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Randomized controlled trial of toothbrushing to reduce ventilator-associated pneumonia pathogens and dental plaque in a critical care unit

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Abstract

Aim: To investigate the effect of a powered toothbrush on colonization of dental plaque by ventilator-associated pneumonia (VAP)-associated organisms and dental plaque removal.

Materials and methods: Parallel-arm, single-centre, examiner- and analyst-masked randomized controlled trial. Forty-six adults were recruited within 48 h of admission. Test intervention: powered toothbrush, control intervention: sponge toothette, both used four times per day for 2 min. Groups received 20 ml, 0.2% chlorhexidine mouthwash at each time point.

Results: The results showed a low prevalence of respiratory pathogens throughout with no statistically significant differences between groups. A highly statistically significantly greater reduction in dental plaque was produced by the powered toothbrush compared with the control treatment; mean plaque index at day 5, powered toothbrush 0.75 [95% confidence interval (CI) 0.53, 1.00], sponge toothette 1.35 (95% CI 0.95, 1.74), $p = 0.006$. Total bacterial viable count was also highly statistically significantly lower in the test group at day 5; Log_{10} mean total bacterial counts: powered toothbrush 5.12 (95% CI 4.60, 5.63), sponge toothette 6.61 (95% CI 5.93, 7.28), $p = 0.002$.

Conclusions: Powered toothbrushes are highly effective for plaque removal in intubated patients in a critical unit and should be tested for their potential to reduce VAP incidence and health complications. Trial registration: ISRCTN21526533.

Key words: critical care; dental plaque; oral health; pneumonia; respiratory tract diseases; ventilator associated

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Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests.

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Ventilator-associated pneumonia (VAP) is a life-threatening condition in critically ill patients receiving mechanical ventilation. The incidence of VAP in intensive care units (ICU) varies between 9% and 45% with a reported mortality of up to 50% and is accompanied by an increase both in length of stay in ICU and healthcare (Rello et al. 2002). Risk factors for VAP include underlying medical conditions, immunosuppression, brain injury, factors related to airway and ventilatory management, presence of naso- or orogastric tubes and medication (Shaw 2005).

Recent systematic reviews have highlighted the potential of oral interventions to reduce VAP incidence (Azarpazhooh & Leake 2006, Chan et al. 2007). Chan et al. (2007) concluded that oral decontamination resulted in a relative risk (RR)

of VAP of 0.56 [95% confidence interval (CI) 0.39, 0.81] compared with controls not receiving oral care interventions. However, there was no statistically significant effect on mortality, duration of mechanical ventilation or stay in ICU. The main strategies that have been investigated have focussed on decontamination of the mouth and oro-pharynx using anti-bacterial or anti-septic applications (Chan et al. 2007). However, in view of the biofilm nature of dental plaque, physical disturbance/removal of plaque bacteria, rather than reliance on anti-septic action, is important (Pratten et al. 1998).

Dental plaque control is challenging in dependent, mechanically ventilated patients. Access for oral hygiene is limited and the evidence suggests that oral care protocols may not be followed (Rello et al. 2007). Furthermore, the sponge toothette commonly used in ICUs appears to have limited efficacy in removing dental plaque compared with a toothbrush (Bowsher et al. 1999). Because of the difficulties highlighted above, we were interested in investigating whether powered toothbrushes might be advantageous for oral hygiene in ICU. Powered toothbrushes have shown some advantages for plaque removal compared with manual toothbrushes (Robinson et al. 2005). Our aim was to investigate the effect of a powered toothbrush on a potential risk factor of VAP, colonization of dental plaque by VAP-associated pathogens and to assess the efficacy of powered toothbrushing on dental plaque removal. The hypothesis was that powered toothbrushing would reduce the colonization of dental plaque by VAP-associated pathogens and dental plaque amount compared with sponge toothettes.

Materials and Methods

We designed a parallel-arm, single-centre, examiner- and analyst-masked randomized controlled trial to compare the effect of two interventions. The study was approved by the Joint UCL/UCLH Research Ethics Committee Alpha (05/Q0502/135) and the trial registered before commencement (ISRCTN21526533).

The setting was the neurocritical care unit (NCU) at the National Hospital for Neurology and Neurosurgery, University College London Hospitals. The NCU is a referral centre for critically ill patients with neurological disease. It has 17 beds and admits approximately 1000 per year; 35–40% of whom are emergency referrals of patients with acute brain injury.

