INTRODUCTION

Teeth that are consistently surrounded by inflamed gingiva have a significantly higher risk of being lost. A determinant of the initiation of gingivitis is supra-gingival plaque accumulation, which involves an established bacterial colonization on the dentition. Dental plaque control through routine oral hygiene is therefore important. It is well established that the toothbrush is effective in reducing levels of dental plaque on the surfaces of teeth, meaning that it plays an important role in the prevention of periodontal diseases. While brushing is a simple and effective means of removing dental plaque, there is clearly room for improvement. Oral hygiene is apparently

Dry brushing: Does it improve plaque removal?
A secondary analysis

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Abstract

Objective: This article is a secondary analysis comparing the effects on plaque removal of brushing with a dry toothbrush and brushing with a prewetted toothbrush.

Methods: The participants had been included in two previous experiments involving single-brushing exercises. The 46 non-dental participants were systemically healthy and ≥18 years of age. In the first experiment, the control intervention was brushing with a prewetted toothbrush, while during the second experiment it was brushing with a dry toothbrush. Both experiments scored plaque before and after the brushing exercises and assessed participants’ perception. The data of these two previous experiments were compared in this secondary analysis.

Results: Plaque score reduction following brushing with a dry toothbrush was 58%, while with a prewetted toothbrush, it was 57%. The mean plaque index score reduction of 0.08 between a dry and a prewetted toothbrush was not significant (P = .096). Prewetting the participants’ toothbrush had no influence on the perception of toothbrush filament stiffness (P = .410) nor on the perception of cleaning capability (P = .449). In both experiments, brushing without dentifrice was judged to be unpleasant.

Conclusion: On average, following a 2-minute brushing exercise, plaque scores were reduced by 57% or more. Dry brushing did not contribute significantly to toothbrush efficacy. The participants did not find that prewetting a toothbrush influenced the cleaning capability and filament stiffness.

Keywords
dental plaque, dry toothbrush, manual toothbrush, manual toothbrush, prewetted toothbrush, secondary analysis
a public and personal health issue, and improved hygiene could be expected to result in benefits in terms of periodontal disease and dental caries.5

It is common practice to combine a toothbrush with dentifrice. Not only do many people like the resultant flavour and freshness, but it also provides the subjective impression of making the mouth feel clean.7 Dentifrice also adds a smooth feeling to tooth surfaces. In 1998, the concept of “dry brushing” was introduced: brushing without dentifrice and a toothbrush not wetted with water.8 The purpose of this was to avoid the smooth perception of tooth surfaces being the results of reduced surface tension, as provided by surfactants of a dentifrice. In addition, a recent systematic review demonstrated that brushing with a dentifrice does not improve the efficacy of mechanical plaque removal.7 It is suggested that dry toothbrushing increases peoples’ ability to feel the bacterial biofilm, as well as to feel the difference in dental plaque on the tooth surfaces before and after brushing.9 Patients are instructed to start brushing on the lower lingual surfaces and to brush until all of the teeth feel clean. In a second variation of the experiment, dentifrice is added and the teeth are brushed once more. In a multicentre practice-based observational study, significant improvements in gingival bleeding were observed after six months of dry toothbrushing.8

Currently, there is no high-quality research that has shown that dry brushing is indeed a more effective method. Plaque removal with a dry toothbrush has not been compared to that of a prewetted toothbrush with water. Recently, we published two similar single-brushing exercises10,11 of which one included brushing with a prewetted10 and the other brushing with a dry toothbrush.11 Both published experiments were initiated as a proof of principal to investigate a certain theory and whether this has practical implications. These two previous experiments used a split-mouth model and were performed under the same conditions with the same participants and the same examiners.

Therefore, a secondary analysis could be performed using the available data of both previous experiments concerning the effectiveness of a dry toothbrush as compared to a prewetted toothbrush.

2 MATERIALS AND METHODS

The secondary analysis is based on the Standardized Reporting of Secondary Data Analyses (STROSA) statement. This checklist evaluates methodological quality and supports authors and readers in critical appraisal. The STROSA statement includes 27 items regarding several aspects on secondary analysis and is available as Appendix S1.12,13

The recommendations for strengthening the reporting of the previous published clinical experiments were followed, as suggested by the guidelines outlined in Consolidated Standards of Reporting Trials (CONSORT)14 and the checklist of the Template for Intervention Description and Replication (TIDieR)15 were used.

