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Original article

Effects of the bass brushing method on dental plaque and pneumonia in older adults hospitalized with pneumonia after discharge: A randomized controlled trial

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ABSTRACT

Aim: The purpose of this pilot study was to evaluate the effects of the Bass brushing method on dental plaque and pneumonia in older adults hospitalized with pneumonia after discharge.
Background: Poor oral hygiene may lead to pneumonia. Complications of pneumonia in older adults can be life-threatening during hospitalization and after discharge.
Methods: Older adults hospitalized with pneumonia (n = 30) were randomly assigned to intervention (with the Bass brushing method; n = 15) or control (with usual care; n = 15) groups. Dental plaque index and pneumonia as detected on chest x-rays were evaluated prior to the intervention (baseline) and every month for six months after discharge.
Results: Participants in the intervention group experienced a sustained reduction in dental plaque from the fourth to the sixth months (p = .024; p = .025; p = .000, respectively) that was not found in the control group. There were no group differences in detected pneumonia throughout the follow-up period. Pneumonia as detected on the chest x-rays at baseline (p = .001) and dental plaque index (p = .021) were significant predictors of the risk of pneumonia across groups.
Conclusions: The Bass brushing method is a simple and effective oral hygiene practice that reduces dental plaque in older adults hospitalized with pneumonia after discharge.

1. Introduction

Dental plaque and pneumonia are critical indicators of oral health in adults aged 65 years and older (Kassebaum et al., 2017; Müller, 2015). Poor oral hygiene can increase dental plaque, caries, and the severity of periodontitis, which may induce oral pathogenic microorganism-related respiratory tract infections such as pneumonia (Danckert, Ryan, Plummer, & Williams, 2016; Pace & McCullough, 2010; Peate & Gault, 2013). Pneumonia caused by inadequate oral care is especially problematic in institutionalized older adults (relative risk = 1.67, 95% confidence interval [CI]: 1.01–2.75) (Yoneyama et al., 2002), and is associated with increased medical costs (Rozenbaum, Mangen, Huijts, van der Werf, & Postma, 2015) and mortality (Sjögren, Wardh, Zimmerman, Almstahl, & Wikstrom, 2016). Repeated hospitalization due to pneumonia (Oda, 2017; Scannapieco, 2014) is a common occurrence in older adults who previously had pneumonia (Dang, Eurich, Weir, Marrie, & Majumdar, 2014), but data are sparse on approaches (e.g., toothbrushing method) to prevent the recurrence of pneumonia

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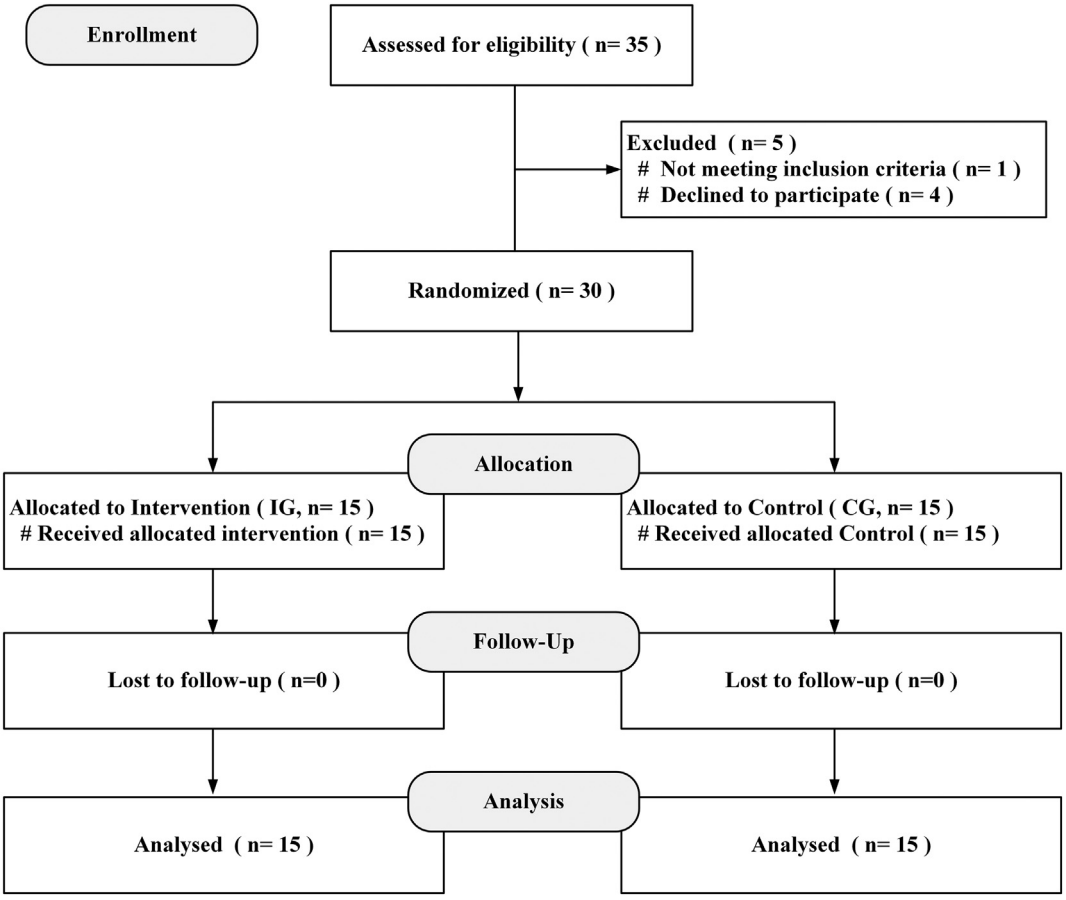