Patient selection

Criteria for inclusion were in hospital for <48 h before admission to NCU, expected to survive for >48 h and expected to be tracheally intubated for longer than 48 h. Those excluded were edentulous patients, known adverse reaction to chlorhexidine, patients with recent history of chest infection and patients who had received anti-bacterial agents in the 3 months before admission.

Recruitment

Patients were recruited in the study as soon as possible after admission to the NCU, but always within 48 h. We did not record the time from intubation to baseline assessment. Assent to participation was sought from relatives or friends. As this proved a barrier to recruitment, we sought and achieved ethical approval to allow recruitment if the relative or friend was not available. In such case, the specialist in charge of the patient's care (not a member of the study team) could agree to include in the study as recommended in the Mental Capacity Act 2005 (Department of Health 2009). Under such circumstances, formal assent could be delayed for up to 48 h and, if it was later withheld, participation in the study was discontinued and data destroyed.

Treatment

The test intervention was a powered toothbrush (Colgate Actibrush, Colgate SARL, Geneva, Switzerland) and the control intervention, a sponge toothette (polygon swabs, Rocialle Medical Ltd, Sawston, Cambridge, UK). Oral hygiene was provided by the bedside nurse four times per day for 2 min., at approximately 06:00, 12:00, 18:00 and 24:00 hours. Because the toothettes were used to apply 0.2% chlorhexidine (Corsodyl, GSK, Weybridge, UK), a standard 20 ml was applied to each sponge or toothbrush head at each oral hygiene episode in order to eliminate the differences between interventions other than mechanical plaque removal. Each oral hygiene episode was standardized at 30 s per quadrant of the mouth (2 min. total). Following this, the oro-pharynx was suctioned to remove excess fluid or debris. Owing to the unpredictable nature of emergency hospital admission and the rota/schedule of the nurses, we designed a pragmatic approach to provision of oral care. We trained all NCU nursing staff (30 nurses) in oral care and the study interventions were provided by the nurse allocated to each patient's medical care.

Training and calibration

Before study commencement, training and calibration of examiners and caregivers was conducted. For trial examiners, a training programme was conducted followed by calibration against a ''gold standard'' examiner. Ten patients were examined by the gold standard and trial examiner and agreement assessed by the Lin's Concordance Correlation Coefficient (ρ_c) and the method of Bland & Altman (1986). Training for critical care nurses in providing the interventions included theory and practical demonstrations of oral hygiene methods and protocol requirements.

Treatment allocation

The randomization sequence was computer generated using the SPSS statistical software package and concealed from those recruiting patients in sequentially numbered, sealed opaque envelopes by the statistician. The opacity was tested to ensure that the code could not be broken without opening the envelope.

Outcome assessment

The primary outcome was colonization of supragingival dental plaque by VAP-associated bacteria. The secondary outcome was dental plaque amount. Dental plaque was measured and sampled at 1 (before oral care), 3 and 5 days following recruitment. Plaque measurements were taken at differing times but not immediately after oral care.

Microbiology

Pooled samples of dental plaque were collected from the target teeth assessed for dental plaque using a sterile graduated periodontal probe (CPITN-C, Ash Dentsply, Addlestone, UK) from 44 enroled patients. The samples were placed in a sterile container with 2.0 ml of Stuart's transport medium (Oxoid Ltd, Basingstoke, UK) and five sterile 2-mm-

diameter glass beads and transported to the laboratory for analysis.

The plaque samples were vortex-mixed for 60 s and serial dilutions were prepared in sterile phosphate-buffered saline (PBS, Oxoid Ltd). Each dilution was inoculated (in duplicate) onto Anaerobe agar (E&O Laboratories, Bonneybridge, UK) supplemented with 5% defibrinated horse blood to determine the total number of cultivable bacteria in the specimen. Colonies were enumerated after 5 days incubation in an anaerobic cabinet at 37°C. The isolation and enumeration of organisms associated with VAP was achieved by inoculation of the dilutions onto the following selective media and incubation at 37°C:

- mannitol salt agar (aerobic incubation) – for *Staphylococcus aureus*,
- cetrimide agar (aerobic incubation) – for *Pseudomonas aeruginosa*,
- blood agar (incubated in 5% CO_2/air) – for *Streptococcus pneumoniae*,
- bacitracin chocolate agar (incubated in 5% CO_2/air) – for *Haemophilus influenzae*,
- MacConkey agar (aerobic incubation) – for *Klebsiella pneumoniae*, *Serratia marcescens*, *Proteus mirabilis*, *Escherichia coil* and *Enterobacter cloacae*,
- minimal salts–acetate (incubated aerobically at 30°C) – for *Acinetobacter* spp.

