The effects of power toothbrushing on C-reactive protein levels in nursing home residents: A randomized controlled trial

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WHY THIS ARTICLE IS IMPORTANT TO DENTAL HYGIENISTS

- Studies show that nursing home residents have poor oral health as well as numerous systemic diseases, all of which lead to elevated levels of C-reactive protein (CRP).
- Reducing oral inflammation through twice daily use of a power toothbrush may lower CRP levels and improve the overall health of this population.
- Although no improvements in systemic inflammation were found, provision of oral care with a power toothbrush is an option for caregivers.

ABSTRACT

Objectives: The aim of this analysis was to investigate whether twice-daily use of a rotating–oscillating power toothbrush (Oral-B Professional Care 1000™) in nursing home (NH) residents over a 6-week period, compared to usual care, would reduce systemic inflammation as measured by C-reactive protein levels. **Methods:** A repeated measures single-blind randomized controlled trial was conducted with residents from 1 nursing home in Winnipeg, Canada, who were randomized to receive either twice-daily toothbrushing with a rotating–oscillating power toothbrush (PB) or usual care (UC) by caregivers. Consent was obtained from residents or their proxies. Participants had some natural teeth; periodontal inflammation; non-aggressive behaviour; no communicable diseases; were non-smokers; and non-comatose. This article reports on a secondary outcome of this trial that measured the systemic inflammation of participants at baseline and 6 weeks, using a high sensitivity C-reactive protein (hsCRP) assay. Changes in hsCRP were not normally distributed, thus data were analysed using non-parametric methods. Within group changes were measured with the Wilcoxon Signed-Rank Test and between group comparisons of ranked differences employed the Kruskal–Wallis Test. **Results:** Of 54 participants, 3 died before study completion leaving n = 51. No significant differences in CRP values were found between study groups ($X^{2(1)} = 0.191$, $p = 0.662$) with a mean rank score of 27.88 for the PB group and 26.02 for the UC group. **Conclusions:** Twice-daily power toothbrushing of NH residents' teeth did not significantly reduce levels of systemic inflammation as measured by hsCRP.

RÉSUMÉ

Objectif : La présente analyse a été effectuée pour déterminer si l'utilisation d'une brosse à dents électrique rotative et oscillante (Oral-B Professional Care 1000[MD]) par les résidants des centres hospitaliers de soins de longue durée (CHSLD) au cours d'une période de 6 semaines réduirait l'inflammation systémique telle que mesurée par les niveaux de protéines C réactives, par rapport aux soins habituels. **Méthodes :** Un essai à mesures répétées, à simple insu, aléatoires et contrôlées a été effectué auprès de 54 résidants d'un CHSLD de Winnipeg, Canada, qui ont été choisis au hasard pour recevoir soit un brossage de dents 2 fois par jour en utilisant une brosse à dents électrique (BÉ) rotative et oscillante ou des soins habituels (SH) par des soignants. Les résidants ou leurs mandataires ont donné leur consentement. Les participants avaient quelques dents naturelles; de l'inflammation parodontale; un comportement non agressif; n'avaient pas de maladies transmissibles; étaient non-fumeurs; et étaient non-comateux. Le présent article signale les résultats secondaires de cet essai qui mesure l'inflammation systémique des participants au départ et à 6 semaines, au moyen d'une épreuve biologique de protéine C réactive très sensible (hsCRP). Les changements dans les hsCRP n'étaient pas normalement distribués, donc les données ont été analysées au moyen de méthodes non paramétriques. Les changements au sein des groupes ont été évalués à l'aide du test Wilcoxon pour les observations appariées et les comparaisons des différences de rangs entre les groupes ont été évaluées à l'aide du test Kruskal–Wallis. **Résultats :** Parmi les 54 participants, 3 personnes sont décédées avant la fin de l'étude, laissant n = 51. Aucune différence significative dans les valeurs des hsCRP n'a été trouvée entre les groupes d'études ($X^{2(1)} = 0,191$; $p = 0,662$), et la note de classement moyenne était de 27,88 pour le groupe BÉ et de 26,02 pour le groupe SH. **Conclusions :** Le brossage de dents 2 fois par jour des résidants de CHSLD au moyen d'une brosse à dents électrique n'a pas réduit de façon significative les niveaux d'inflammation systémique tels que mesurés par les hsCRP.