2.1 Ethical procedures

Both original experiments approximated the Good Clinical Practice (CPMP/ICH/135/95) guidelines, in agreement with the ethical principles of the Declaration of Helsinki (2013) and in accordance with the Medical Research Involving Human Subjects Act (WMO), as well as applicable local regulations. The experiments10,11 were approved by the medical ethical committee at Amsterdam Medical Centre (AMC) (#2014_118) and were registered at the Dutch Trial Register (#NTR4604). The experiments took place at the Department of Periodontology of the Academic Centre for Dentistry of Amsterdam (ACTA) in the Netherlands in the period from June until September 2014. Before enrolment, all volunteers were given verbal and written information concerning the aim, rationale and duration of the original experimental aims. The investigator explained the details and potential risk involved. Prior to the study procedures, an informed consent form was signed by all eligible subjects that had agreed to participate, who were informed that they were free to withdraw at any time. Both previous experiments are separately published in the public domain as full scientific papers.10,11

In February 2018, the same ethical committee of the AMC approved the re-use of the data sets of the previous experiments for this secondary analysis.

2.2 Recruitment and inclusion

The participants had been included in two previous experiments involving two single-brushing exercises.10,11 They had been recruited from various universities and colleges in and around Amsterdam and had been screened by a dental hygienist (MPCL). To qualify for inclusion, the subjects were required to be ≥18 years old, right-handed brushers, classified as systemically healthy (as assessed by the medical questionnaire), periodontally healthy (scoring the Dutch periodontal screening index (DPSI) ≤3 minus)16 and retaining ≥5 teeth per quadrant. Excluded were those who presented the researchers with any of the following: an orthodontic appliance or a removable (partial) denture, overt caries, any pathological alterations of the oral mucosa, pregnancy or the use of medications within 2 weeks of the appointment. The latter included antibiotics or chronic use of non-steroidal anti-inflammatory drugs, although it excluded birth control pills.

2.3 Design

Both clinical experiments had a single-examiner blind design and used a split-mouth model in which contra-lateral quadrants were randomly assigned to treatment.2,7 There was one study coordinator, (EVDS) who supervised the assignment of both brushing procedures. For each of the clinical experiments,10,11 sample size calculation was performed “a priori” which revealed that at least 40 participants were needed to be able to reject the null hypothesis. For this secondary analysis, no sample size was calculated and was analysed based on the data of the two previous experiments.
Each participant received a unique subject identification number that was used in both experiments. No stratification was applied. Randomization was performed within each experiment, using true random numbers that were generated by sampling and processing a source of atmospheric noise. The randomization code was kept in a sealed envelope in the investigator site file and was only accessible through the coordinator, who was therefore responsible for allocation concealment. To conceal the intervention from the examiners, the participants were instructed to not reveal their assignment in any way. Records of earlier examinations were not available to the examiner at any time.

2.4 | Outcomes

In the first experiment, a prewetted toothbrush was used and in the second experiment a dry toothbrush. The data of the control interventions of these two experiments were compared in this secondary analysis. The main study parameter was the level of dental plaque scored according to the criteria of the modified Silness & Löe plaque index (PI). Where 0 = no plaque, 1 = a film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may be seen in situ only after a probe on the tooth surface, 2 = moderate accumulation of soft deposits on the tooth and gingival margin that can be seen with the naked eye, 3 = abundance of soft matter on the tooth and gingival margin. No disclosing solution was used.

Throughout the experiments, examinations were sequentially carried out by one and the same experienced trained examiner (NLHH) under the same conditions. The secondary outcome was an evaluation of the self-perception of the participants as derived from their answers to a questionnaire. After the assessment, the participant completed the questionnaire, which has been designed to evaluate their opinion and their perception concerning the 48-hour non-brushing period, the toothbrush and the procedure used. They were requested to place a vertical mark on a 10-cm long uncalibrated line (0-10). The left extreme represented the negative (score 0), whereas the right extreme represented the positive (score 10). The investigator measured the distance along the line from the left extreme to the marking made by the participant.

2.5 | Study procedure

Text messages (short message service) were sent to remind each participant before the visits concerning the study procedures and appointments. A 48-hour non-brushing period was instigated in order to accumulate an adequate amount of plaque to assess the incremental effect on plaque scores of both single-brushing exercises. Firstly, a full-mouth dental plaque score was performed. Before the brushing exercise of each visit, a short verbal instruction was given to the participant. The supervised brushing procedure was performed according to the bass method, using a new Oral-B indicator P35 soft toothbrush without dentifrice for each experiment. The brushing order was carefully standardized and controlled, including guidance through the randomized set of contra-lateral quadrants. Each buccal or lingual side of a quadrant was brushed for 15 seconds, meaning that a total of 30 seconds was spent per quadrant, as controlled through the use of a timer. No mirror was available during the brushing procedures, and the participants were able to expectorate if necessary.

