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ORIGINAL ARTICLE

A 1-year follow-up of a randomized clinical trial with focus on manual and electric toothbrushes' effect on dental hygiene in nursing homes

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ABSTRACT

Objective: A 2-month randomized clinical trial (RCT) study comparing electric and manual toothbrushes used by residents in nursing homes showed significant reduction in plaque score for both groups. The aim of this follow up study was to study if the effect sustained in a longer perspective when toothbrushes were used according to resident's own preference.

Materials and methods: One year after baseline of the RCT-study, 100 participants were re-examined. The simplified oral hygiene index (OHI-S) was used as outcome measure on dental plaque.

Results: The mean age was 86.6, 78.1% had three or more medical diagnoses and 52.2% had moderate to severe cognitive impairment. The mean number of natural teeth was 18.8. After 1 year, mean plaque scores was significantly reduced within the population, from 1.2 to 0.7 ($p < .001$). A total of 46 participants preferred to use an electric toothbrush and 54 preferred manual. No significant difference in plaque score was found between electric and manual toothbrushes.

Conclusion: After 1 year, the improvement in dental hygiene from the RCT study sustained for users of both electric and manual toothbrush. Focus upon tooth brushing seems to be efficient and both manual and electric toothbrushes should be available in nursing homes.

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Introduction

Approximately one in 10 cases of pneumonia in elderly nursing home residents may be prevented by improving oral hygiene [1]. Poor dental hygiene is associated with accumulation of dental plaque. Within 24 h, the microflora in dental plaque will produce toxins and acids that will harm the enamel surface of the tooth and the adjacent tissue [2] and predispose for oral infections and proliferation of risk to other parts of the body as well as impaired nutritional status and quality of life [3–5]. As elderly population increase worldwide, it also causes an increase in the number of people who retain their natural teeth throughout life [6]. This population have a complexity of dental restorations [7,8]. These restorations have micro- and macroscopic edges that retain far more plaque than sound enamel. In addition, physical limitations, multi-morbidity, hyposalivation and polypharmacy impede the ability to maintain dental hygiene. The amount of dental plaque in nursing home residents is shown to be extensive [6–8] and proper routines for plaque control are essential to maintain good oral health. Prior studies have suggested several interventions to improve oral health, such as educational programmes and the presence of dental hygienists in nursing homes [1,4,9,10]. These interventions are often time-consuming and lack of time and scant resources are frequently reported as barriers to supporting oral health interventions [9,11]. It has also been shown that positive effects from clinical intervention studies in a restricted period subside over time [12]. Thus, it is important to investigate how dental hygiene changes in a longer perspective after trials with studies that focus on single interventions aimed to improve oral hygiene.

In a 2-month randomized clinical trial (RCT), we compared the effect of electric toothbrushes versus manual toothbrushes in 180 nursing home residents [13]. A significant improvement in dental hygiene was found in both groups, without difference in plaque reduction in participants who used manual toothbrushes and those who used electric toothbrushes. Few intervention studies for improving dental hygiene in nursing homes have been followed up and there is a need to know more about the long-term effects of oral hygiene interventions.

The main aim of the present study was to investigate if the improvement in dental hygiene achieved in the RCT study, endured in a longer time perspective. Secondary aims were to study the preference pattern when participants are given a free choice between types of toothbrush and factors associated with changes in plaque scores after 1 year.

Materials and methods

Examinations at follow-up were conducted 1 year after baseline [13] with participants from the nine nursing homes

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taking part in the study. All participants who completed the RCT study were included. After their participation in the RCT study, the participants were offered new toothbrushes of their own preference, with accompanying instructions and 1450 ppm sodium fluoride toothpaste (Oral-B. Sensitive®), made in Germany, distributed by Procter & Gamble, Stockholm, Sweden. Hence, the participants were back in 'real-life settings', where dental routines and equipment were adjusted to individual preferences and availability. There was no contact between the researchers and the nursing home nurses during the follow-up period and there was no other systematic change in oral health care during the study period.

