# Conventional versus comprehensive dental prophylaxis: comparing the clinical outcomes between rubber cup and air polishing and the importance of plaque disclosure

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**Objective:** This study aimed to compare the clinical outcomes in dental prophylaxis between rubber cup polishing and an air polishing system using erythritol powder, with or without prior dental plaque disclosure. **Method and materials:** In this single-blind, randomized, controlled, split-mouth clinical trial, healthy participants with full-mouth plaque score ≥ 60% were recruited. Quadrants in each participant were randomly assigned to four treatment groups: air polishing with prior plaque disclosure; air polishing without plaque disclosure; rubber cup polishing with prior plaque disclosure; or rubber cup polishing without plaque disclosure. Plaque scores and treatment time for each quadrant were recorded. Posttreatment satisfaction questionnaires for both the participants and operators were also completed. **Results:** In total, 88 participants consisting of 42 men and 46 women (mean age 23.1 ± 2.0 years) were recruited. Air polishing with prior plaque disclosure had significantly lower posttreatment marginal mean plaque score (21.7 ± 17.5%) compared to air polishing (33.5 ± 23.4%) or rubber cup polishing (34.5 ± 19.7%) without prior plaque disclosure ($P < .001$). Marginal mean treatment time for air polishing (325 seconds; SE = 10 seconds) was significantly shorter compared to rubber cup polishing (407 seconds; SE = 15 seconds) ($P < .001$). Both the participants and operators preferred air polishing over rubber cup polishing ($P < .001$). **Conclusion:** Prior plaque disclosure enhanced the effectiveness of plaque removal. Air polishing exhibited better treatment efficiency than rubber cup polishing and was the patients' and clinicians' preferred treatment modality. *(Quintessence Int 2021;52:264–274; doi: 10.3290/j.qi.a45602)*

**Key words:** air polishing, biofilm, dental prophylaxis, periodontal disease, rubber cup

Recent reviews of epidemiologic studies have reported that untreated dentin caries lesions in permanent teeth was the most prevalent global condition in 2010, affecting 35% of the human population,[1] and severe periodontitis was the sixth most common global disease, with an overall prevalence of 11.2%.[2] These oral conditions are caused by dental biofilms that consist of a highly variable structural entity of microorganisms, embedded within an extracellular polymeric matrix, which adheres to the hard nonshedding tooth surfaces.[3] These conditions are responsible for the initiation and progression of common oral disorders such as dental caries and periodontal diseases, which if left untreated can lead to tooth loss and reduction in quality of life.[4] Therefore, the removal of dental biofilms is an important prerequisite in preventing dental caries and periodontal diseases. Hence the key rationale behind mechanical debridement is the periodic mechanical removal of dental plaque and calculus to reduce the oral bacterial load to a level compatible with health.

Plaque removal is conventionally achieved by using a rubber cup with pumice or fine polishing paste. This treatment modality might prove to be challenging in hard-to-reach areas. As a result, air powder polishing systems which utilize pressurized air and water to deliver a controlled stream of powder slurry directed towards the tooth surface to remove dental plaque, surface stains, and other soft deposits have been used in prophylaxis.[5] These systems are shown to be as effective as

rubber cup polishing in plaque removal,[6-9] with an additional benefit of the air powder being able to access difficult to reach surfaces, such as furcations, flutings, close root proximity areas, and even subgingivally in moderately deep pockets.[10] Therefore, air powder polishing systems are perceived to be a paradigm shift in mechanical plaque removal.[11] They were shown to be more effective than curettes, cause less gingival erosion, and perceived to be as or even more comfortable than conventional prophylaxis methods,[12,13] thus offering great promise as a professional plaque control measure.

In order to facilitate improved plaque removal by patients and clinicians, plaque can be disclosed so that it is visible to both parties.[14-16] In this way, clinicians can better focus on specific areas of concerns during instrumentation and thus maximize clinical efficacy and patient comfort while minimizing fatigue. Patients, on the other hand, can be educated and motivated to perform more effective home care. Unfortunately, plaque is not routinely disclosed prior to dental prophylaxis. Consequently, over-treatment of certain sites may occur resulting in adverse effects like over-instrumentation, dentin hypersensitivity, and gingival recession. As such, comprehensive prophylaxis involving prior plaque disclosure, followed by air polishing to remove the identified dental plaque, was included as part of the eight steps in the prophylaxis guideline, Guided Biofilm Therapy.[17]

This study was designed to compare the effectiveness of air polishing and rubber cup polishing in terms of its ability to remove dental plaque, with or without prior plaque disclosure, and the total treatment duration taken to complete the prophylaxis. Operators' and patients' preferences between the two treatment methods were also evaluated. The following null hypotheses were tested:

- There is no difference in dental plaque removal ability between the use of air polishing and rubber cup polishing for prophylaxis, with or without prior plaque disclosure.
- There is no difference in treatment duration between the use of air polishing and rubber cup polishing for prophylaxis, with or without prior plaque disclosure.
- There is no preference in treatment option between the use of air polishing and rubber cup polishing for prophylaxis for both operators and patients.