Fig. 1. Flowchart of the longitudinal randomized pilot study.

after patients are discharged (Sjögren, Nilsson, Forsell, Johansson, & Hoogstraate, 2008).

According to Mojon's (2002) proposed mechanism of oral health and respiratory infection, adequate oral hygiene can decrease the incidence of pneumonia (Müller, 2015) and improve quality of life in older adults (Bissett & Preshaw, 2011; Müller, Shimazaki, Kahabuka, & Schimmel, 2017). Among older adults, physical weakness, cognitive impairment, and psychosocial isolation can limit older adults' ability to practice good oral hygiene, and cause worsening pneumonia (Kandelman, Petersen, & Ueda, 2008; Oda, 2017). This is especially concerning given that fully symptomless or functional recovery from pneumonia can take three to six months (El Moussaoui et al., 2006; El Solh, Pineda, Bouquin, & Mankowski, 2006), and elderly patients with pneumonia are at a higher risk of mortality compared to their younger counterparts (Rozenbaum et al., 2015). In previous interventions, dental hygienists and caregivers have received instructions in how to clean older adults' teeth after every meal (Adachi, Ishihara, Abe, & Okuda, 2007; Adachi, Ishihara, Abe, Okuda, & Ishikawa, 2002; Yoneyama et al., 2002), but proper oral techniques are challenging to maintain for extended periods of time even after the provision of oral hygiene instructions (Weinstein, Milgrom, Melnick, Beach, & Spadafora, 1989). Therefore, an effective and easy-to-follow tooth brushing method is critical for older adults with pneumonia during and after hospitalization (Coker, Ploeg, Kaasalainen, & Carter, 2017; Forsell, Kullberg, Hoogstraate, Johansson, & Sjögren, 2011; Weening-Verbree, Huisman-de Waal, van Dusseldorp, van Achterberg, & Schoonhoven, 2013).

The purposes of this longitudinal study were to evaluate the effects of the Bass brushing method on dental plaque and pneumonia in older adults hospitalized with pneumonia from discharge through six months after discharge. The Bass brushing method has been shown to be an effective oral hygiene practice that removes dental plaque successfully (Graetz et al., 2012; Poyato-Ferrera, Segura-Egea, & Bullón-Fernández, 2003). We hypothesized that compared to usual care, older adults hospitalized with pneumonia who use the Bass brushing method would have less dental plaque and recurrent pneumonia.

2. Methods

2.1. Study design

This study used a longitudinal randomized pilot design aimed at evaluating the effect of the Bass brushing method on dental plaque and pneumonia during the six month follow-up period after discharge. The study was approved by the Institutional Review Board of Taichung Veterans General Hospital (No. CF16095A).

