical analysis

Statistical analysis was performed using PASW Statistics 18. The time required for complete removal of extrinsic stains was compared between groups using the Wilcoxon signed-rank test. The data obtained from the patient questionnaires were compared between each group using the test of marginal homogeneity. The data obtained from the operator questionnaires were subjected to descriptive analysis. The level of significance was $P < 0.05$.

RESULTS

Thirty-five participants completed the study, and no adverse events were noted by any participant during the study. Thirty-one participants were male, and four participants were female, with an average age of 39.5 ± 12.5 years. The participant's characteristics are shown in Table 1. Typical index teeth before and after air polishing treatment are shown in Figure 1.

A total of 420 sites (two per tooth) were recorded. When comparing the Lobene score stain index at baseline between grain sizes of 65 and 40 μm, we found that in all participants, including smokers and nonsmokers, there was no significant difference as shown in Table 2.

Immediately following treatment, the Lobene score stain index in both groups approached to zero. Table 3 shows the mean time required to completely remove all external stains in all participants, smokers and nonsmokers. For all the participants, the mean time to remove all stains was 4.5 ± 3.6 min using the powder with a grain size of 65 μm and 4.4 ± 3.8 min with the grain size of 40 μm. The time did not differ significantly between the groups. For both smokers and nonsmokers, there was no significant difference in the mean time to remove all stains between the grain size of 65 μm and grain size of 40 μm.

Table 1: Participant's characteristics at baseline

Characteristics	
Sex, *n* (%)	
Male	31 (88.6)
Female	4 (11.4)
Age range (years), mean±SD (years)	19-66, 39.5±12.5
Smoking status, *n* (%)	
Smoker	27 (77.1)
Nonsmoker	8 (22.9)

SD: Standard deviation

Table 2: Lobene score at baseline in all, smoker and nonsmoker participants

Lobene score	Grain size		*P*
	65 μm	40 μm	
All participants	4.9±1.7	5.0±1.7	0.837*
Smoking status			
Smoker	4.8±1.7	4.8±1.7	0.737*
Nonsmoker	5.6±1.4	5.5±1.7	0.913*

*Lobene score was not significantly different between groups at baseline

Figure 1: Pictures of index teeth before treatment (a, c, and e) and after treatment (b, d, and f)

Table 3: Mean time required to remove all stains using sodium bicarbonate powder with grain sizes of 65 and 40 µm

Subjects	Time required for removal of all stains (mean±SD, mins) Grain size		*P*
	65 µm	40 µm	
All participants	4.5±3.6	4.4±3.8	0.461*
Smokers	4.4±3.4	4.3±3.6	0.913*
Nonsmokers	5.0±4.3	4.7±4.7	0.575*

*Mean time required to remove all stains was not significantly different between the grain size of 65 µm and grain size of 40 µm.
SD: Standard deviation

Table 4: Evaluation of patient acceptance after treatment

Questions	Patient opinion	Grain size		*P*
		65 µm (%)	40 µm (%)	
Patient comfort after treatment	Fair	1 (2.9)	1 (2.9)	0.317*
	Good	12 (34.3)	15 (42.9)	
	Excellent	22 (62.9)	19 (54.3)	
Patient acceptance of smoothness of teeth after treatment	Fair	5 (14.3)	4 (11.4)	0.774*
	Good	16 (45.7)	15 (42.9)	
	Excellent	14 (40)	16 (45.7)	
Patient acceptance of the taste of the powders	Poor	2 (5.7)	1 (2.9)	0.431*
	Fair	8 (22.9)	6 (17.1)	
	Good	9 (25.7)	14 (40)	
	Excellent	16 (45.7)	14 (40)	
Overall patient satisfaction	Fair	4 (11.4)	1 (2.9)	0.174*
	Good	10 (28.6)	15 (42.9)	
	Excellent	21 (60)	19 (54.3)	

*No significant difference between grain size of 65 µm and grain size of 40 µm

To assess patient acceptance, all 35 participants completed the entire questionnaire directly after the treatment. The questionnaire asked about comfort after treatment, smoothness of the teeth, taste of the powder, and overall patient satisfaction. There were no significant differences in the answers for all four questions between the sodium bicarbonate powder with a grain size of 65 µm and grain size of 40 µm, as shown in Table 4.

The operators' opinions were assessed based on the answers of five operators to 11 questions. Unfortunately, the last two questions on the ease and frequency of powder chamber filling were only answered by three operators. The answers to all questions were comparable for the two powders [Table 5].

DISCUSSION

The main purpose of this study was to compare the stain removal efficacy of sodium bicarbonate powders with grain sizes of 65 and 40 µm. The different grain sizes (65 and 40 µm) had equivalent efficacies in removing heavy dental stains, as indicated by the lack of significant difference in the time required to remove heavy dental stains on the index teeth. Patient acceptance did not differ significantly between the two powders, and the operators' opinions on all questions were comparable for the two types of powders although the latter results could not be compared by statistical analysis.

Dental staining is a major problem during treatment because its removal requires so much time. Air polishing has consequently been studied to address this problem and is of interest to many clinicians to remove dental stains. A previous study comparing the stain removal efficacy of air polishing and a curette found that air polishing removed stains 3.15 times faster than a curette.[4] However, the most common procedure used to remove dental stains is a rubber cup with pumice. Weaks *et al*. demonstrated that air polishing required less time to completely remove dental stains than a rubber cup with pumice. To remove dental stains from five teeth, air polishing required 5.5 ± 3.6 min (1.1 ± 0.7 min/tooth), whereas the rubber cup with pumice required 13.4 ± 6.0 min.[3] The time used to remove dental stains from three teeth in this study was 4.5 ± 3.7 (1.5 ± 1.2 min/tooth), similar to the results presented by Weaks *et al*.