Key words: C-reactive protein, nursing homes, power toothbrushing, randomized controlled trial, systemic inflammation

CDHA Research Agenda category: risk assessment and management

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INTRODUCTION

It is well recognized that the number of seniors is increasing worldwide. The World Health Organization predicts that, between 2015 and 2050, the proportion of the world population over 60 years will nearly double, rising from 12% to 22%.[1] Similarly, the proportion of Canadians 65 years and older is projected to rise from 14% to 25% by 2036.[2] In addition to these population projections, nursing home (NH) residents' degree of illness has increased notably in recent years,[3] and researchers have suggested the demand for NH use will increase considerably in future years.[3,4]

In 2012, Matthews and colleagues reported that 66% of Canadian NH residents had periodontal disease.[5] Similar findings were reported by Compton and Kline in a student assessment of the oral status of residents of chronic care facilities in 2015.[6] Although caregiver staff are responsible for daily oral care, several studies[7-9] including a recent systematic review[10], have reported the oral health of NH residents is in many instances deplorable, not only in Canada but worldwide. These studies have demonstrated that NH staff are reluctant to provide this important activity of daily living to their residents, with factors such as lack of provider time; resident resistance; fear of being bitten; and outright aversion to the provision of this care cited as reasons.[7-10]

While maintaining good oral health into older adulthood has many important health and quality of life benefits, growing evidence also suggests a link between oral and certain systemic diseases, such as cardiovascular disease, stroke, respiratory disease, diabetes, obesity, metabolic syndrome, and more recently Alzheimer disease, arthritis, and end-stage renal disease.[11-13] While no causal linkages have been affirmed, of significance is that, in all of these chronic diseases, including periodontal disease, systemic inflammatory biomarkers, such as C-reactive protein (CRP), a non-specific inflammatory biomarker of systemic inflammation, are elevated.[11-18] CRP is produced by macrophages, endothelial cells, and smooth muscle, and is considered to be an important cardiovascular marker of inflammation. A speculated role of CRP may be in foam cell formation during atherogenesis and, as such, it is considered an important cardiovascular risk predictor.[16,17]

This literature has been derived almost exclusively from within the general population.[11-17] No studies on NH residents exist other than those that examine associations between oral health and aspiration pneumonia.[18,19] Numerous community-based oral health studies have shown reductions in overall CRP values following a variety of oral interventions.[20-25] Additionally, several researchers have reported improved oral health to be associated strongly with improved cardiac function among community-dwelling people,[22-27] and also with a reduction of aspiration pneumonia in NHs.[18,19] To date, however, there is no evidence of the extent to which reductions in oral inflammation due to improved oral care are associated with reductions in systemic inflammation among NH residents.

The reportedly poor state of oral health among NH residents, the reluctance of NH staff to provide adequate daily oral care, and the increasingly frail state of these residents call for an intervention that would improve this state of affairs. Several educational interventions have been attempted but with insufficient evidence of their effects as reported in a recent systematic review that included 9 randomized controlled trials and over 3000 NH residents.[28] In a study conducted by Wolden et al.[29] NH caregivers preferred delivering oral care using a power toothbrush, to alleviate their fears of being bitten. The current randomized controlled trial tested the use of a rotating–oscillating power toothbrush as the prime intervention with usual care being the comparison group. The purpose of the secondary analysis reported in this article was to test the extent to which twice-daily oral care using a rotating–oscillating power toothbrush versus usual care for 6 weeks reduced CRP levels as a marker of systemic inflammation.

METHODS

Design

This research used a 2-factor repeated measures single-blinded randomized controlled study design and followed an "intention to treat" protocol (ITT). Ethics approval to conduct this trial was obtained from the University of Manitoba Research Ethics Board for Research on Human Subjects (Bannatyne Campus; Reference # H2012:227) and also from the Deer Lodge Centre (DLC) Research Review Committee where the research took place.