2.2. Study setting and sample

Patients were recruited from a 35-bed geriatric ward in a medical center from June 1st, 2016 to May 31st, 2017. Patients were eligible if they: (1) were ≥65 years old, (2) were admitted with clinician-diagnosed pneumonia and in stable physical condition, (3) had at least one tooth, and (4) were able to provide consent and participate after verbal explanation. Patients were ineligible if they: (1) refused to participate in this study, (2) used an electric toothbrush, (3) were unconscious, (4) or had pneumonia with respiratory-related side-effects or symptoms, such as severe asthma or low oxygen saturation that necessitated using a ventilator.

It was determined that 18 participants would be needed to detect a medium effect ($f = 0.25$; $\alpha = 0.05$; power = 0.80; groups = 2; repetitions = 7; correlation among repeated measures = 0.5; nonsphericity

Table 1
Participant characteristics (n = 30)

Variables	IG (n = 15)	CG (n = 15)	t	p
Age (years), Mean (SD)	82.3 (5.7)	84.5 (8.7)	0.824	0.417
Natural teeth, Mean (SD)	15.3 (9.3)	15.9 (8.4)	0.206	0.838

	n	(%)	n	(%)	χ^2	p
Sex[a]						1.000
Male	12	(80.0)	13	(86.7)		
Female	3	(20.0)	2	(13.3)		
Comorbidities						
1. COPD						1.000
Yes	7	(46.7)	7	(46.7)		
No	8	(53.3)	8	(53.3)		
2. DM[a]						1.000
Yes	3	(20.0)	3	(20.0)		
No	12	(80.0)	12	(80.0)		
3. Hypertension[a]						0.109
Yes	13	(86.7)	8	(53.3)		
No	2	(13.3)	7	(46.7)		
Previous pneumonia within 6 months					2.143	0.143
Yes	10	(66.7)	6	(40.0)		
No	5	(33.3)	9	(60.0)		
Dental clinic visit						0.136
within 6 months	4	(26.7)	8	(53.3)		
over 6 months ago	11	(73.3)	7	(46.7)		
Oral hygiene practice						
1. Brushing teeth after meals					0.000	1.000
Yes	9	(60.0)	9	(60.0)		
No	6	(40.0)	6	(40.0)		
2. Daily brushing times						0.713
Once	7	(46.7)	6	(40.0)		
at least two times	8	(53.3)	9	(60.0)		
3. Brushing duration						0.028*
≥3min	4	(26.7)	10	(66.7)		
< 3min	11	(73.3)	5	(33.3)		
4. Bass brushing method						
4–1 Placing bristles along the gumline at a 45° near the crown and brushing teeth from gumline to crown					0.536	0.464
Yes	6	(40.0)	8	(53.3)		
No	9	(60.0)	7	(46.7)		
4–2 Brushing teeth beginning at the right and ending at the right					0.600	0.439
Yes	9	(60.0)	11	(73.3)		
No	6	(40.0)	4	(26.7)		
4–3 Cleaning teeth from inside to outside and upper dentition to lower dentition.					2.143	0.143
Yes	6	(40.0)	10	(66.7)		
No	9	(60.0)	5	(33.3)		

Note. IG = intervention group; CG = control group; COPD = Chronic Obstructive Pulmonary Disease; DM = Diabetes mellitus.
[a] Fisher's test.
* $p < .05$.

correction epsilon = 1) with two equal groups and seven repetitions (calculated using G*Power version 3.1.9.2, EG Electronics). To account for participant attrition, the sample size was set at 30. Participants were randomized in equal numbers to the intervention (n = 15) and control groups (n = 15) by withdrawing computer randomized sampling numbers (using Microsoft Excel 2010) from concealed envelopes to determine their group status (Fig. 1.).

2.3. Intervention and measures

The Bass brushing method includes three procedures: (1) placing bristles along the gumline at a 45° near the crown and brushing teeth from gumline to crown; (2) brushing teeth beginning at the right and ending at the right; and (3) cleaning teeth from inside to outside and upper dentition to lower dentition (Graetz et al., 2012; Sato et al., 2008). Three nursing researchers were in charge of recruitment and instruction, and their consistency of the Bass brushing method was 90%. The intervention group received instructions for using the Bass brushing method and an oral health education leaflet about using a toothbrush and toothpaste at least once every day. The control group received the same oral health education leaflet, toothbrush, and toothpaste, but they brushed their teeth as usual and without individual guidance.

The following participant characteristics were collected at baseline: (a) demographics: age, sex, and number of natural teeth; (b) pneumonia-related: comorbidities and diagnosis of pneumonia within the previous six months; and (c) oral health-related: current periodontal disease, oral hygiene behaviors, and tooth brushing method.