The results of our study showed that the time required to remove dental stains from smoking was not significantly different from the time required to remove stains from other sources. Extrinsic stains from tobacco smoking and chewing occur by the same mechanism, direct staining of the pellicle.[6] However, because components of tobacco smoke can stick to the tooth surface, some clinicians feel that nicotine stains are more difficult to remove than stains from food.[7] In the present study, the efficacy of removing nicotine stains did not differ significantly between the different grain sizes (65 and 40 µm) of sodium bicarbonate powder.

Some clinicians feel that air polishing results in patient discomfort due to its effect on soft and hard tissues.[8] In this study, four questions in the questionnaire were used to assess patient acceptance of treatment with sodium bicarbonate powder with a grain size of either 40 or 65 µm. The patients answered the questionnaire immediately after complete treatment. Most of the patients' answers corresponded to the categories of "good" and "excellent" [Table 4], and there was no significant difference in patient acceptance between the two powders.

Table 5: Evaluation of operator opinion after using sodium bicarbonate powder with grain sizes of 65 and 40 μm

	Operator opinion	Grain size	
		65 μm (%)	40 μm (%)
Efficacy in removing heavy stains	Fair	1 (20)	2 (40)
	Good	3 (60)	3 (60)
	Excellent	1 (20)	0
Time required to remove stains	Poor	1 (20)	2 (40)
	Good	2 (40)	1 (20)
	Excellent	2 (40)	2 (40)
Smoothness of the teeth	Poor	1 (20)	0
	Fair	1 (20)	1 (20)
	Good	0	2 (40)
	Excellent	3 (60)	2 (40)
Amount of powder required to remove stain	Bad	2 (40)	1 (20)
	Poor	0	2 (40)
	Fair	3 (60)	1 (20)
	Good	0	1 (20)
Dust from using powder	Poor	1 (20)	1 (20)
	Fair	1 (20)	3 (60)
	Good	2 (40)	1 (20)
	Excellent	1 (20)	0
Environment in the work place	Poor	2 (40)	2 (40)
	Fair	2 (40)	2 (40)
	Good	1 (20)	1 (20)
Ease in removing heavy dental stains	Bad	1 (20)	1 (20)
	Poor	0	1 (20)
	Fair	2 (40)	1 (20)
	Good	2 (40)	1 (20)
	Excellent	0	1 (20)
Patient comfort during powder use	Poor	1 (20)	1 (20)
	Fair	0	1 (20)
	Good	4 (80)	2 (40)
	Excellent	0	1 (20)
Ease of filling the chamber	Poor	1 (33.3)	1 (33.3)
	Fair	2 (66.7)	2 (66.7)
Frequency of filling the chamber	Fair	2 (66.7)	2 (66.7)
	Good	1 (33.3)	1 (33.3)
Overall satisfaction	Poor	1 (20)	2 (40)
	Fair	1 (20)	0
	Good	1 (20)	3 (60)
	Excellent	2 (40)	0

One concern with the use of air polishing is the risk of inducing emphysema. Air emphysema was noted in three case reports after supragingival air polishing with sodium bicarbonate powder.[9-11] However, emphysema did not occur in any of the 35 pars treated in our study. Adverse events after treatment with sodium bicarbonate powder were reviewed in two previous studies. In one study, 75% of patients had subjective symptoms during supragingival treatment with sodium bicarbonate powder, and 45% had subjective symptoms immediately after treatment.[12] In another study, three patients complained about peeling off of the inner aspects of the lower lip after supragingival polishing with sodium bicarbonate powder.[13] By contrast, no adverse events or symptoms during or after treatment with air polishing were observed in the present study.

This study is the first to also investigate operator opinion. The operators answered 11 questions using rankings of "bad" to "excellent." For the two questions about the amount of powder required to remove stains and the ease of removing heavy dental stains, only one operator indicated "bad." This operator felt that air polishing was inconvenient.

The time required to remove dental stains varied depending on the intensity and extent of dental

stains present on the tooth surface at the baseline. Weaks *et al*.[3] did not provide concrete inclusion criteria, noting only that patients exhibited "substantial observable stain." This scoring system raises questions about whether the dental stains used to compare the time required to remove dental stain were comparable between air polishing and rubber cup and pumice. The Lobene score[5] used in this study was calculated by multiplying intensity by extent to provide quantitative data for comparing baseline staining between groups. The use of the Lobene score supports the reliability of our study.

The level of staining before treatment was a crucial consideration. In the present study, the Lobene score[5] at baseline varied greatly, ranging from two to nine. This wide range of baseline scores resulted in a wide range of time to remove stain of 0.59–16.73 min. However, the dental stains included in this study represented the population with moderate to heavy stains, resulting in greater scattering of the data. The results revealed that sodium bicarbonate powder with a grain size of either 65 or 40 μm had comparable efficacy in removing moderate to heavy dental stains. Further studies should be conducted using teeth with heavy staining only to reduce the range of staining and to clarify the efficacy of both powders in removing heavy dental stains.

Patient acceptance in this study was recorded using a questionnaire that included only five choices, which might obscure the true differences between the two powders. Further studies should be conducted using other tools, such as the visual analog scale (VAS), to more closely reflect similarities or differences between the two types of powders. The VAS score records data using interval measurements and not ordinal measurements.

CONCLUSIONS

This study showed that sodium bicarbonate powder with grain sizes of 65 and 40 μm resulted in similar times required to remove moderate to heavy dental stains. With respect to handling, the operators' opinions of the two powders were comparable. Patient acceptance did not differ significantly between the two types of powders. Therefore, the 40 and 60 μm sodium bicarbonate powders were equally efficient and acceptable for removing dental stains.

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Conflicts of interest

There are no conflicts of interest.

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