## Method and materials

Ethical approval was obtained from the local review board (National Healthcare Group Domain Specific Review Board of Singapore reference number: 2016/00916) prior to study commencement.

### *Sample population*

Subjects were recruited and treated at the University Dental Cluster, National University Hospital, Singapore. The inclusion criteria were:

- individuals capable of independent consent, between the ages of 21 and 35 years (inclusive)
- systemically healthy (ASA I)
- nonsmokers
- assessed to have poor oral hygiene as defined by a baseline full-mouth plaque score (FMPS),[14] of at least 60%
- had refrained from any oral hygiene practices for 24 hours prior to the prophylaxis visit.

The exclusion criteria were:

- individuals with active chronic or aggressive periodontitis
- individuals undergoing active orthodontic treatment or with fixed lingual retainers
- pregnant and lactating females
- failure to comply with study protocol and had performed oral hygiene practices 24 hours prior to the prophylaxis visit.

### *Pre-study protocol*

After consent taking, the recruited participants received a comprehensive dental and periodontal examination. Plaque was disclosed using a plaque disclosing agent (PlaqSearch, TePe) containing hydrated dextrates, magnesium stearate, and sodium starch glycolate. Subsequently, pre-study plaque and calculus removal was performed for all participants using ultrasonic scalers, hand instruments such as curettes and sickles, and rubber cup polishing with fine grit prophylaxis paste. All enrolled participants were instructed to abstain from oral hygiene practices for at least 24 hours prior to the study visit.

### *Calibration of operators and examiners*

Prior to study commencement, four dental undergraduate student operators were trained and calibrated on the use of the air polishing system (Airflow Master Piezon, EMS Electro Medical Systems) with erythritol powder of mean powder size 14 µm (Airflow Plus powder, EMS Electro Medical Systems), and rubber cup polishing with fine grit prophylaxis paste (Zircon-F, Henry Schein). The three examiners (JHF, LBW, HJT) were also calibrated on disclosed plaque detection and FMPS calculation. The inter-examiner reliability as assessed by intra-class correlation coefficient (ICC) was found to be high at 0.989 (95% confidence interval [CI] 0.649 to 1.000).