Following incubation in the appropriate atmosphere, the various colony types on each medium were counted and identified by determining atmospheric growth requirement, Gram-stain reaction, haemolysis, catalase, oxidase and coagulase reactions and optochin sensitivity. Species identification was carried out using the api strip system (API20, API20NE, Biomerieux, UK). Isolates that could not be identified using these methods were characterized by partial sequencing of the 16S rRNA gene, as described previously (Ready et al. 2006).

Dental plaque extent

Dental plaque was assessed using the Turesky modification of the Quigley and Hein plaque index (Turesky et al. 1970) on the mesiobuccal aspect of up to six target teeth (Ramfjord teeth UR6, UL1, UL4, LL6, LR1 and LR4). If teeth were missing or obscured by the endotracheal tube, adjacent teeth were sampled. Halogen head torches were used for illumination.

Protection from bias

Oral hygiene assessment, microbial sampling, microbial assessment and data analysis were masked with regard to experimental group status. The randomization code was only broken after completion of statistical analyses.

Patient characteristics

Age, sex, pre-morbidities, initial presentation and antibiotics were recorded for each patient.

Sample size

In the study of Bergmans et al. (2001), VAP-associated pathogens were detected in 63% of patients in one control group and in 10% of intervention patients. Assuming this difference to be genuine, a study would require 16 patients per group to have 80% power to detect such a difference with an α of 0.05. Based on the assumption of Shaw (2005) that 50–70% of cases of VAP are caused by VAP-associated pathogens, a reduction from 63% of VAP-associated pathogen-positive patients to 10% could equate to a highly clinically relevant reduction in the prevalence of VAP of between 42% and 59%. In comparison, Fourrier et al. (2000, 2005) detected VAP-associated pathogens in 46% of patients at day 10. If this could be reduced to 5%, then a study would require 22 patients per group to detect such a difference at 80% power and an α of 0.05. Therefore, we planned on a sample of 50 participants to allow for losses to follow-up.

Statistical methods

Independent samples *t*-tests were undertaken to compare test and control groups at day 1 for both mean plaque scores and for mean Log_{10} total bacterial counts. Analysis of covariance was utilized to compare means for both of these outcomes between groups on days 3 and 5 and these were adjusted for baseline values. Within-group means were compared at days 3 and 5, respectively, to the day 1 means by use of paired samples *t*-tests. Fisher's exact test was used to compare the prevalence of individual bacterial species days 1, 3 and 5.

Results

Five hundred and sixty-two patients were screened for participation in the study from March 2007 to May 2009. Forty-six participants were recruited to the trial (Table 1) and microbiology data were available for 44. All participants had six or more teeth. The baseline characteristics were similar between groups with the exception of age. Test group 53.0 years (SD 12.5), control group 42.7 years (SD 12.8), $p = 0.008$. At day 3, data were available from 18 patients of control group and 23 patients of test group and at day 5, 10 control participants and 18 test participants. Losses to follow-up were due to early tracheal extubation, death or transfer to another facility.

Examiner calibration

Levels of agreement following training were assessed using the Lin's Concordance Correlation Coefficient (ρ_c) and the Bland Altman limits of agreement method. This resulted in a ρ_c of 0.934 with limits of agreement from -0.718 to 0.618 and no significant bias detected ($p = 0.260$) using the Turesky modification of the Quigley Hein plaque index. The second examiner was calibrated against the first examiner and achieved a ρ_c of 0.864 with limits of agreement