Figure 1 describes the study design. To assure that the examination was performed in an 'everyday' situation, only the staff supervisors knew when the examiners would show up to perform the examinations; the residents and their nurses did not know. The same dentist and dental hygienist as in the RCT study [13] performed all examinations. Only dental mirrors and a head torch were used. The registration was single-blind, the examiners did not know whether an electric or manual toothbrush had been used as a dental aid. The toothbrushes provided at no charge to the residents were oscillating, rotating toothbrushes (Oral-B. Professional care 1000®, made in Germany, distributed by Procter&Gamble, Stockholm, Sweden) and a standard soft, manual toothbrush (Oral-B. 123 Indicator®, made in Ireland, distributed by Procter & Gamble, Stockholm, Sweden).

At baseline (T0), nursing home nurses provided information about the study and invited residents to participate. Physicians decided, based on clinical judgment, whether participants were competent to give consent. Consent was given by the participants, or next-of kin in cases with cognitive impairment. Only participants with at least six remaining natural teeth and admission to long-term care were included in the study. Both residents who could manage their own dental hygiene and those who relied on assistance were included.

Background data were obtained from the nursing home's files at baseline and follow-up: gender (M/F), age (years), length of long-term care residency (months), medical data (number of diagnoses, number of prescription drugs), Body Mass Index (BMI), nutritional status and weight loss, activities of daily life (ADL) functions and cognitive impairment (CI) were evaluated by physicians in the respective nursing homes. Assistance with dental care was recorded as yes (receives assistance always or sometimes) and no (never receives assistance). Handgrip strength was assessed as a parameter of a resident's medical condition [14]. A Baseline Hydraulic handgrip dynamometer (model 12-0240; Fabrication Enterprises, White Plains, NY) was used. Grip strength was measured in a seated position with elbow flexed at 90°. Grip strength was measured three times for both arms. Median score (pounds) was registered. The number of teeth present and dental plaque was recorded. Oral dryness was reported as positive if the mirror slide-test [15] indicated adhesion of dental mirror to buccal mucosa and if clinical inspection showed that the floor of the mouth lacked normal saliva pool and a dry and fissured tongue. The debris index (DI) from the Simplified Oral Hygiene Index (OHI-S) [16] was used as outcome measure of dental hygiene. For this, we used six indicator teeth, usually 16, 26, 36, 46, 11 and 31 (FDI two-digit notation). If the preferred tooth was not present, we examined the adjacent tooth. Each tooth was rated with scores from 0 to 3. Mean score of the six indicator teeth represents the DI-S score. Cut-off points for DI-S score evaluating dental hygiene quality were rated as 0–0.6 good, 0.7–1.8 acceptable and >1.8 as unacceptable [16,17].