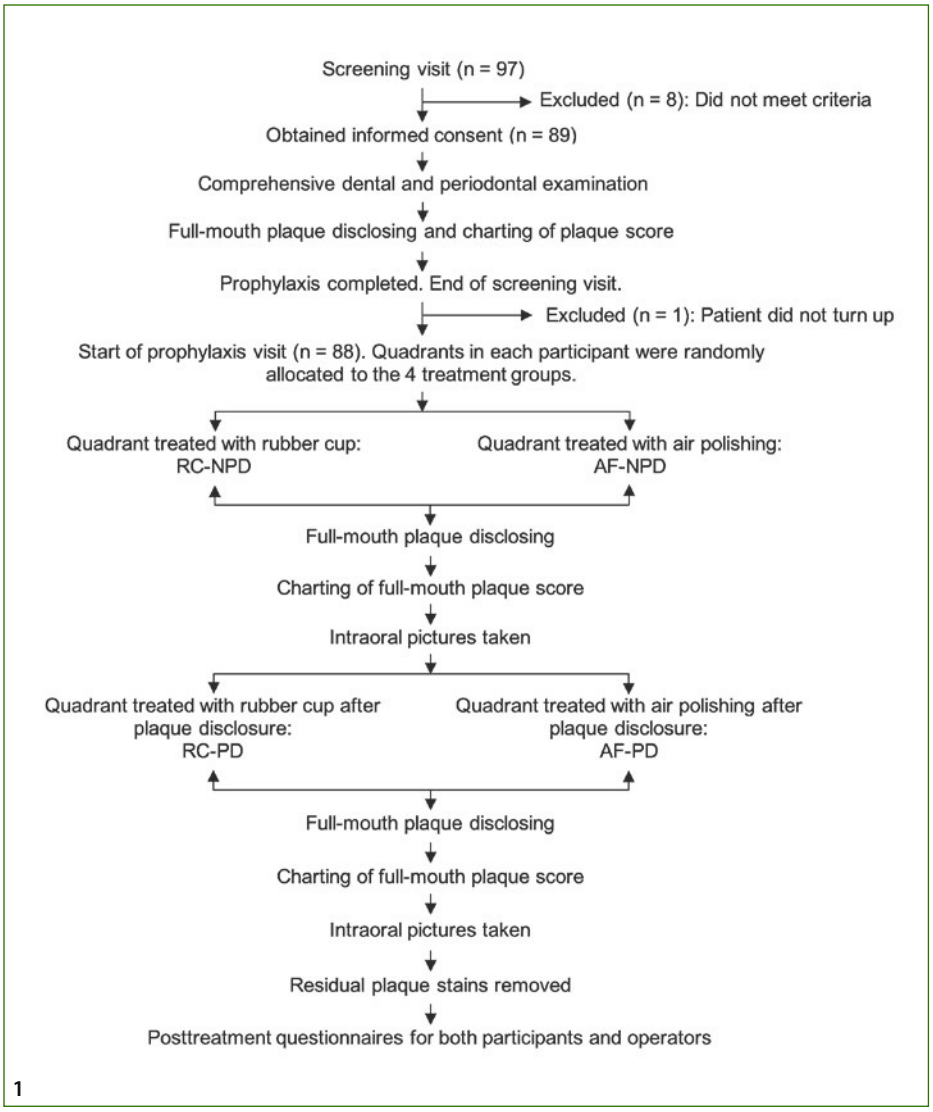


**Fig 1** Study workflow.

## *Study design and treatment groups*

To test the hypotheses raised, a single blind, randomized, controlled clinical trial with a split-mouth design was conducted. In each participant, the mouth was divided into four quadrants, which were randomly assigned into one of the following four treatment groups:

- air polishing with prior plaque disclosure (AF-PD) (positive test)
- air polishing without prior plaque disclosure (AF-NPD) (negative test)
- rubber cup polishing with prior plaque disclosure (RC-PD) (positive control)
- rubber cup polishing without prior plaque disclosure (RC-NPD) (negative control).

## *Randomization, blinding, and allocation concealment of the sample population*

A computer software-generated simple random sequence was used to randomly assign the treatment quadrants within each participant into the four study groups. Similarly, operators and examiners were also randomly assigned to each participant using simple randomization. Information on the treatment allocation was prepared by the research assistant and sealed in an opaque envelope. The assigned research assistant would only

**Fig 2** Clinical view after completion of RC-NPD (maxillary right) and AF-NPD (maxillary left) quadrant treatments.

**Fig 3** Clinical view after completion of RC-PD (mandibular right) and AF-PD (mandibular left) quadrant treatments.

reveal the treatment allocation to the operators immediately prior to treatment commencement. All examiners were blinded to the group allocation for each quadrant. Although the participants were not aware of the treatment allocation for each quadrant, there could be a discernable distinction between the sensations of the equipment used, hence the participants were considered to be unblinded to the study groups.

### *Study protocol*

The study workflow is illustrated in Fig 1. For each participant, the quadrant that was assigned to receive RC-NPD was treated first followed by the quadrant assigned to receive AF-NPD. Plaque was then disclosed in all four quadrants and the assigned calibrated examiner proceeded to chart the FMPS (Fig 2). Subsequently, the quadrant assigned to receive RC-PD was treated, followed by the quadrant assigned to receive AF-PD, and FMPS was charted again (Fig 3). Any aberrant findings in occlusion, tooth alignment, or extra/missing teeth were also noted. Treatment duration for each quadrant was timed using a digital stopwatch by an independent observer.

### *Posttreatment satisfaction questionnaire*

Upon finishing of all treatment quadrants, a posttreatment self-reported questionnaire was completed by the participants and operators. On a scale of 1 to 10, the participants compared the treatment experience between air polishing and rubber cup based on the following factors: level of discomfort, sensitivity, pain, duration of treatment, messiness, fear-inducing, noise level, and overall satisfaction. They were also asked to state their preferred treatment option. For the operators, the following factors were compared: perceived effectiveness, ergonomics, operator fatigue, duration of treatment, messiness, ease of usage, noise level, and overall satisfaction. They were also asked to state their preferred system.

### *Statistical analysis*

Descriptive statistics (means and standard deviations) were used to summarize the plaque score and treatment duration for each study group. Two-way repeated measure ANOVA test was employed to examine the study hypotheses that air polishing was more effective in plaque removal compared to rubber cup polishing and that plaque disclosure prior to prophylaxis increased the thoroughness of the prophylaxis, with Bonferroni correction for multiple comparison. Two-way repeated measure ANOVA test was also performed to compare the treatment duration between the two treatment regimens with or without plaque disclosure prior to prophylaxis, with Bonferroni correction for multiple comparison. In a secondary analysis, the operator effect (between-subject effect) was tested and accounted in the analysis. Chi-square test (for deviation of observed frequencies from expected frequencies) was used to study the participant's and operator's preference for each treatment modality based on various yardsticks and overall, respectively. The level of significance was set at $P < .05$. All statistical analyses were carried out using a statistical package (SPSS version 24.0, IBM).