2.6 | Statistical analysis

The data of both experiments were merged and allocated. Only participants that completed both experiments were taken into account for this secondary analysis (per protocol analysis). The data of two contra-lateral quadrants that were used in both experiments as control sites were extracted. The statistical analysis was performed using a statistical package (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0; IBM Corp, Armonk, NY, USA). The primary parameter was the overall dental plaque score for which the mean and standard deviation of all readings were calculated for each participant. In addition, the mean incremental difference and proportional change were computed. Dental plaque scores were analysed by each regimen. The mean scores and standard deviation regarding the VAS questions were calculated. A parametric statistical approach was used through a paired sample t test. Values of \( P \leq .05 \) were accepted as statistically significant.

3 | RESULTS

3.1 | Participants

In Figure 1, the study design flow of both experiments is illustrated, including the same participants and performed by the same research group. Regarding eligibility, a total of 50 participants were assessed and, accounting for potential drop-outs, 48 participants were included for the first experiment. From the same study population, 46 participants also willingly entered the second experiment. The two other participants lost to the follow-up experienced scheduling conflicts, which was interpreted as drop-outs unrelated to the interventions. Therefore, a total of 46 participants could be included for this secondary analysis. The mean age was 22.5 (2.86), with a range of 20-34 years. More female participants were included in these clinical experiments (N = 27; 59%) than men (N = 19; 41%). No adverse events were reported.

3.2 | Primary outcome

Table 1 shows the mean and standard deviation of the overall dental plaque scores of brushing with a dry toothbrush and a prewetted toothbrush. For prebrushing, the mean plaque scores were not significantly different (\( P = .54 \)). With regard to post-brushing, the mean plaque scores also did not differ significantly (\( P = .713 \)). A mean plaque score reduction in 0.75 (0.33) with the prewetted toothbrush was found, while the dry toothbrush showed a reduction in 0.76 (0.38). The numerical incremental mean difference of 0.08 between the regimens was not statistically significant (\( P = .96 \)).
3.2.1 | Analysis of covariance

Prebrushing plaque scores were close to being significantly different ($P = .054$), which could have affected the primary outcome. Therefore, in addition, an analysis of covariance (ANCOVA) was performed. For this analysis, the prebrushing scores were used as a covariate. A statistical difference was not detected for either the post-brushing scores ($P = .269$) or the incremental differences ($P = .269$).

3.3 | Secondary outcome

A questionnaire regarding the participants’ perception was completed in both experiments. In total, four questions were identical.
and could be analysed in this secondary analysis (Table 2). The specific instruction to refrain from oral hygiene for 48 hours was experienced as an uncomfortable experience in both experiments (2.57 and 2.59, respectively). Brushing without dentifrice was also judged to be unpleasant irrespective of the fact whether the toothbrush was dry (3.21) or prewetted (3.01). Toothbrush filament stiffness was judged to be in the middle between soft and rigid (4.87) for the prewetted toothbrush and 3.21 for a dry toothbrush ($P = .410$). The perception of cleaning capability received mean VAS scores of 6.04 and 6.29. None of the outcomes to the questions indicated a significant difference between dry brushing or brushing with a prewetted toothbrush.

### 4 | DISCUSSION

Approximately 20 years ago, it was suggested that brushing without dentifrice allows the patient to more distinctly feel the layer of dental plaque before and after brushing. This was considered not to be the case with a dentifrice due to associated flavour and wetting agents.\(^8\) By the use of a secondary analysis, the aim of this study was to evaluate the effectiveness of a dry toothbrush as compared to a prewetted toothbrush on plaque removal. The overall reduction in dental plaque scores was at least 57% following a 2-minute brushing exercise (preshed toothbrush 57%, dry toothbrush 58%). Consequently, dry brushing did not contribute significantly to toothbrush efficacy. Based on the results of this secondary data analysis, the recommendation to use a dry toothbrush is not supported by evidence. Prewetting a toothbrush neither improved nor reduced plaque removal efficacy. The minimal 57% overall reduction in dental plaque scores found in the present analysis was higher than the 42% reduction established as the average effect that can be expected from a brushing exercise.\(^23\) This implies that the participants of the present experiments were above-average brushes. There are almost twice as effective as the average participant of those studies reporting efficacy according to Quigley and Hein\(^{24}\) plaque scores, who on average achieved a 30% reduction.\(^{23}\) Supervised brushing may have improved plaque score reduction in the current experiment. Supervision was performed to ensure that the study procedures including brushing duration were according to the protocol.\(^{25}\)