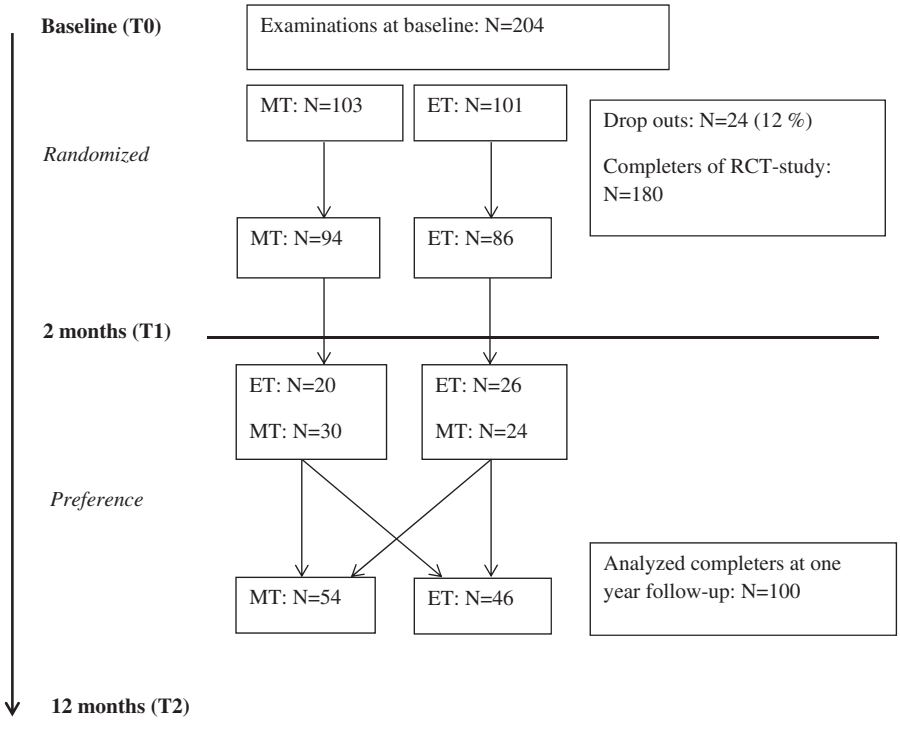

Figure 1. Flowchart over study design and distribution of electric (ET) and manual (MT) toothbrush.

Background variables at follow-up examinations are presented in Table 1.

Ethics and clinical trial registry

The Regional Committee for Research Ethics approved the study, project number 2011/915, as a follow-up from the 2-month RCT study [13]. The study has been registered in ClinicalTrialsGov (ClinicalTrials.gov Identifier: NCT03298620).

Statistics

Continuous variables were presented as mean and standard deviation, binary variables as number and percentage. Independent samples t-test was used when comparing OHI-S scores between two groups, and Chi-square test was used when comparing binary variables in two groups. Cohen's *d* was used as measure of effect size. Linear regression analysis was used to identify variables associated with plaque reduction after one year. A significance level of 5% was used. All analyses were performed using SPSS, version 20 for Windows (SPSS Inc. Chicago, IL.

Results

At 1 year follow-up, we were able to examine 100 of the 180 participants who completed the RCT study (55%, 76 women, 24 men). During the 10-month follow-up period, 49 of the participants died and 31 were too ill to be examined or had moved to another nursing home. Baseline variables between completers and non-completers in the follow-up study were compared. There was one significant difference in background variables: more of the non-completers scored lower in functions regarding ADL.

At 1-year follow-up, the mean age was 86.6 ± 8.3 and ranged from 48 to 105 years. The stay in the nursing home varied from 12 to 125 months, mean 24 ± 23 months. The majority had several diagnoses (78.1%) and over half had moderately to seriously impaired cognitive function (52.2%). Mean handgrip strength for both male and female participants was low; the mean score was 26 ± 16 pounds for the right hand. The mean number of natural teeth was 18.8 ± 0.6 and only 15 participants used removable dentures (partial or one complete denture). About 51.7% of the participants received assistance with dental hygiene. Table 1 shows the background variables at follow-up.

Changes in plaque scores at 1-year follow-up

There was no significant difference in plaque reduction between electric toothbrush-users and manual toothbrush-users ($p = .47$) at 1-year follow-up. For all participants, mean OHI-S was 1.2 ± 0.6 at baseline (T0), 0.9 ± 0.5 after the 1-month RCT-study (T1) and 0.7 ± 0.5 at 1-year follow-up (T2). OHI-S scores were significantly reduced from baseline to one year ($p < .001$). Mean reduction was 0.46 ± 0.6. Plaque score was reduced in 82% of the participants at 1-year follow-up and 47% had good dental hygiene according to OHI-S's cut-off points (Table 2). Effect size concerning reduction of plaque was 0.85 (high) for all participants from baseline to follow-up. No significant difference was found neither between electric and manual toothbrush for participants who received assistance, nor in participants who brushed their own teeth.

Table 2. Participants ($n = 100$) change in plaque score.