**Table 1** Summary of mean pre- and posttreatment plaque scores for the four treatment groups

| Treatment group | Baseline plaque score (%), mean ± SD | Posttreatment plaque score (%), mean ± SD |
|---|---|---|
| AF-PD | 81.0 ± 15.5 | 21.7 ± 17.5 |
| AF-NPD | NA | 33.5 ± 23.4 |
| RC-PD | 81.1 ± 13.6 | 25.5 ± 15.2 |
| RC-NPD | NA | 34.5 ± 19.7 |

AF-NPD, air polishing without plaque disclosure; AF-PD, air polishing with plaque disclosure; NA, not applicable; RC-NPD, rubber cup polishing without plaque disclosure; RC-PD, rubber cup polishing with plaque disclosure; SD, standard deviation.

**Table 2** A comparison of mean posttreatment plaque scores (%) between the four treatment groups

| | AF | RC | Difference | *P* value | NPD | PD | Difference | *P* value |
|---|---|---|---|---|---|---|---|---|
| **Marginal mean** | 27.6 | 30.0 | −2.4 | .219 | 34.0 | 23.6 | 10.4 | < .001 |
| **SE** | 1.9 | 1.6 | 1.95 | | 1.9 | 1.4 | 1.6 | |
| **95% CI** | 23.7–31.5 | 26.9–33.2 | −6.3–1.5 | | 30.3–37.7 | 20.8–26.5 | 7.3–13.5 | |

| | | Mean difference | SE | *P* value* |
|---|---|---|---|---|
| **AF-PD** | AF-NPD | −11.749 | 2.080 | < .001 |
| | RC-NPD | −12.804 | 2.551 | < .001 |
| | RC-PD | −3.781 | 2.021 | .388 |
| **AF-NPD** | RC-NPD | −1.055 | 2.682 | 1.000 |
| | AF-PD | 11.749 | 2.080 | < .001 |
| | RC-PD | 7.968 | 2.443 | .009 |
| **RC-PD** | AF-NPD | −7.968 | 2.443 | .008 |
| | RC-NPD | −9.023 | 2.040 | < .001 |
| | AF-PD | 3.781 | 2.021 | .388 |
| **RC-NPD** | AF-NPD | 1.055 | 2.682 | 1.000 |
| | AF-PD | 12.804 | 2.551 | < .001 |
| | RC-PD | 9.023 | 2.040 | < .001 |

AF, air polishing; CI, confidence interval; NPD, without plaque disclosure; RC, rubber cup polishing; PD, with plaque disclosure; SE, standard error of the mean.
*Bonferroni correction for multiple comparison.

## Results

A total of 97 participants were screened, of which eight did not meet the inclusion criteria and one did not show up for the prophylaxis visit. Thus, 88 participants, consisting of 42 men and 46 women, with a mean age of 23.1 ± 2.0 years, were eventually recruited and all participants completed the study. Most participants had well-aligned teeth except for 17 participants (19.3%), of which 15 (88.2%), had slight mandibular anterior crowding. The mean baseline FMPS was 80.8 ± 12.9% with an almost symmetric plaque distribution between the left and right sides (left side 80.5% and right side 81.1%).

A summary of the mean pre- and posttreatment plaque scores for the four treatment groups is illustrated in Table 1. Groups that had prior plaque disclosure (AF-PD and RC-PD) had lower mean posttreatment plaque scores, of which the group that received air polishing with prior plaque disclosure (AF-PD) had the lowest mean posttreatment plaque score (21.7 ± 17.5%)

among the four groups (Table 1). Groups that received air polishing showed greater plaque removal ability (marginal mean posttreatment plaque score 27.6%; standard error [SE] 1.9 %; 95% CI 23.7 to 31.5) compared to groups that received rubber cup polishing (marginal mean posttreatment plaque score 30.0%; SE 1.6%; 95% CI 26.9 to 33.2), although this was not statistically significant ($P = .219$) (Table 2). However, when air polishing with prior plaque disclosure was compared with rubber cup polishing without plaque disclosure, the difference in plaque removal ability was significant ($P < .001$) (Table 2).

The marginal mean posttreatment plaque score obtained for the two groups that had plaque disclosure prior to prophylaxis was lower (23.6%; SE 1.4%; 95% CI 20.8 to 26.5) as compared to that obtained for the two groups without prior plaque disclosure (34.0%; SE 1.9%; 95% CI 30.3 to 37.7). The difference was significant ($P < .001$) (Table 2). There was no significant interaction between treatment modality and presence or absence of plaque disclosure prior to prophylaxis ($P = .315$) (Fig 4).