Table 1. Baseline clinical characteristics by allocated group

Characteristic	Control	Powered brush	*p*-value*
Mean age in years (SD)	42.7 (12.8)	53.0 (12.5)	0.008
Mean plaque score (SD)	1.84 (0.72)	1.67 (0.60)	0.382
Mean temperature (°C) (SD)	36.4 (0.9)	36.8 (1.0)	0.202
Mean white blood cell count ($\times 10^9$) (SD)	13.4 (4.8)	10.8 (4.5)	0.071
Mean CRP (mg/l) (SD)	44.8 (63.4)	50.9 (50.2)	0.725
Number male (%)	13 (56.5)	14 (60.9)	1.00
Number having active cooling (%)	0 (0)	0 (0)	1.00
Number prescribed antibiotics (%)	0 (0)	0 (0)	1.00
Total number enrolled	23	23	NA

*Independent samples *t*-test for continuous data, continuity-corrected chi-squared for frequency data.

from -0.682 to 0.882 and no significant bias detected ($p = 0.057$).

Microbiological data

Presence of VAP pathogens (Table 2)

Although 18 out of 44 (40.9%) subjects harboured one or more VAP-associated pathogens at day 1, the prevalence of specific pathogens was low throughout the study. *S. aureus* was most commonly detected in 33.3% (control group) and 26.1% (test group) of participants at day 1, with a median viable count of 8.5×10^3 and 4.8×10^4 CFU/sample recovered from control and test subjects, respectively. There were no statistically significant differences between experimental groups for prevalence of bacterial species at any sampling point.

Total bacterial counts (Table 3)

Before treatment commenced, the median total viable microbiota recovered from the control and test subjects was 2.75×10^7 and 1.1×10^7 CFU/sample, respectively. There was no difference between experimental groups at baseline. However, there was a statistically significant decrease in bacterial counts for the powered toothbrush group from day 1–3 ($p < 0.001$) and day 3–5 ($p = 0.009$). Furthermore, differences between test and control groups were statistically significantly different at both day 3 ($p = 0.001$) and day 5 ($p = 0.002$). The difference at these time points was in the order of 1 log base lower, i.e. a tenfold difference in favour of the participants from the powered toothbrush group (Fig. 1).

Dental plaque (Table 4)

Plaque levels decreased with time in both study groups. The plaque index decreased in the test group by 1.00 (95% CI 0.7, 1.30), $p < 0.001$ and in the control group by 0.62 (95% CI -0.03, 1.27), $p = 0.059$. Comparing the two groups, there was a statistically significantly greater decrease in dental plaque in the powered toothbrush group compared with the sponge brush group of 0.55 (95% CI 0.17, 0.93), $p = 0.006$ (Fig. 2).