	T0 *n*	T1 *n*	T2 *n*
Good	17	29	47
Acceptable	68	69	50
Unacceptable	15	2	3

T0: baseline examinations; T1: examinations after 2 months (RCT); T2: examinations after 1 year.

Table 1. Background variables at 1-year follow-up.

		Toothbrush, preferred type		
		Electric $N = 46$	Manual $N = 54$	All participants $N = 100$
Female gender	*n/N* (%)	36/46 (78.3)	40/54(74.1)	76/100 (76.0)
Competence to give consent	*n/N* (%)	36/46 (78.3)	43/54 (79.6)	79/100 (79.0)
Age	Mean (SD)	87.3 ± 7.0	85.9 ± 9.4	86.6 ± 8.3
Duration of nursing home residency (month)	Mean (SD)	20.3 ± 22.2	27.2 ± 23.0	24.1 ± 22.8
3 diagnoses or more	*n/N* (%)	31/40 (77.5)	40/51(78.4)	71/91 (78.1)
Impaired cognitive function[a]	*n/N* (%)	23/43 (53.5)	24/47 (51.0)	47/100 (52.2)
Weight loss last 3 months	*n/N* (%)	7/40 (17.0)	16/49 (31.4)	23/89 (25.0)
Number of prescription drugs	Mean (SD)	5.3 ± 3.0	3.8 ± 2.6	4.5 ± 2.9
BMI (Body Mass Index)	Mean (SD)	23.0 ± 6.7	23.0 ± 5.8	23.0 ± 6.2
MNA (Mini Nutritional Assessment)	Mean (SD)	10.5 ± 1.9	9.5 ± 3.1	9.9 ± 2.7
Assistance with daily functions, i.e. dressing or washing				
Always	*n/N* (%)	29/43 (67.4)	36/48 (75.0)	65/91 (71.4)
Sometimes	*n/N* (%)	13/43 (30.2)	11/48 (22.9)	24/91 (26.4)
Never	*n/N* (%)	1/43 (2.3)	1/48 (2.1)	2/91 (2.2)
Without dental care assistance	*n/N* (%)	19/42 (45.2)	24/47 (51.1)	43/89 (48.3)
Number of natural teeth	Mean (SD)	20.1 ± 5.9	17.8 ± 5.9	18.8 ± 6.0
Mouth dryness	*n/N* (%)	2/46 (4.3)	5/53 (9.4)	7/99 (7.1)
Removable dentures[b]	*n/N* (%)	7/33 (21.7)	8/36 (22.7)	15/69 (22.2)

n: number of cases, *N*: number of observations (some variables have missing data).
[a]Moderate or severe cognitive impairment.
[b]Number of participants with removable dentures.

Preference pattern of manual versus electric toothbrush

Half of the participants in both groups chose to switch toothbrushes. Figure 1 describes the number of participants in each RCT group who switched toothbrushes after the trial. None of the baseline variables differed significantly between those who preferred an electric toothbrush and those who preferred a manual toothbrush.

Factors associated with changes in plaque scores after 1 year

Change in dental plaque (OHI-S) after 1 year was used as a dependent variable and the background variables in Table 1 were used as independent variables in a regression analysis. Only one factor was associated with change in plaque scores; level of plaque score at baseline. A higher level of plaque at baseline was significantly associated with a higher level of plaque reduction after 1 year (β: +0.64, $p < .001$). This implies that 1.00 score increase in OHI-S at baseline is associated with a plaque reduction of 0.64.

Discussion

This study showed a statistically significant reduction in dental plaque score over the 12-month follow-up period. There were no differences in the effect of electric toothbrushes as opposed to manual toothbrushes, thus supporting the results from the RCT-study [13]. The only new initiative concerning oral health care in the study period was the use of new toothbrushes of the residents' own choice, along with standardized user manuals. New available equipment may have increased focus and thereby affected prioritization and execution of dental hygiene maintenance throughout the course of the study. There might also be a question about the influence of the instruction cards, but in clinical practice should dental aides always be accompanied by instructions. The results suggest that this simple and time-efficient effort has a positive effect on dental hygiene in nursing home residents over a longer period of time.