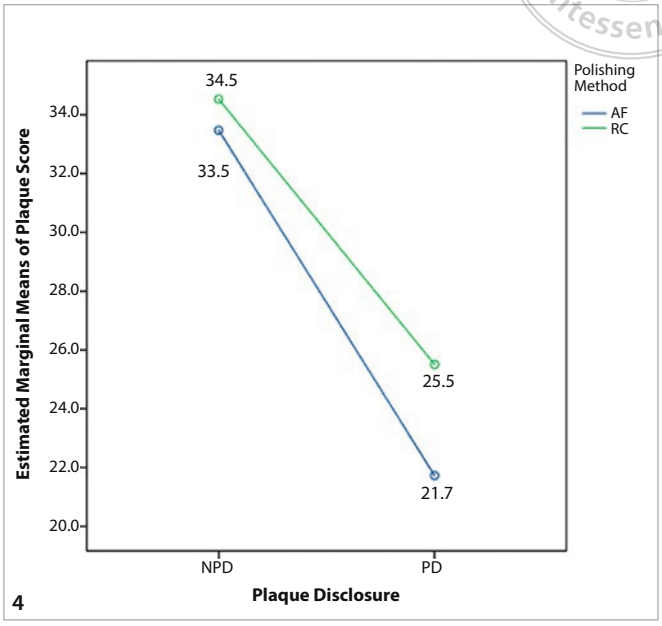


**Fig 4** Line diagram illustrating the main effect of the polishing method and treatment concept and no interaction ($P = .315$) (AF, air polishing; RC, rubber cup).

Groups that had air polishing (AF-PD, 325 ± 109 seconds; AF-NPD, 325 ± 101 seconds) had lower mean treatment durations compared to groups that had rubber cup polishing (RC-PD, 412 ± 149 seconds; AF-NPD, 403 ± 149 seconds) (Table 3). Treatment duration for the two groups using air polishing (marginal mean treatment duration 325 seconds; SE 10 seconds; 95% CI 305 to 344) was completed in a significantly shorter duration compared to the two groups using rubber cup polishing (marginal mean treatment duration 407 seconds; SE 15 seconds; 95% CI 377 to 437) ($P < .001$) (Table 4). The marginal mean treatment time taken to complete the prophylaxis using air polishing with prior plaque disclosure (marginal mean treatment duration 325 ± 109 seconds) was significantly shorter compared with rubber cup polishing without plaque disclosure (marginal mean treatment duration 403 ± 149 seconds) ($P < .001$) (Table 4). Disclosing plaque prior to prophylaxis did not significantly affect the marginal mean treatment duration (marginal mean treatment duration difference 4 seconds; SE 8 seconds; 95% CI −21 to 12; $P = .589$) (Table 4). Interaction between treatment modality and plaque disclosure was not observed ($P = .433$) (Fig 5).

In terms of posttreatment plaque score, no significant difference was observed across the four operators ($P = .245$). However, in terms of treatment duration, a significant difference was observed across the four operators ($P < .001$), although this did not affect the final result after adjusting for operator difference (Table 5).

The participants generally preferred air polishing compared to rubber cup polishing ($P < .001$) (Table 6). They expressed that the air polishing treatment was more comfortable, less sensitive, less painful, faster, less fear inducing, and was overall the more preferred system. On the other hand, participants reported that rubber cup polishing was comparatively less messy and less noisy. Qualitatively, 13 participants (14.8%) described an unpleasant taste from the powder used with the air polishing system, and three participants (3.4%) felt that there were "bulky instruments in the mouth" as the handpiece and high vacuum suction were used together during treatment in the air polishing system. Only one participant felt that the air polishing cleaned his teeth better than the rubber cup polishing.

Likewise, the four operators were evaluated, and all preferred using air polishing over rubber cup polishing ($P < .001$) (Table 7). Qualitative feedback by the operators revealed that all of them found the air polishing to be more effective, more ergonomic, easier to use, more efficient, and required less effort as compared to the rubber cup polishing. Posttreatment gingival bleeding was observed by all operators when using the air polishing system to remove plaque around visibly inflamed gingiva, although the participants did not report significant discomfort during and after the treatment. Conversely, the operators were also of the opinion that rubber cup polishing was quieter and neater compared to the air polishing.

**Table 3** Summary of treatment duration for the four treatment groups

| Treatment group | Treatment duration (s) | Mean |
|---|---|---|
| AF-PD | 324.5 | 109.3 |
| AF-NPD | 324.7 | 101.3 |
| RC-PD | 411.7 | 148.9 |
| RC-NPD | 402.7 | 148.5 |

AF-NPD, air polishing without plaque disclosure; AF-PD, air polishing with plaque disclosure; RC-NPD, rubber cup polishing without plaque disclosure; RC-PD, rubber cup polishing with plaque disclosure.