The concept of “dry brushing” was introduced based on a multicentre observational study.\(^8\) However, this study, however, lacks a control group. Furthermore, for evaluating the effectiveness of interventions, a randomized controlled trial (RCT) would be more appropriate, as RCTs are generally placed at the top of the research hierarchy when considering original experimental studies. This secondary analysis used the data of two previous experiments and found a larger effect in overall reduction in dental plaque scores compared to the dental plaque score reduction as shown as the average effect of a single-brushing exercise.\(^{24}\) The advantage of the larger effect size is that it is possible to detect a difference between interventions in smaller sample numbers, whereas a smaller effect size would require larger sample sizes.\(^{26}\) Subsequently this secondary analysis shows that dry brushing does not contribute to plaque-removing efficacy. Therefore, dental care professionals should focus on several aspects of toothbrushing, such as duration, type of toothbrush and systematics rather than focussing on one specific instruction only (eg, prerinsing of dry or prewetted toothbrush). Individually tailored advice is the most important part of an oral hygiene instruction.\(^{27}\)

### 4.1 | Study design used

Both original experiments were based on a split-mouth randomization.\(^{17}\) The participants with a dry toothbrush brushed as a control intervention in one experiment,\(^{11}\) while they brushed with a prewetted toothbrush in the other experiments.\(^{10}\) In each experiment, the population brushed one set of the two randomized contra-lateral quadrants (either the 1st and 3rd or the 2nd and 4th quadrant), as the control treatment was similar for each participant quadrants in the two experiments. Because this was a secondary analysis, the interventions (dry or prewetted) were not randomized. Theoretically, the examiner could have known which intervention was performed in each experiment, which may have influenced the judgement. However, if existent, the impact of this influence is presumably small.

<table>
<thead>
<tr>
<th>N = 46</th>
<th>Extreme</th>
<th>From</th>
<th>To</th>
<th>Prewetted toothbrush</th>
<th>Dry toothbrush</th>
<th>Statistical analysis(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you think of refraining from 48 h before the appointment?</td>
<td>Very uncomfortable</td>
<td>Very comfortable</td>
<td>2.57 (1.57)</td>
<td>2.59 (1.73)</td>
<td>0.930</td>
</tr>
<tr>
<td>2</td>
<td>I think the toothbrush is cleaning my teeth well enough.</td>
<td>Totally not agree</td>
<td>Fully agree</td>
<td>6.04 (2.05)</td>
<td>6.29 (1.93)</td>
<td>0.449</td>
</tr>
<tr>
<td>3</td>
<td>I think that the stiffness of the toothbrush filament is...</td>
<td>Very soft</td>
<td>Very rigid</td>
<td>4.87 (1.65)</td>
<td>3.21 (2.45)</td>
<td>0.410</td>
</tr>
<tr>
<td>4</td>
<td>Brushing without toothpaste was...</td>
<td>Very unpleasant</td>
<td>Very pleasant</td>
<td>3.01 (2.45)</td>
<td>3.21 (2.33)</td>
<td>0.711</td>
</tr>
</tbody>
</table>

\(^{a}\)Paired sample t test.
because in each experiment, another intervention was also performed in the opposing quadrants assigned for the test (eg, prerin- sing with water and a specific brushing sequence). The examiner was blinded for the two randomized interventions (test and control). In fact for in the present analysis, the randomization of dry and wet brushing was not performed. The decision to compare the data on the use of a dry or a wet toothbrush was made after both previous experiments had been published, and the aims of both papers were different from the present analysis. As the conceptual idea of this secondary analysis evaluating a dry toothbrush to a prewetted toothbrush on plaque removal was developed after analysing the data from the previous two original experiments, the lack of randomization has most likely also not influenced the examiner.

### 4.2 Several "dry brushing" definitions

Dry toothbrushing was already reported over 30 years ago and was described as brushing "without the use of a dentifrice." In those days, this was suggested to minimize the classroom disruption and the length of time associated with daily brushing in a kindergarten classroom. In addition, other studies most likely reported the use of a "dry toothbrush" as brushing without dentifrice, although this was mainly for practical or research purposes rather than the intention of improving plaque removal. The original O’Hehir and Suven study suggested that dry toothbrushing was both without dentifrice and without water. This message was reinforced in an "expert opinion" publication. A recent systematic review concluded that the mechanical action as provided by the use of a toothbrush appears to be the main factor in the plaque removal process. Dentifrice did not contribute to toothbrushing efficacy.