Population

DLC is a government-owned NH with a total of 431 beds; 235 of these beds are located in the NH portion of DLC, comprising 6 units housing between 27 and 36 residents each. One of these units (47 beds) contains 36 regular NH beds plus a specialized "lock down" area with 11 beds. The remaining 196 beds at DLC are part of a chronic care long-term stay hospital. The director of the medical laboratory at DLC, which is operated by a separate organization, Diagnostic Services of Manitoba (DSM), provided the principal investigator (PI) with the laboratory services required for gathering the data for this secondary outcome measure.

Participant recruitment was conducted at the resident-level in 2 stages by the PI and aided by DLC nurse managers in charge of a nursing unit. These nurse managers provided the PI with a list of all residents in their respective units who had some natural teeth present and who, in their opinion, did not normally exhibit overly aggressive behaviour. These professionals also provided proxy contacts for residents unable to consent for themselves. From this initial list, the PI approached those residents or their proxies, who met the

broad inclusion criteria, to discuss the study and procure consent. Residents were recruited from 7 of the nursing units in DLC sequentially (6 NH units and 1 chronic care unit) to facilitate the training of caregiver staff and to monitor study progress. Baseline data collection was scheduled in the DLC dental clinic on a unit-by-unit basis once recruitment in the unit was complete.

At the second stage of delimitation, all consenting residents who met the broad inclusion criteria (some natural teeth, no communicable diseases, non-smokers, non-ventilated, non-comatose) were examined orally by the study research assistant—a registered dental hygienist—to ensure that each had some degree of inflammation surrounding their natural teeth as measured by the Modified Gingival Index (MGI)[30] and the Papillary Bleeding Index (PBI).[31] No participants were excluded during this latter stage of delimitation.

Demographic data were collected at study commencement for all participants, including classification of their cognitive status according to the Cognitive Performance Scale (CPS)[32] which appears in their medical chart, in addition to all comorbidities recorded in their medical charts.

Randomization

The PI randomly assigned consenting participants using a restricted randomization technique, where group numbers were placed in sequentially numbered sealed envelopes opened only at the commencement of the study by the PI, to either the power toothbrush (PB: n = 29) or usual care (UC: n = 25) group. The principal outcome of the study assessed the effects of power toothbrushing on oral inflammation (reported elsewhere)[33], while a secondary outcome measured the effects of this intervention on CRP levels, reported in this article. Although the primary study began with 57 participants, only 54 participants consented to having their blood drawn and were included in this analysis, which was conducted over a 6-week period for each resident, but lasted 9 months staggered over 7 nursing units at DLC.

Variables

Independent variables included a) twice-daily power toothbrushing (Oral-B Professional Care 1000™) and b) usual care, for a period of 6 weeks. The dependent variable for this secondary objective was systemic inflammation measured for each participant at baseline and again at the end of the 6-week study. Systemic inflammation was identified utilizing a high-sensitivity test (hsCRP) for the detection of C-reactive protein in the circulating blood. This high-sensitivity test detects much smaller levels of C-reactive protein than the standard test for CRP, at values ≥0.9 mg/L.[14,34,35] Mean CRP values between 2.5 and 5.0 mg/L of blood correspond to the Centers for Disease Control and Prevention's identification of cardiovascular risk.[34]

Clinical procedures

Caregivers in each DLC unit were informed of the study and taught to use the power toothbrush twice daily for individuals assigned to the PB group and instructed to perform usual care twice daily for those participants in the UC group. This usual care consisted primarily of manual toothbrushing but sometimes included only mouth rinsing, based on resident preference. Additionally, some of the residents were capable of performing their own oral care and preferred to do so. In this instance, staff were instructed to remind and observe the residents conducting their oral care.

Laboratory procedures

One vial of blood was drawn by a DLC registered laboratory technologist from each study participant at baseline and at the end of the 6-week study period; the technologist was blinded to the participants' study group. Once blood was drawn, it was centrifuged and aliquoted within an hour by the laboratory technologist and stored in an ice-packed cooler. On the same day of blood withdrawal, the PI transported the blood samples to the Intercity Medical Laboratory for hsCRP analysis. The Intercity Laboratory utilizes the Mayo Clinic technique for hsCRP analysis comprised of a Tina-quant CRP HS assay on a Roche/Hitachi 917 analyzer (Diamond Diagnostics – USA, Holliston, MA).[35] Results were faxed to the PI within 1 week of analysis.