**Table 4** A comparison of mean treatment duration(s) between the four treatment groups

| | AF | RC | Difference | P value | NPD | PD | Difference | *P* value |
|---|---|---|---|---|---|---|---|---|
| **Marginal mean** | 324.6 | 407.2 | −82.6 | < .001 | 363.7 | 368.1 | −4.4 | .589 |
| **SE** | 10.0 | 15.0 | 9.9 | | 12.4 | 12.47 | 8.1 | |
| **95% CI** | 304.7–344.4 | 377.3–437.1 | −102.2 – −63.0 | | 339.0–388.4 | 343.3–392.9 | −20.5–11.7 | |

| Treatment group comparison | | Mean difference | SE | *P* value* |
|---|---|---|---|---|
| **AF-PD** | AF-NPD | −0.227 | 10.281 | 1.000 |
| | RC-NPD | −78.227 | 14.135 | < .001 |
| | RC-PD | −87.227 | 12.109 | < .001 |
| **AF-NPD** | RC-NPD | −78.000 | 10.787 | < .001 |
| | AF-PD | 0.227 | 10.281 | 1.000 |
| | RC-PD | −87.000 | 11.197 | < .001 |
| **RC-PD** | AF-NPD | 87.000 | 11.197 | < .001 |
| | RC-NPD | 9.000 | 9.672 | 1.000 |
| | AF-PD | 87.227 | 12.109 | < .001 |
| **RC-NPD** | AF-NPD | 78.000 | 10.787 | < .001 |
| | AF-PD | 78.227 | 14.135 | < .001 |
| | RC-PD | −9.000 | 9.672 | 1.000 |

AF, air polishing; CI, confidence interval; NPD, without plaque disclosure; PD, with plaque disclosure; RC, rubber cup polishing; SE, standard error of the mean.
* Bonferroni correction for multiple comparison.

## Discussion

Regular and thorough plaque control is important in preventing the initiation and progression of caries and periodontal diseases.[18,19] A thorough supra- and subgingival prophylaxis has the potential to protect the patient's dentition and periodontium from heavy microbiologic insults for the next 3 to 6 months,[20] and is therefore an important requirement for long-term dental care. When air polishing was compared with rubber cup polishing, there was no significant difference in the reduction of mean plaque score. Hence, both treatment modalities were effective in removing dental plaque, indicating that the first null hypothesis, in the absence of prior plaque disclosure, was accepted. It is worth noting that in this sample population, only 19.3% of the participants had misaligned teeth, of which 88.2% had only mandibular anterior crowding. It can be speculated that the difference in plaque removal ability may become significant if the sample population included a larger

proportion of participants with misaligned teeth, in view of the potential for air polishing to access difficult-to-reach plaque-retentive areas in overcrowded dentitions. Further study designs can focus on target sample population, for example, in patients with severe overcrowding.

Air polishing was found to be significantly faster than rubber cup polishing, with a mean difference of 83 seconds in treatment duration per quadrant ($P < .001$); thus the second null hypothesis was rejected. If this was extrapolated to air polishing of all four quadrants, approximately 5.5 minutes per patient could be saved, thereby facilitating faster patient turnover with the reduced chair time. A clinical trial that evaluated cost-effectiveness of nonsurgical and surgical periodontal therapies showed that 1 minute of chair time cost 6 Euros,[21] so a 5.5-minute reduction in treatment duration would translate to a cost saving of 33 Euros, which brings about a substantial economic benefit in the long term. Therefore, air polishing can potentially enhance treatment efficiency as well as improve cost effectiveness for the clinicians.

The results of this study highlighted the significance of prior plaque disclosure over the instrument used, as the groups with prior plaque disclosure had significantly lower posttreatment mean plaque score compared to the groups without prior plaque disclosure. This finding could be attributed to the fact that staining plaque improved the clinicians' ability to visualize and better target plaque accumulation at certain difficult-to-reach areas, which could be easily missed during routine prophylaxis. In addition, the time taken to apply the plaque disclosing agent did not significantly increase the treatment duration, implying that prior plaque disclosure can enhance treatment effectiveness in the clinical setting without compromising treatment efficiency. Furthermore, air polishing with prior plaque disclosure significantly reduced more plaque compared to rubber cup polishing without prior plaque disclosure. Plaque disclosure prior to prophylaxis has clear clinical benefits and synergistic effect when used with air polishing. As such, air polishing with prior plaque disclosure can be considered routine practice when performing dental prophylaxis.

The majority of the participants (53.4%) preferred air polishing to rubber cup polishing in terms of comfort and efficiency, despite reporting it to be ranked less favorably in terms of noise and tidiness. Likewise, the majority of the operators (86.4%) favored air polishing over rubber cup polishing because they found it to be more efficient and ergonomic. The preference for air polishing for both the participants and the operators was significant ($P < .001$), therefore the third null hypothesis was rejected. This is in concordance with previous studies and a systematic review, which concluded that air polishing resulted in lower levels of patient discomfort as compared to conventional instrumentation using hand curettes and ultrasonic scalers.[9,13] The pressurized air and fine powder generated from air polishing may account for the less favorable ranking in tidiness as compared to rubber cup polishing, especially when the operator or the assistant did not position the high volume evacuator correctly to capture the splatter and aerosol generated. In view of the possible risk of transmission of infectious diseases like coronavirus disease 2019 (COVID-19) through aerosol,[22] the proper use and positioning of a high volume evacuator during air polishing treatment is mandatory to reduce the amount of airborne contamination by more than 95%.[23]