In our study at 1-year follow up, 51.7% received assistance with dental hygiene, as opposed to only 26.7% at baseline. The most likely explanations for this are that more of the remaining participants were more care-dependant and needed more assistance. In the RCT study, better plaque reduction was found in patients who received assistance with dental hygiene in the electric toothbrush group compared to the manual toothbrush group. This was not confirmed in the follow-up study where use of manual or electric toothbrush was equally effective regardless of assistance. As sample size in this analysis is small, it could be of interest to explore the effect of assistance in trial with more participants in future research. The participants in our study had better dental hygiene measured by plaque scores than comparable studies [7,8,18]. This discrepancy may have several explanations. First, this may reflect a general positive development in the nursing care facilities. Second, in our study, only seven participants were registered as having oral dryness. This is a low number compared with other reports from populations of frail elderly [18]. As mouth dryness is a common side effect of polypharmacy, one would anticipate that the number of participants with mouth dryness would be higher. The method for assessing oral dryness in our study is coarse and the results should be interpreted with caution. Nevertheless, it may contribute to explain why dental plaque scores are lower, because low saliva flow plays an important role in dental health [19]. Removable dentures may be a source of plaque retention, but there were few participants with dentures in this study.

Almost half of the residents preferred an electric toothbrush when given the choice, although they were not previously used to it. This suggests that electric toothbrushes could be introduced when morbidity occurs even if the patient has no previous experience with an electric toothbrush. The only influence on improvement in dental hygiene was plaque level at baseline, indicating best effectiveness for those who need it most. The majority of participants had several diagnoses and used many medications. Handgrip strength was lower for this population than in a representative population >75 years [20] indicating that the participants were frail and had lower muscle strength in muscles important for proper dental cleaning. Participants had an average hospitalization time of 2 years and they were dependent on several functions of daily living. More than half of the participants had impaired cognition, with many natural teeth (mean = 18.8 ± 6.0) and extent high degree of frailty. This suggests that increased focus on the need for assistance, and commitment to a basic initiative, like making manual and electric toothbrushes available, yield substantial oral health benefits, regardless of general health conditions in the patients.

The present study has several strengths. Two examiners performed blinded clinical assessments. The study was conducted in the participant's natural environment; hence, the study reflects real life settings and thereby clinical relevance and transferability. However, the study has some limitations. The nurses who provided information and invited residents to participate in the study may have caused selection bias among the participating residents. Highly motivated nurses may include more residents than do poorly motivated nurses. More motivated residents would also be more likely to participate. Residents may also be more aware of the fact that they were participating in a study and this could influence the results positively. On the other hand, 1 year is considered a relatively long time in this population and could suggest that the intervention actually was integrated in daily routines in the nursing homes. Our presence at the nursing homes was unannounced which strengthen the findings. Including another nursing home as a control may have been beneficial, but were not within the limits of this study. The study also had many non-completers as one might anticipate considering this frail population sample, but analysis revealed few significant differences between completers and non-completers. Some of the background variables had missing data as it proved difficult to retrieve complete datasets from the nursing homes files. As not all staff members had access to patient journals, some data are missing. Our results should be interpreted with these limitations in mind.

Dental hygiene continued to improve over 10 months within a frail population of nursing home residents. We found no significant difference in improvement between manual toothbrush users and electric toothbrush. Choice of toothbrush was about equally divided between electric and manual toothbrush. This indicates that focus on tooth brushing and individually chosen toothbrushes have a beneficial long-term effect on dental hygiene in a frail population irrespective of background factors. Both manual and electric toothbrush should be available in nursing homes.

Disclosure statement

Dental aids were donated by Oral B®, Procter & Gamble Sverige AB, regulated by contract with the Faculty of Dentistry/UiO. The authors designed, performed and analysed the study project independently without involving the sponsor. The authors declare no conflicts of interest.

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