Statistics

Sample size was calculated using an alpha of 0.05 and a power of 0.8 based on the primary study outcome of oral inflammation (reported elsewhere)[33] and not the secondary outcome reported in this article. Based on these calculations, the minimum sample size was set at 28 residents in each of the intervention and usual care groups. A target sample size was set at 60 residents (30 per group) allowing for a 10% death rate during the course of the study. Although 57 participants began the study, only 54 residents consented to having their blood drawn for the secondary outcome (CRP) analysis.

Change values in hsCRP levels deviated significantly from a normal distribution. As there is no non-parametric equivalent to repeated measures testing, data were analysed in 2 steps. Within-person differences in CRP levels were analysed using the Wilcoxon Signed-Rank Test.[36] This test is typically used as an alternative to the paired student t-test for matched pairs or the t-test for dependent samples, when the population cannot be assumed to be normally distributed.[36] The Kruskal–Wallis non-parametric test was then used to determine if the overall amount of change varied significantly between study groups.[37] This rank-based test may be used on independent variables that are either continuous or ordinal.[37] All tests of statistical significance were set at $p < 0.05$.

RESULTS

A total of 54 individuals or their proxies provided written consent to participate in the systemic outcome phase of this study. These 54 participants were randomly assigned at the beginning of the primary study to 1 of the 2 intervention groups: 29 in the PB group and 25 in the UC group. Two UC participants and one PB participant passed away after baseline data were collected but prior to study closure. None withdrew as a consequence of the study, thus the ITT protocol was not applied to these individuals. Data from the remaining 51 participants (PB = 28; UC = 23) who completed the 6-week period of intervention were analysed.

This study was conducted in a former veteran's facility where several beds are reserved for veterans. Sixty-seven percent (67%) of the study sample was male, with no statistical difference between study groups ($p < 0.335$) (Table 1). The mean age of study participants was 85.5 years, also with no significant difference between study groups ($p < 0.825$). The majority of participants had some form of cognitive impairment as measured using the Cognitive Performance Scale (CPS)[32] (Table 1). Twenty-two percent (22%) of all participants were either cognitively intact or borderline cognitively intact (CPS score of 0 to 1); forty-one percent (41%) were mild to moderately impaired (CPS score of 2 to 3); while 37% of participants were moderate-severe to very severely cognitively impaired (CPS score of 4 to 6). No significant differences in CPS levels were found between the study groups ($p < 0.599$).

All study participants had at least 1 physical chronic disease, and the majority (81%) had 3 or more chronic diseases (Table 1). While there was no significant difference in the number of comorbid participants between study groups ($p < 0.795$), significantly more individuals had

Table 1. Comparisons of mean age, gender, cognitive performance scores, and comorbidities across study groups at baseline

	Both groups (n = 54)	Usual care (n = 25)	Powerbrush (n = 29)	*P* value
Mean age (SD)	85.53 (8.54)	85.24 (9.44)	85.76 (7.68)	0.825
Sex				0.335
Male (%)	36 (67)	15 (60)	21 (72)	–
Female (%)	18 (33)	10 (40)	8 (28)	–
CPS scores (%)				0.599
0 to 1 (Intact-borderline)	12 (22.2)	7 (28.0)	5 (17.2)	–
2 to 3 (Mild to moderate impairment)	22 (40.7)	10 (40.0)	12 (41.4)	–
4 to 6 (Severe to very severe impairment)	20 (37.1)	8 (32.0)	12 (41.4)	–
Comorbidity				
A) Overall (%)				0.795
0 disease	0 (0)	0 (0)	0 (0)	–
1 to 2 diseases	10 (19)	5 (20)	5 (17)	–
>3 diseases	44 (81)	20 (80)	24 (83)	–
B) Specific diseases (%)				
Dementia/Alzheimer	39 (72)	17 (68)	22 (76)	0.529
Stroke	14 (26)	9 (36)	5 (17)	0.121
CVD	39 (72)	20 (80)	19 (66)	0.244
Arthritis	10 (19)	1 (4)	9 (31)	0.010
Diabetes	11 (20)	2 (8)	9 (31)	0.037
Cancer	10 (19)	9 (36)	1 (3)	0.002
Other	30 (56)	13 (52)	17 (59)	0.625