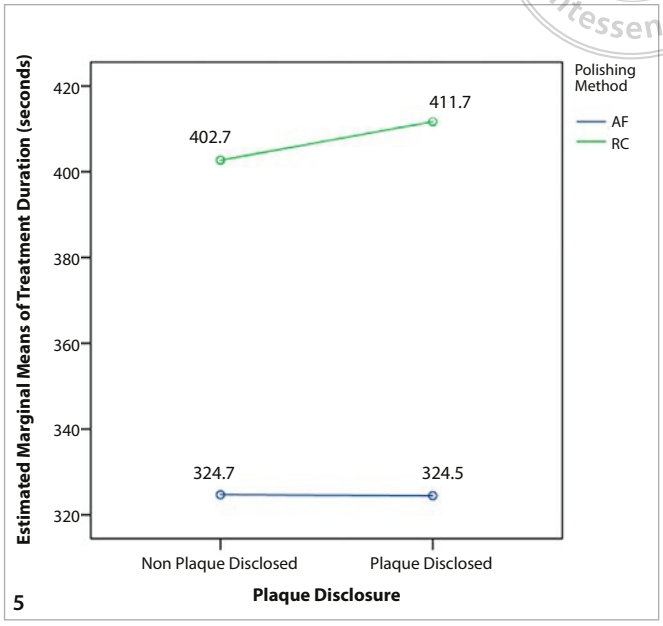


**Fig 5** Line diagram illustrating the main effect of the treatment duration and treatment concept and no interaction ($P = .433$).

Despite the advantages of the air polishing system, rare adverse events can occur during air polishing, including air emphysema, subcutaneous facial emphysema, and pneumoparotitis.[24] Between 1977 and 2001, there were a total of nine air emphysema and three air embolism incidents related to the use of air polishing devices.[25] These adverse events happened mainly when larger particle sized powder were used. They usually resolved without treatment within 24 to 72 hours in the otherwise healthy patients.[26-28] Although no adverse event from the use of erythritol air polishing powder has been

**Table 5** Summary of mean posttreatment plaque score and treatment duration for each treatment group presented based on the operator

| | | Mean plaque score ± SD (%) | | | | Mean treatment duration ± SD (s) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operator | N | RC-NPD | AF-NPD | RC-PD | AF-PD | RC-NPD | AF-NPD | RC-PD | AF-PD |
| 1 | 13 | 27.8 ± 18.8 | 21.2 ± 19.6 | 19.9 ± 8.1 | 20.6 ± 17.4 | 477.1 ± 94.1 | 442.5 ± 90.9 | 527.0 ± 156.8 | 418.5 ± 133.3 |
| 2 | 23 | 38.3 ± 20.1 | 38.7 ± 26.3 | 26.9 ± 18.8 | 24.6 ± 20.5 | 495.0 ± 132.4 | 330.1 ± 76.0 | 491.4 ± 110.4 | 329.0 ± 86.4 |
| 3 | 24 | 33.5 ± 18.6 | 36.9 ± 21.8 | 25.7 ± 14.5 | 18.0 ± 16.2 | 337.2 ± 138.0 | 259.3 ± 94.8 | 361.9 ± 157.9 | 308.4 ± 123.3 |
| 4 | 28 | 35.4 ± 20.8 | 32.0 ± 22.7 | 26.9 ± 15.4 | 23.1 ± 16.4 | 348.5 ± 140.8 | 321.5 ± 80.6 | 335.4 ± 91.0 | 290.9 ± 77.0 |
| Total | 88 | 34.5 ± 19.7 | 33.5 ± 23.4 | 25.5 ± 15.2 | 21.7 ± 17.5 | 402.7 ± 148.5 | 324.7 ± 101.3 | 411.7 ± 147.9 | 324.5 ± 101.3 |
| *P* value | | .245 | | | | < .001 | | | |

AF-NPD, air polishing without plaque disclosure; AF-PD, air polishing with plaque disclosure; N, no. of patients; RC-NPD, rubber cup polishing without plaque disclosure; RC-PD, rubber cup polishing with plaque disclosure; SD, standard deviation.

**Table 6** Overall preference of participants

| Preference | Frequency | Percentage (%) | *P* value |
|---|---|---|---|
| Preferred RC | 16 | 18.2 | < .001 |
| Preferred AF | 47 | 53.4 | |
| No preference | 25 | 28.4 | |
| Total | 88 | 100.0 | |

AF, air polishing; RC, rubber cup polishing.

**Table 7** Overall preference of operators

| Preference | Frequency | Percentage (%) | *P* value |
|---|---|---|---|
| Preferred RC | 5 | 5.7 | < .001 |
| Preferred AF | 76 | 86.4 | |
| No preference | 7 | 8.0 | |
| Total | 88 | 100.0 | |

AF, air polishing; RC, rubber cup polishing.

reported so far, it is recommended to avoid the use of air polishing in patients suffering from chronic bronchitis, asthma, or upper respiratory tract infections as any loose powder in the air might trigger respiratory difficulties.