Discussion

Principal findings

The principal findings were that VAP-associated pathogens were detected in

Table 2. Prevalence of detected microorganisms throughout the study period

Organism	Day 1, no. of positive samples (%)			Day 3, no. of positive samples (%)			Day 5, no. of positive samples (%)		
	bacterial count (range, CFU/ml)			bacterial count (range, CFU/ml)			bacterial count (range, CFU/ml)		
	control	powered brush	*p*-value*	control	powered brush	*p*-value*	control	powered brush	*p*-value*
Staphylococcus aureus	7 (33.3) (2.5×10^1–2.5×10^5)	6 (26.1) (2.0×10^2–7.8×10^7)	0.744	5 (27.8) (2.5×10^1–2.2×10^4)	2 (8.7) (1.4×10^3–2.5×10^3)	0.209	3 (30.0) (7.5×10^2–1.0×10^3)	2 (11.1) (3.3×10^2–3.7×10^3)	0.315
Pseudomonas aeruginosa	0 (0)	0 (0)	–	0 (0)	1 (4.3) (3.5×10^4)	1.000	0 (0)	1 (5.6) (2.3×10^5)	1.000
Streptococcus pneumoniae	0 (0)	0 (0)	–	0 (0)	0 (0)	–	0 (0)	0 (0)	–
Haemophilus influenzae	0 (0)	0 (0)	–	0 (0)	0 (0)	–	0 (0)	0 (0)	–
Klebsiella pneumoniae	1 (4.8) (6.6×10^5)	1 (4.3) (1.2×10^5)	1.000	1 (5.6) (5.0×10^5)	2 (8.7) (3.3×10^4–5.3×10^4)	1.000	1 (10.0) (2.3×10^3)	3 (16.7) (5.0×10^1–1.8×10^4)	1.000
Serratia spp.	1 (4.8) (3.9×10^4)	2 (8.7) (2.5×10^1–7.5×10^6)	1.000	0 (0)	1 (4.3) (1.8×10^4)	1.000	0 (0)	1 (5.6) (3.0×10^3)	1.000
Proteus mirabilis	0 (0)	0 (0)	–	0 (0)	0 (0)	–	0 (0)	0 (0)	–
Escherichia coli	0 (0)	2 (8.7) (5.0×10^5–1.0×10^6)	0.489	0 (0)	3 (13.0) (3.8×10^2–2.8×10^3)	0.243	0 (0)	1 (5.6) (6.5×10^2)	1.000
Enterobacter cloacae	2 (9.5) (3.8×10^4–1.5×10^5)	2 (8.7) (7.0×10^3–9.5×10^5)	1.000	1 (5.6) (1.5×10^4)	3 (13.0) (3.3×10^2–8.0×10^4)	0.618	1 (10.0) (1.5×10^3)	2 (11.1) (4.3×10^4–3.7×10^5)	1.000
Enterococcus spp.	0 (0)	0 (0)	–	0 (0)	0 (0)	–	0 (0)	0 (0)	–
Acinetobacter spp.	0 (0)	0 (0)	–	0 (0)	0 (0)	–	0 (0)	0 (0)	–
Haemophilus parainfluezae	1 (4.8) (1.6×10^3)	0 (0)	0.477	0 (0)	0 (0)	–	0 (0)	0 (0)	–
Enterobacter aerogenes	0 (0)	1 (4.3) (1.0×10^6)	1.000	2 (11.1) (7.2×10^4 – 6.8×10^6)	1 (4.3) (3.5×10^5)	0.573	0 (0)	1 (5.6) (1.4×10^4)	1.000
Total number of patients providing samples	21	23		18	23		10	18	

*Fisher's exact test.

Table 3. Between- and within-group differences in Log^{10} mean total bacterial counts throughout the study period

	Control		Powered brush (Pb)		Between-group differences (C – Pb)		*p*-value*
	mean (95% CI)	*n*	mean (95% CI)	*n*	crude mean (95% CI)	adjusted mean (95% CI)	
Day 1	7.23 (6.80, 7.66)	21	7.05 (6.73, 7.37)	23	0.18 (– 0.34, 0.70)	NA	0.481
Day 3	6.97 (6.59, 7.35)	18	6.02 (5.67, 6.37)	23	0.95 (0.45, 1.45)	0.88 (0.38, 1.37)	0.001
Day 5	6.61 (5.93, 7.28)	10	5.12 (4.60, 5.63)	18	1.49 (0.67, 2.30)	1.44 (0.59, 2.30)	0.002
Within-group differences		*p*-value**		*p*-value**			
Day 1 – day 3	0.38 (– 0.19, 0.95)	0.176	1.03 (0.68, 1.39)	<0.001			
Day 3 – day 5	0.42 (– 0.08, 0.92)	0.090	0.93 (0.26, 1.59)	0.009			
Day 1 – day 5	0.91 (0.07, 1.76)	0.037	2.02 (1.40, 2.63)	<0.001			

*Independent samples *t*-test at day 1, ANCOVA for subsequent days (adjusted for baseline).
**Paired samples *t*-test.

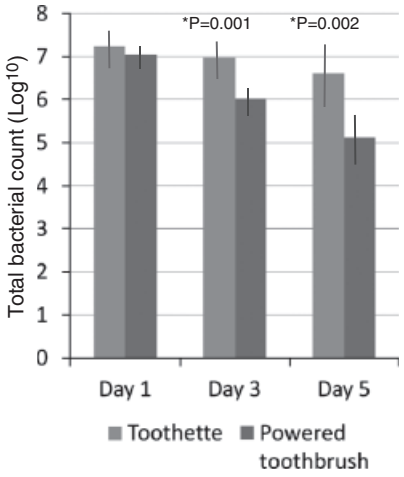

Fig. 1. Between- and within-group differences in Log_{10} mean total bacterial counts [95% confidence interval (CI)] throughout study period.

low proportions throughout the study with no difference detected between study groups. However, the powered toothbrush produced statistically significantly greater reductions in both total bacterial counts and dental plaque extent than the sponge toothette. The difference amounted to a tenfold difference in bacterial counts and more than half a unit of dental plaque index.