Table 2. Baseline comparisons in hsCRP measures across study groups

Outcome	Both Groups Median (Interquartile range)	Usual Care Median (Interquartile range)	Powerbrush Median (Interquartile range)	*P* value
High sensitivity C-reactive protein (hsCRP)*	4.0 (2.7 to 10.0)	5.2 (2.7 to 10.4)	3.5 (2.08 to 8.5)	0.407

*Scores below 1.0 mg/L indicate no risk for cardiovascular events. Anything above a 3.0 is associated with a higher risk of cardiovascular disease.

arthritis in the PB group (31%) compared to the UC group (4%) ($p < 0.01$). Similarly, significantly more individuals in the PB group had diabetes (31%) as compared to participants in the UC group (8%) ($p < 0.03$). Conversely, a larger proportion of residents in the UC group had cancer (36%) compared to one resident (3%) in the PB group ($p < 0.002$). No other statistically significant differences in resident characteristics were noted between the study groups.

No significant differences were found between study groups in systemic measures of inflammation using hsCRP ($p = 0.463$). The median score of hsCRP at baseline for both study groups combined was 4.0 (IQ, 2.7 to 10), and ranged from 3.5 (IQ, 2.08 to 8.5) for PB residents versus 5.2 (IQ 2.70 to10.4) for UC members (Table 2).

Resident changes in hsCRP during the 6-week study period are shown in Table 3. For both study groups combined, the median change (week 6 minus baseline) in hsCRP was 0.2 (IQR of –2.10 to 4.28), representing a slight but not statistically significant increase in this marker of systemic inflammation. UC group residents experienced an average decrease in hsCRP scores during the study period (median change value of –0.100; IQR of –5.00 to 5.60), while residents in the PB study group experienced a slight increase in hsCRP during this same time (median change value of 0.375; IQR of –1.78 to 2.47).

Comparisons between study groups of the changes in hsCRP are shown in Table 4. As with the descriptive findings, hsCRP values changed non-significantly over time for both study groups individually (PB: $p = 0.564$; UC: $p = 0.839$) and combined, ($p = 0.719$) and the rank order of these differences did not vary significantly by study group ($X^{2(1)} = 0.191$, $p = 0.662$) with a mean rank score of 27.88 for the PB group and 26.02 for the UC group.

Table 3. Changes (week 6 minus baseline) in high-sensitivity C-reactive protein (hsCRP) scores, overall and for both study groups

6-Week CRP–Baseline CRP	Median (Interquartile range)
Both groups (n = 51)	0.200 (–2.10 to 4.28)
Usual care (n = 23)	–0.100 (–5.00 to 5.60)
Powerbrush (n = 28)	0.375 (–1.78 to 2.47)

DISCUSSION

This study was conducted in a large NH in Winnipeg, Canada; residents were randomly allocated to receive twice-daily oral care using a power toothbrush or standard (usual) care for a 6-week period. The purpose of the present analysis was to determine if power toothbrush use (versus usual care) resulted in a statistically significant reduction in levels of C-reactive protein (as a measurement of systemic inflammation) across study groups.

The results of this research failed to reject the null hypothesis of this question that the level of CRP, as a marker of systemic inflammation, would be improved with the intervention of the power toothbrush as compared to usual care. Given the many factors influencing systemic inflammation in NH residents (e.g., numerous chronic diseases, proximity to death)[13,16,34,38,39], it is not surprising that CRP data were highly skewed at both baseline and follow-up. With these caveats, no significant improvement in CRP was found from baseline to week 6 of this study, overall or in either study group. One potential explanation for this result may be the poor levels of caregiver adherence to oral care (reported elsewhere).[39] This explanation, however, is not likely, given the documented improvements in oral health in this study (reported elsewhere).[33] This result is in contrast to numerous studies, albeit not conducted in NHs, which have shown clear associations between improvements in oral health and reductions in CRP.[40-43]

Oral health is only one of many factors thought to influence systemic levels of inflammation. Cardiovascular disease, arthritis, cancer, dementia/Alzheimer disease, and diabetes all are inflammatory in nature and therefore influence systemic CRP levels.[27,38,44-46] Since periodontal disease is only one source of inflammation, and given the high prevalence of comorbid chronic diseases among residents, the lowering of this single source of inflammation is likely insufficient to over-ride the effects of all other contributing factors. In this study population, the majority (81%) had 3 or more comorbidities such as diabetes, arthritis, cardiovascular disease, and dementia, all of which are inflammatory in nature.