The primary outcome was the dental plaque index. The Plaque Control Record (PCR) was used to record the presence of dental plaque on six surfaces of each stained tooth (O'Leary, Drake, & Naylor, 1972), and verified for accuracy by the senior dentist. The dental plaque index was defined as the number of plaque-containing surfaces divided by the total number of available surfaces.

The secondary outcome was pneumonia as detected on chest x-rays. Pneumonia manifested on the chest x-ray images with airspace opacity, lobar consolidation or interstitial opacities. If the chest x-ray image evidenced the above signs of pneumonia, patients were determined to have detected pneumonia. If there were no signs of pneumonia on the chest x-ray image, then the patients were determined to have undetected pneumonia. However, all patients were screened for clinical evidence of pneumonia and treated for symptoms of pneumonia, such as fever, cough, and shortness of breath (Long, Long, & Koyfman, 2017).

2.4. Data collection

All participants were evaluated seven times: at the beginning of the intervention in the hospital (baseline), and once a month for six months after discharge. At each assessment, participants gargled with a diluted 10 cc disclosing solution (9:1 water and 1.5% dental disclosing solution (GUM RED-COTE®, Sunstar Americas, Inc., Chicago, USA) for three minutes and a nurse researcher who was guided by a senior dentist assessed and calculated the dental plaque index. A senior chest medicine physician took responsibility for the outcome of the chest x-ray.

2.5. Statistical analysis

Descriptive statistics (means, standard deviations, frequency distribution, and percentages) were used to characterize participant characteristics, dental plaque index, and pneumonia as detected by chest x-rays. Chi-square tests and independent t-tests were used to examine differences in baseline attributes between groups. Variables significant at baseline ($p < .05$) were included as covariates in multivariate analyses. Generalized estimating equations (GEE) and generalized linear mixed models (GLMM) were used to analyze the effect of the Bass brushing method on dental plaque and pneumonia. Little's missing completely at random (MCAR) test was used to examine the type of missing data. Analyses were conducted using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., New York, NY, USA), and significance levels were set at $\alpha = 0.05$.

3. Results

3.1. Participant characteristics

A total of 35 older adults hospitalized with pneumonia were approached for participation. One patient was younger than 65 years old, and four declined to participate in the study (Fig. 1). The final sample comprised 30 older adults hospitalized with pneumonia, and no

participants dropped out of the study.

Participant characteristics are presented in Table 1. The mean age of participants in the intervention group and control group was 82.3 and 84.5 years, respectively. Patients were primarily male (80.0% in the intervention group and 86.7% in the control group). The mean number of natural teeth was 15.9 ± 8.4 in the intervention group and 15.3 ± 9.3 in the control group. An equal number of participants in each group had chronic obstructive pulmonary disorder (COPD) and diabetes mellitus (DM), but 86.7% of those in the intervention group had hypertension compared to 53.3% in the control group. A total of 66.7% and 40% of subjects in the intervention group and control group were diagnosed with pneumonia in the previous six months, respectively.

Regarding oral health-related attributes, 80% of participants suffered from periodontal disease and received regular dental check-ups, and 60% could brush their teeth after meals in both groups. For participants in the intervention group, 73.3% had not visited a dental clinic within the previous six months as compared to 46.7% in the control group, and 53.3% of participants in the intervention group brushed their teeth at least two times per day compared to 60.0% of participants in the control group. Participants in the intervention group were less likely to brush their teeth for at least 3 min compared to participants in the control group (26.7% vs. 66.7%).

3.2. Effect on dental plaque

Means and standard deviations for the dental plaque index are presented in Table 2 and displayed visually in Fig. 2. At baseline, there was no significant difference in dental plaque between the two groups ($\beta = -0.124$, $p = .137$), even after adjusting for brushing duration ($\beta = -0.029$, $p = .671$) in the GEE model (Table 3). For participants in the intervention group, dental plaque was significantly lower at four ($\beta = -0.225$, $p = .024$), five ($\beta = -0.223$, $p = .025$), and six months ($\beta = -0.488$, $p = .000$) after discharge when compared to baseline levels. For participants in the control group, dental plaque was significantly lower at one month ($\beta = -0.180$, $p = .012$) and three months ($\beta = -0.167$, $p = .031$) after discharge as compared to baseline. No participants reported adverse effects of the dental disclosing solution.