Likewise, rubber cup polishing has several disadvantages. For example, the rubber cup is unable to reach challenging areas such as furcations, root concavities, and grooves. Rubber cup polishing involves the use of prophylaxis paste, which contains abrasive particles like pumice, aluminum oxide, silicon carbide, garnet, feldspar, zirconium silicate, emery, and perlite. There are concerns that the use of prophylaxis paste may cause loss of enamel, dentin, and cementum over time.[24] In an in vitro study, it was shown that the use of highly abrasive paste during toothbrushing resulted in significant enamel wear, and the effect was enhanced if the enamel was demineralized, for example, in white spot lesions.[29] The development of finer air polishing powder like glycine (average particle size < 45 µm) and erythritol (average particle size 14 µm) has reduced its abrasive nature and thus expanded its application to subgingival dental plaque removal. In addition, current literature has supported the use of glycine or erythritol air powder polishing on root surfaces and soft tissue because of their low abrasiveness.[12,30] Hence, application of air polishing using glycine and erythritol powder on susceptible areas such as demineralized sites or erosive lesions may be feasible due to the low abrasiveness of these powders.

This study is not without limitations. A split-mouth design was adopted to compare the importance of plaque disclosure versus no plaque disclosure prior to polishing, with the assumption that dental plaque would be distributed in a similar manner between the left and right sides of the mouth. This assumption was supported by a clinical trial whereby symmetry of plaque distribution and other clinical signs of periodontal disease were observed.[31] In this study, the baseline FMPS taken as part of the pre-study protocol showed that there was a relatively even distribution of plaque throughout the mouth, which supported the assumption. In addition, participants were asked to abstain from oral hygiene practices for 24 hours prior to the prophylaxis to allow plaque accumulation on all tooth surfaces, thereby reinforcing the fairly uniform plaque distribution throughout the dentition. Random allocation of the quadrants to the four different treatment modalities also

minimized the actual differences and the potential confounding effect of uneven plaque distribution. In this way, the data collected could be analyzed based on the mean posttreatment plaque scores. In addition, only short-term treatment effect was evaluated. Thus, this study fulfilled the basic prerequisites for the use of a split-mouth design.[32]

However, a split-mouth design might introduce a carry-across effect from one randomized segment to another.[33] To avoid the carry-across effect in the present study, quadrants were divided strictly and treatments rendered in the four groups were unlikely to affect one another in terms of posttreatment plaque scores, as each score was recorded prior to the start of the next treatment quadrant. A split-mouth design was required in this study to allow participants to experience and draw a comparison between the air polishing system and rubber cup polishing. Therefore, participants were unblinded to the treatment groups. In order to minimize any potential bias, randomization in the allocation of operators and the examiners to the participants was applied. Lastly, although the examiners were well calibrated (ICC 0.989; 95% CI 0.649 to 1.000), the assessment of posttreatment plaque scores could be analyzed in a more objective manner using computer software to evaluate calibrated intraoral images of stained plaque.[17]

In summary, the present study established that comprehensive prophylaxis using 14-µm particle size erythritol powder air polishing with prior plaque disclosure removed more plaque in a shorter period of time and had higher operator and patient satisfaction scores compared to conventional prophylaxis using rubber cup polishing with fine grit prophylaxis paste. The results reinforced the importance of prior plaque disclosure for effective plaque removal, without which the choice of instrument, be it air polishing or rubber cup polishing, may not be significant in influencing treatment outcome. The additional benefits of choosing air polishing over rubber cup polishing may lie in the improved efficiency in terms of treatment duration and better comfort level for the patients. The application of comprehensive prophylaxis can be extended to patients undergoing active fixed orthodontic treatment or those with multiple implant-supported fixed prostheses requiring long-term maintenance. Whether comprehensive prophylaxis is effective in providing long-term periodontal stability for these patient groups will warrant further investigation; for example, a longitudinal study can be conducted to evaluate the resolution of gingival inflammation during the posttreatment evaluation visit, and subsequent maintenance visits. In addition, future studies on the acceptance level for comprehensive prophylaxis among pediatric patients may be warranted.

## Conclusion

Disclosing plaque prior to prophylaxis demonstrated significantly greater plaque removal compared to polishing alone. Air polishing with prior plaque disclosure demonstrated significantly greater plaque removal ability as compared to conventional prophylaxis using rubber cup alone. Furthermore, the treatment duration was significantly shorter compared to rubber cup polishing with better clinician and patient satisfaction. Therefore, air polishing with prior plaque disclosure seems to be an effective method for routine prophylaxis.

## Declaration

EMS South East Asia sponsored the Airflow Plus powder used in this study. However, all data belonged to the authors and by no means did the sponsor interfere with the conduct of the study or the publication of its results.

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