One of the limitations of this study was the vast amount of variance in CRP levels at baseline with values ranging from 0.37 mg/L to 84.6 mg/L. No exclusion criteria were applied to CRP values as this was not the primary study question. Categorizing participants according to baseline CRP scores may have resulted in a different outcome.

Table 4. Assessment of changes in hsCRP over time, within people and across study groups

	Mean rank	*P* value	
Within-person change			
Both groups (n = 51)	32.48	0.719*	
Powerbrush (n = 28)	18.33	0.564*	
Usual care (n = 23)	14.32	0.839*	
Between-group differences			
Powerbrush (n = 28)	27.88	*P* value	$X^{2(1)}$
Usual care (n = 23)	26.02	0.662*	0.191*

*All computations are based on negative ranks

However, it would have also required a much larger sample size to accommodate randomization into 2 groups.

Numerous studies including 3 systematic reviews have confirmed that individuals with periodontitis have higher serum CRP concentrations as compared to those without periodontitis.[14,15,19-21] Similarly, a case–control study by Pejcic et al.[22] reaffirmed these findings, not only reporting significantly higher levels of CRP in those with periodontitis, but also demonstrating a dose–response effect by separating subjects with periodontitis into moderate and severe periodontitis groups.

It would seem logical that removing this source of oral inflammation would help to lower overall levels of systemic inflammation. Interestingly, several studies[23-25] have documented such positive reductions in overall CRP following periodontal interventions including several systematic reviews and meta-analyses[19-21], while other similar studies have not demonstrated the same results[47-49]. Reasons for these inconsistencies at this time are unknown, however the possibility of alternate disease pathways may be one explanation. Another possible explanation may be the overall burden of disease as suggested by the current study outcome. However, the results of a recent systematic review by Teeuw[21] and colleagues were in direct contrast to the current study findings; Teeuw and colleagues reported significant reductions in CRP levels in only those with other comorbidities. They speculated this result was due to higher levels of baseline CRP for those study participants compared to those without a comorbidity.[21]

Since the majority of these studies employed more invasive interventions such as scaling and root planing, perhaps the daily toothbrushing utilized in this current study was not sufficient enough to have an effect on lowering CRP levels. However, a large epidemiological study conducted in Scotland found reduced levels of CRP in those who brushed regularly compared with non-brushers.[50] The difference was that the study population in the de Oliveira[50] study was the general public rather than NH residents.

The potential for oral care strategies to reduce CRP levels in the body and to improve endothelial dysfunction and carotid intima media lumen size may have major health benefits for NH residents. CRP has also been identified as an important diagnostic and prognostic tool in NH-associated pneumonia.[51] Arinzon and colleagues found CRP to be positively correlated with the rate of death in those with pneumonia ($r = 0.493$, $p < 0.001$) and suggested that CRP values be determined for all NH patients suspected of having pneumonia.[51]

For frail older adults, such as NH residents, who have numerous chronic diseases that elevate their systemic inflammatory levels, more invasive oral interventions may be required to reduce their systemic inflammatory levels. A combination of frequent periodontal debridement treatments along with daily tooth brushing may subsequently reduce systemic inflammation, hence helping to improve their overall health. Further studies, therefore, are required to investigate such combinations of procedures conducted with NH residents to lower their CRP levels.

CONCLUSION

Oral hygiene interventions using either twice-daily brushing with a power toothbrush or standard care both failed to lower CRP values in NH residents over a 6-week period. The authors conclude that daily toothbrushing efforts are not sufficient enough to lower the high levels of CRP in NH residents given the presence of 3 or more chronic comorbidities found in over 80% of study participants. More invasive oral hygiene interventions may be required to have an impact on lowering systemic inflammation in this unique population group.

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest.

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