Strengths and weaknesses

This was a rigorously conducted trial with examiner and statistician masking. Training and calibration of examiners and caregivers were conducted to ensure implementation of the protocol and appropriate methods of assessment, although no formal assessment of compliance with provision of the intervention was made. However, we assessed the efficacy of the oral care intervention directly by measuring dental plaque. Weaknesses of the study were the lack of care-giver blinding. Because the interventions were very different, it was impossible to mask this aspect. A further weakness was that recruitment did not reach the projected sample size of 50 subjects. It is therefore possible that the study was underpowered to detect a difference in the primary outcome. However, the differences between groups in bacterial colonization were very small throughout the study and unlikely to be meaningful. The losses to follow-up from early tracheal extubation, death or transfer to another facility may have led to selection bias and the results should be viewed with this in mind. In view of the numbers of participants, we did not undertake a multivariate analysis to account for age differences between groups, as the robustness of such an approach would be questionable. In terms of generalizability, we screened 562 patients to recruit 46 participants. We did not collect information on the non-participants and do not know whether they differed systematically from the study patients. In addition, as with other similar studies, losses to follow-up occurred, primarily due to extubation, death or transfer to other units and this may have introduced selection bias.

Strengths and weaknesses in relation to other studies

Some studies have shown higher levels of pathogens at baseline (Okuda et al. 2003, Mori et al. 2006), while others have reported similar levels of detection (El-Solh et al. 2004). A significant reduction in the microbial load was seen in subjects who received oral care with a powered toothbrush and this reduction was greater than that observed in subjects receiving the toothette regime, suggesting that physical disruption of the oral biofilm provided additional benefit to the anti-microbial effects of chlorhexidine. The relatively low rate of colonization by respiratory pathogens may be an effect of the use of chlorhexidine four times per day in both groups. Another aspect that might have had an effect on colonization was that we chose to assess dental plaque amount at mesiobuccal sites. Other locations might have had greater plaque amount and this might have influenced colonization by VAP-associated pathogens. This site was chosen due to the marked difficulties of access to the mouth in tracheally intubated people. Target respiratory pathogens were recovered from 18 (41%) of the 44 patients, which concurs with a previous study that found target pathogens in the oral secretions of 60% of patients undergoing mechanical ventilation (Heo et al. 2008).

We have shown clear evidence of efficacy of oral care through reductions in dental plaque and we believe this to be an important finding even though it was a secondary outcome. The reductions in total bacterial counts mirrored the clinical dental plaque assessment and the difference between the powered toothbrush and the sponge toothette group was in the order of a tenfold difference. We decided to use the toothette as the control, as it was the standard of care at the hospital and it remains so in many units. Furthermore, there are no robust data indicating superiority of any one oral hygiene tool in VAP prevention.

While reduction of VAP incidence and mortality is the overall aim of the intervention, measuring dental plaque removal is important in order to understand the direct efficacy of the intervention, i.e. was it applied effectively? To highlight this, Okuda et al. (2003) demonstrated that reductions in respiratory pathogens occurred in their experimental group receiving toothbrushing and systemic antibiotics but not for the group receiving antibiotics alone, suggesting that dental plaque removal is important. However, one of the few

Table 4. Between- and within-group differences in mean plaque scores throughout study period

	Control		Powered brush		Between-group differences (C – Pb)		*p*-value*
	mean (95% CI)	*n*	Mean (95% CI)	*n*	crude mean (95% CI)	adjusted mean (95% CI)	
Day 1	1.84 (1.53, 2.15)	23	1.67 (1.41, 1.93)	23	0.17 (– 0.22, 0.57)	NA	0.382
Day 3	1.29 (1.05, 1.54)	18	0.86 (0.68, 1.05)	23	0.43 (0.14, 0.72)	0.40 (0.14, 0.66)	0.004
Day 5	1.35 (0.95, 1.74)	9	0.75 (0.53, 1.00)	18	0.60 (0.21, 0.99)	0.55 (0.17, 0.93)	0.006
Within-group differences		*p*-value**		*p*-value**			
Day 1 – day 3	0.48 (0.18, 0.78)	0.004	0.81 (0.55, 1.06)	<0.001			
Day 3 – day 5	0.24 (– 0.09, 0.56)	0.130	0.24 (– 0.05, 0.54)	0.099			
Day 1 – day 5	0.62 (– 0.03, 1.27)	0.059	1.00 (0.70, 1.30)	<0.001			

*Independent samples *t*-test at day 1, ANCOVA for subsequent days (adjusted for baseline).
**Paired samples *t*-test.