Table 2
Dental plaque index and pneumonia as detected on chest x-rays in older adults hospitalized with pneumonia after discharge ($n = 30$)

	IG (n = 15)		CG (n = 15)		ES (f)
	Mean	SD	Mean	SD	
Dental plaque index					
Baseline	48.0%	24.6%	59.2%	25.9%	0.216
1 Month	34.0%	27.8%	42.2%	30.8%	0.136
2 Months	32.2%	25.8%	54.6%	37.4%	0.260
3 Months	23.6%	22.7%	46.0%	28.6%	0.421
4 Months	28.4%	28.0%	60.1%	28.6%	0.562
5 Months	16.2%	8.8%	53.5%	18.1%	1.335
6 Months	12.9%	11.0%	72.9%	35.9%	1.127

	n	%	n	%	
Pneumonia as detected on chest x–rays					
Baseline	12	80.0	10	66.7	–0.143
1 Month	2	13.3	4	26.7	0.182
2 Months	2	13.3	3	20.0	0.093
3 Months	1	6.7	2	13.3	0.116
4 Months	2	13.3	1	6.7	–0.108
5 Months	2	13.3	1	6.7	–0.108
6 Months	1	6.7	1	6.7	0.000

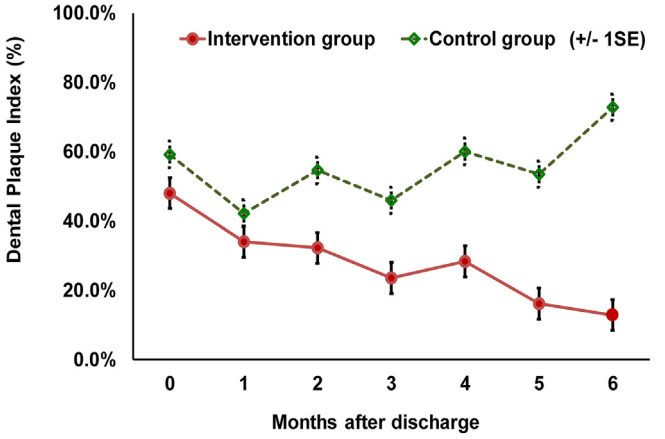

Fig. 2. Trend in dental plaque index in older adults hospitalized with pneumonia after discharge.
Note. 0 = baseline data.

Table 3
GEE analysis of the Bass brushing method on the dental plaque index in older adults hospitalized with pneumonia after discharge

Variables	β	SE	95% C.I.	p
(Intercept)	0.612	0.070	[0.475, 0.749]	.000***
Group effect	–0.124	0.083	[–0.287, 0.039]	.137
Time effect				
1 Month	–0.180	0.071	[–0.320, –0.040]	.012*
2 Months	–0.081	0.138	[–0.351, 0.190]	.558
3 Months	–0.167	0.077	[–0.318, –0.016]	.031*
4 Months	0.011	0.083	[–0.151, 0.172]	.899
5 Months	–0.059	0.077	[–0.210, 0.093]	.449
6 Months	0.174	0.112	[–0.044, 0.392]	.119
Group by time effect				
Intervention group × 1 Month	0.041	0.091	[–0.138, 0.220]	.656
Intervention group × 2 Months	–0.095	0.153	[–0.395, 0.206]	.537
Intervention group × 3 Months	–0.081	0.093	[–0.263, 0.101]	.382
Intervention group × 4 Months	–0.225	0.100	[–0.420, –0.030]	.024*
Intervention group × 5 Months	–0.223	0.099	[–0.418, –0.028]	.025*
Intervention group × 6 Months	–0.488	0.132	[–0.747, –0.229]	.000***
Brushing time (≥ 3 min/ < 3 min)	–0.029	0.069	[–0.165, 0.106]	.671

Note. × = interaction–related effects.
* $p < .05$.
*** $p < .001$.