The current study is the first of its kind to specifically evaluate the use of a new toothbrush wetted with water before its use in the mouth compared to an identical new and dry toothbrush. Considering that there are more options on how a "dry toothbrush" can be interpreted in the literature, it is advisable that studies should report interventions in greater detail. For the ultimate reliability and completeness of interventions, the Template for Intervention Description and Replication (TIDieR) checklist is developed. The TIDieR checklist and guide should improve the reporting of interventions and facilitate authors structuring accounts of their interventions, reviewers and editors assessing the descriptions and readers using the information. The use of this checklist in addition to the CONSORT is a recommendation for the reporting of research in the future.

### 4.3 Participant’s perceptions

Another finding of the current study is that participants do not appear to like brushing without a dentifrice, irrespective of whether or not the brush is prewetted. As early as 1960, Dudding et al concluded that almost 50% of people would not brush their teeth if they could not use a dentifrice. These patient-reported outcomes have become more important and meaningful over time, as these directly reflect how the participant feels or functions in relation to his/her health condition. Therefore, in the present studies, the self-perception of the participants was assessed using the VAS. The fourth question of Table 2 illustrates that, in both original experiments, the participants brushing without dentifrice score on the negative side of the VAS. It was judged on a scale of 0-10 where "5" is considered as neutral, with mean scores of 3.21 and 3.01 the perception on the left (negative) side of the perception. Traditionally, dentifrices have played an important role in improving oral freshness and combating tooth discoloration and this may subsequently stimulate daily oral self-care. As suggested by Valkenburg et al, future research into the psychosocial factors that might influence attitude towards and performance in oral hygiene is needed. Dentifrices are also the most effective fluoride carriers, and their contribution to the prevention of caries is well established. They may also contain chemical agents for the treatment of malodour, staining, caries, gingivitis, dental plaque, dental calculus, demineralization and dental hypersensitivity. The present study did not use dentifrice; a direction for further research may be the use of a dry or prewetted toothbrush in combination with dentifrice, as wetting may improve the availability of chemotherapeutic agents from the paste.

### 4.4 Secondary analysis

Currently, a secondary analysis is a rather uncommon method of analysis in dental research. A combination of data sharing and secondary analysis of archived data can contribute to the advancement of knowledge and greater transparency in scientific inquiry. The analysis of existing data is a cost-efficient way to make full use of data that have already been collected. This is performed to both address new research questions and provide a considerate assessment of the primary results of the original study. Until recently, there was no guideline for systematic, transparent and complete reporting of secondary data. However, a Standardized Reporting of Secondary Data Analyses (STROSA) statement has been published in the German language. This includes 27 items regarding methodological quality and supports authors and readers in critical appraisal. This checklist was prepared by the authors of the present paper and adapted for the present study. It is available as Appendix S1.

### 4.5 Limitations

- Earlier research has suggested that, without dentifrice, people brush for much longer and more evenly around the mouth. In order to reduce the number of variables, in the two original experiments, time was restricted to 30 second per quadrant, and participants were supervised and guided through the brushing procedure. Therefore, the possible stimulating effect of brushing without dentifrice could not be evaluated.
- The experiments were well controlled and performed in a clinical setting. Participants possibly could have been more at ease while brushing at home and may have behaved accordingly differently.
5 | CONCLUSION

On average, a 2-minute brushing exercise dental plaque scored were reduced by 57% or more. Dry brushing did not contribute significantly to toothbrush efficacy. The participants did not find that prewetting a toothbrush influenced filament stiffness and the cleaning capability. They also perceived brushing without dentifrice to be uncomfortable.

6 | CLINICAL RELEVANCE

6.1 | Scientific rationale

Dry brushing is suggested to improve the perception of “smoothness” for those surfaces that are clean after brushing. A secondary data analysis was used to compare the effects on plaque removal of a dry toothbrush with that of prewetted toothbrush.

6.2 | Principal findings

There is no significant difference between the two interventions. On average, a dry toothbrush reduced the plaque scores by 58%, and a prewetted toothbrush did so by 57%.

6.3 | Practical implications

This secondary analysis showed that dry brushing provided similar outcomes to brushing with a prewetted toothbrush in the reduction of place scores. Dental care professionals should encourage patients to brush even in the absence of a wetting agent as it is just as effective at plaque removal. In addition, participants clearly indicated that they prefer brushing with dentifrice.

ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES


SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.