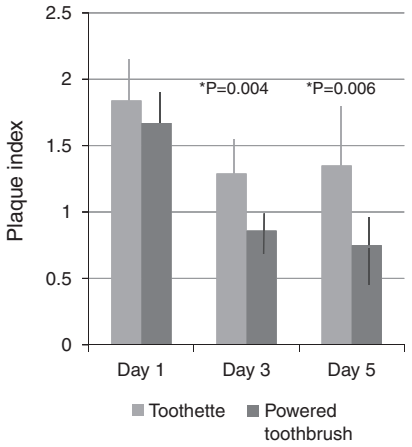

Fig. 2. Between- and within-group differences in mean plaque scores [95% confidence interval (CI)] throughout the study period.

studies to report dental plaque changes found no effect of the interventions on reducing dental plaque, thereby questioning the efficacy of the interventions (Scannapieco et al. 2009). Understanding efficacy of the oral intervention is also problematic in a recent trial investigating powered toothbrushes for VAP prevention (Pobo et al. 2009). While the results showed no statistically significant benefit for the electric toothbrush group, the authors concluded that one of the reasons that might have contributed to this finding was a lack of proof of efficacy (or compliance) of the intervention in relation to oral hygiene. Furthermore, the trial was stopped after 38% enrolment with possible resulting type II error.

Meaning of the study

The evidence linking dental plaque and VAP causation is compelling. The mechanism of infection appears to be bacterial colonization of dental plaque by putative pathogens followed translocation to the lungs. This hypothesis has been strengthened by the findings of genetic similarity between organisms isolated from dental plaque and bronchoalveolar lavage (El-Solh et al. 2004, Heo et al. 2008). Furthermore, dental plaque organisms precede the development of the clinical infection of VAP. In view of these findings and of the statistically significant effect of oral care on reduction of VAP (Chan et al. 2007), dental plaque should be targeted to reduce VAP incidence.

The differences between oral decontamination and dental plaque removal need to be highlighted. Oral decontamination employs the use of topical antiseptics, mostly without mechanical removal of dental plaque for instance by toothbrushing. The effectiveness of oral decontamination alone to prevent VAP has been questioned (Dallas & Kollef 2009). Dental plaque is a biofilm suggesting that mechanical disruption is an important aspect of any planned intervention (Pratten et al. 1998). However, dental plaque removal for intubated patients is challenging and critical care nursing staff do not receive extensive training in oral care (Rello et al. 2007). Therefore, strategies that are practical to perform in critical care and are effective in this setting are of great interest.

Future research

The next step will be to assess the effect of the test intervention on the definitive outcomes including VAP incidence, mortality and health economic. The systematic review and meta-analysis of Chan et al. (2007) calculated a pooled RR of 0.56 (95% CI 0.39, 0.81) for the incidence of VAP in studies of chemical oral decontamination with a median control group event rate of 18%. A RCT to detect a similar result would need to analyse data from 390 patients per group in order to achieve 80% power for a two-sided test at α 0.05. Allowing for drop-outs, such an approach would most likely require the enrolment of over 1000 participants in total.

Conclusions

Brushing the teeth of intubated patients with a powered toothbrush by critical care nurses can remove more dental plaque than sponge toothettes. No evidence for a difference in colonization of dental plaque by VAP pathogens was noted between experimental groups, although levels of pathogens were low throughout the study. A definitive trial is urgently needed to test whether the observed superiority of the powered brush can translate into health and economic benefits.

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Clinical relevance

Scientific rationale for the study: VAP is a life-threatening condition. Dental plaque can be colonized by respiratory pathogens and may be a risk factor for VAP. We designed a trial to investigate whether powered toothbrushes could reduce bacterial colonization of plaque in critical care units.

Principal findings: There were no differences in colonization of plaque between the powered toothbrush and control groups although pathogen levels were low. The powered toothbrush produced a highly statistically significant reduction in plaque amount.

Practical implications: Powered toothbrushes show promise for critical care units. Further studies are needed to establish impact on VAP.