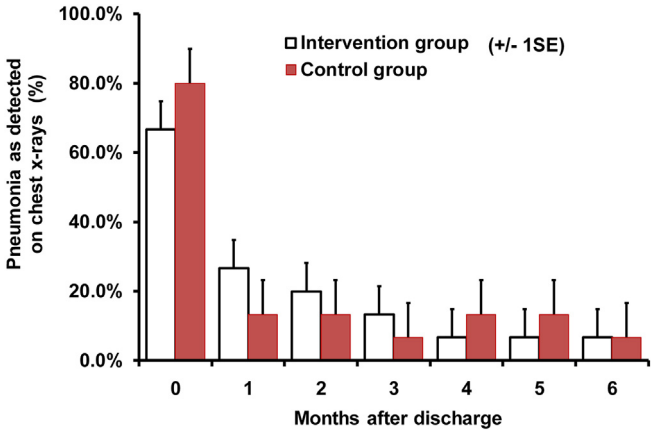

Fig. 3. Trend in pneumonia as detected on chest x-rays in older adults hospitalized with pneumonia after discharge.
Note. 0 = baseline data.

Table 4
GLMM analysis of the Bass brushing method on pneumonia as detected on chest x-rays for older adults hospitalized with pneumonia after discharge

Variables	β	SE	t	95% C. I.	*p*	Exp(B)
(Intercept)	–4.753	1.941	–2.448	[8.638, –0.870]	0.017*	0.009
Group effect	0.674	1.772	0.380	[–2.872, 4.219]	0.705	1.961
Pneumonia at baseline (detected/undetected)	5.765	1.707	3.377	[2.350, 9.180]	0.001***	318.862
Dental plaque index	4.363	1.843	2.368	[0.677, 8.049]	0.021*	78.515
Time effect						
1 Month	–2.578	1.677	–1.537	[–5.933, 0.777]	0.130	0.003
2 Months	–2.403	1.727	–1.392	[–5.857, 1.051]	0.169	0.090
3 Months	–4.201	1.961	–2.142	[–8.124, –0.278]	0.036*	0.015
4 Months	–4.334	2.074	–2.090	[–8.483, –0.186]	0.041*	0.013
5 Months	–3.631	2.033	–1.786	[–7.698, 0.435]	0.079	0.026
6 Months	–14.295	61.402	–0.233	[–137.117, 108.527]	0.817	0.000
Group by time effect						
Intervention group × 1 Month	–1.897	2.140	–0.887	[–6.178, 2.383]	0.379	0.150
Intervention group × 2 Months	–1.839	2.194	–0.838	[–6.227, 2.549]	0.405	0.159
Intervention group × 3 Months	1.373	2.680	0.512	[–3.988, 6.733]	0.610	3.946
Intervention group × 4 Months	2.425	2.709	0.895	[–2.995, 7.844]	0.374	11.297
Intervention group × 5 Months	0.912	2.508	0.364	[–4.106, 5.930]	0.717	2.490
Intervention group × 6 Months	10.994	61.448	0.179	[–111.920, 133.909]	0.859	59536.090

Note. × = interaction–related effects.
* $p < .05$.
*** $p < .001$.

3.3. Effect on pneumonia

Frequencies and percentages for pneumonia as detected on chest x-rays are presented in Table 2 and displayed visually in Fig. 3. From baseline to six months after discharge, the number of participants with detected pneumonia gradually decreased for both groups. Results from Little's MCAR test indicated that missing chest x-ray data were missing completely at random ($\chi^2 = 50.314$, df = 59, $p = .782$). Results from the GLMM model (Table 4) indicated no statistically significant difference between groups in pneumonia as detected on chest x-rays (β = 0.674, Exp [B] = 1.961; $p = .705$). Across groups, there was a significant reduction in the rates of pneumonia as detected on the chest x-rays at three months (β = −4.201, Exp [B] = 0.015; $p = .036$) and four months (β = −4.334, Exp [B] = 0.013; $p = .041$) when compared to baseline. There were no significant changes over time in the intervention group, indicating that the Bass brushing method did not directly influence participants' pneumonia progression. However, pneumonia as detected on chest x-rays at baseline (β = 5.765, Exp [B] = 318.862; $p = .001$) and dental plaque (β = 4.363, Exp [B] = 78.515; $p = .021$) emerged as statistically significant predictors of the risk of pneumonia for both groups.

4. Discussion

Standard tooth brushing is a vital self-care practice that can improve oral health and may improve arm-joint motion and muscle strength (Inada et al., 2015). Low muscle strength and poor physical performance can impede the implementation of tooth brushing (Beenakker et al., 2010; Cruz-Jentoft et al., 2010), which is of particular concern among older patients who may lose considerable muscle strength within three days of going on bed rest or being hospitalized (Kortebein, Ferrando, Lombeida, Wolfe, & Evans, 2007). In this intervention, we aimed to evaluate the effects of the Bass brushing method on dental plaque and pneumonia in older adults after hospital discharge. Results from this study indicated that the Bass brushing method was effective at sustaining dental plaque removal over time. Consistent with existing literature, the Bass brushing method was also more effective at removing dental plaque than brushing duration (Graetz et al., 2012). However, at baseline, up to 60% of subjects in the intervention group were not able to implement the procedures of the Bass brushing method. Thus, participants may have understood the importance of brushing their teeth every day, but they may have had difficulty implementing the complete procedures of tooth brushing.

Results of this study indicated a clear relationship between dental plaque and the risk of pneumonia, consistent with existing literature (Sjögren et al., 2008), and confirmed the utility of the Bass brushing method as an evidence-based strategy for oral hygiene (Poyato-Ferrera et al., 2003). Participants in the intervention group were counseled about the severe consequences of pneumonia, which may have led to them to be more amenable to follow a standard tooth brushing method to maintain adequate oral health (Adachi et al., 2002; Ishikawa, Yoneyama, Hirota, Miyake, & Miyatake, 2008; Nishiyama, Inaba, Uematsu, & Senpuku, 2010; van der Maarel-Wierink, Vanobbergen, Bronkhorst, Schols, & de Baat, 2013). Considering the deconditioning cycle of pneumonia recovery, participants may have experienced difficulty in maintaining good oral hygiene during the critical recovery period between three and four months after discharge (El Moussaoui et al., 2006; El Solh et al., 2006). After this recovery period and through the sixth month after discharge, participants in the intervention group experienced significant sustained reductions in dental plaque compared to participants in the control group. This difference may be explained by better oral self-care habits facilitated by the intervention (Kakudate & Morita, 2012; Oda, 2017), and a stable physical condition. Future studies would benefit from a larger sample size, longer follow-up period, and an examination of discharged older adults' quality of life after receiving oral hygiene education. In addition, it would be worthwhile to apply evidence-based oral hygiene to other pneumonia-related populations, such as patients with lung cancer, who have been admitted to the ICU, or are under 65 years old.

Strengths of this study include examining patients over time after hospital discharge and employing a longitudinal randomized design with GEE and GLMM to examine the effects of the Bass brushing method on dental plaque and pneumonia. Limitations include patients not receiving regular chest x-rays after clinical examination, which resulted in missing data during the follow-up period. However, data missing completely at random in RCTs can be mitigated by using unweighted GEE and mixed models (Bell, Fiero, Horton, & Hsu, 2014).

5. Conclusion

In summary, our results suggest that the Bass brushing method is a useful oral hygiene practice for removing dental plaque in previously

hospitalized older adults with pneumonia following hospital discharge. The dental plaque index can be used to monitor oral health and the risk of pneumonia in frail older adults after discharge. Care providers may also seek to provide older patients with reminders and encouragement to follow a standard tooth brushing method and undergo regular dental examinations after discharge.

Author's note

Authors' contributions

Ms. Ju and Ms. Chang made the concept and design of this study. Ms. Chung, Ms.Yang, and Ms. Huang were in charge of recruitment and education. Ms. Ju checked participants' oral health and calculated the DP-index after Dr. Huang' training and verification. Dr. Chin confirmed all chest x-ray images. Dr. Weng and Ms. Chang performed the data analysis and interpretation. Ms. Ju, Dr. Weng, Dr. Hoogland, and Ms. Chang drafted the manuscript and revised it critically for the important intellectual content.

Conflict of interests

The authors declare that there is no conflict of interest.

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This study was conducted by the multidisciplinary team of the Department of Nursing, Center for Geriatrics and Gerontology, Division of Endodontics and Periodontics, Division of Chest Medicine, Taichung Veterans General Hospital, Taiwan and Department of Health Outcomes and Behavior, Moffitt Cancer Center, USA. This study was supported by Taichung Veterans General Hospital Research Program (TCVGH-1057405B) and Ministry of Science and Technology, Taiwan (MOST 106-2314-B-075A-003). The authors gratefully acknowledge the contribution of all participants in this study and the Biostatistics Task Force of TCVGH for assistance in statistics. The authors sincerely appreciate the assistance of the Center for Translational Medicine of Taichung Veterans General Hospital, Taichung, Taiwan.

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