

Use of a powered toothbrush to improve oral health in individuals with mild cognitive impairment

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Abstract

Objectives: The aim of the study is to investigate whether the use of a powered toothbrush could maintain oral health by reducing the dental plaque (PI), bleeding on probing (BOP), and periodontal pocket depth (PPD) ≥ 4 mm in a group of individuals with MCI and also if changes in oral health affect various aspects of quality of life.

Background: People with cognitive impairment tend to have poor oral hygiene and poorer Quality of life. In the present study, the participants were asked to use a powered toothbrush for at least 2 min morning and evening and no restrictions were given against the use of other oral care products. The participant survey conducted at each examination demonstrated that 61.2% of participants at baseline claimed to have experience of using a powered toothbrush, 95.4% at 6 months and 95% after 12 months. At the same time, the use of manual toothbrushes dropped from 73.3% to 44.7% from baseline to the 12-month check-up. This shows that several participants continue to use the manual toothbrush in parallel with the powered toothbrush, but that there is a shift towards increased use of the powered toothbrush. Removal of dental biofilm is essential for maintaining good oral health. We investigated whether using a powered toothbrush reduces the presence of dental plaque, bleeding on probing and periodontal pockets ≥ 4 mm in a group of older individuals with mild cognitive impairment.

Materials and methods: Two hundred and thirteen individuals with the mean age of 75.3 years living without official home care and with a Mini-Mental State Examination (MMSE) score between 20 and 28 and a history of memory problems in the previous six months were recruited from the Swedish site of a multicenter project, Support Monitoring And Reminder Technology for Mild Dementia (SMART4MD) and screened for the study. The individuals received a powered toothbrush and thorough instructions on how to use it. Clinical oral examinations and MMSE tests were conducted at baseline, 6 and 12 months.

Results: One hundred seventy participants, 36.5% women and 63.5% men, completed a 12-month follow-up. The use of a powered toothbrush resulted, for the entire group, in a significant decrease in plaque index from 41% at baseline to 31.5% after 12 months ($P < .000$). Within the same time frame, the values for bleeding on probing changed from 15.1% to 9.9% ($P < .000$) and the percentage of probing pocket depths

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≥4 mm from 11.5% to 8.2% ($P < .004$). The observed improvements in the Oral Health Impact Profile 14 correlate with the clinical improvements of oral health.

Conclusion: The use of a powered toothbrush was associated with a reduction of PI, BOP and PPD over 12 months even among individuals with low or declining MMSE score. An adequately used powered toothbrush maintain factors that affect oral health and oral health-related Quality of Life in people with mild cognitive impairment.

KEYWORDS

mild cognitive impairment, oral health, powered toothbrush, quality of life

1 | BACKGROUND

Oral health is considered an essential factor in healthy ageing.^{1,2} The concept of oral health has been defined and approved by the World Dental Federation (FDI). It includes the ability to speak, smile, smell, taste, touch, chew, swallow and convey a range of emotions through facial expressions with confidence and without pain, discomfort and disease of the craniofacial complex. It is also a fundamental component of health and physical and mental well-being and reflects the physiological, social and psychological attributes essential for quality of life (QoL).³

Preventive-oriented dentistry and the availability of dental insurance have impacted the prevention of oral diseases.⁴ As a result, an increasing proportion of older adults now retain their teeth throughout life.^{5,6} In Sweden, edentulous people with complete dentures in the age group 40-70 have decreased from approximately every sixth individual in 1973 to zero in 2013.⁷ In 2019, the older in Sweden above 90 years of age had a median of 20 remaining teeth.⁸

In Sweden, as in many parts of the world, life expectancy is increasing.^{9,10} However, the prevalence of mild cognitive impairment (MCI)¹¹ and dementia has also increased.¹² It is estimated that, in 2010, 35 million people in the world were affected by dementia, and it is estimated that, by 2050, 115 million individuals will have been diagnosed with dementia.¹³

Dementia and cognitive impairment are reported to result in a rapid deterioration of oral health, increased incidence of oral diseases and a poorer quality of life (QoL).¹⁴ A recently published literature review concluded that pain and functional problems are associated with compromised QoL and that a functioning dentition is essential for the experience of high QoL.¹⁵ Individuals with dementia, regardless of type, are more likely to have poor oral hygiene, deep periodontal pockets and caries than non-demented people.^{16,17} As part of dementia, eating behaviours and dietary intake can be affected. The changes differ between different forms of dementia and can be seen as cravings for sweeter food, difficulty in chewing and swallowing and increased appetite.^{18,19} Changes like these combined with reduced saliva flow due to medication intake or decline in salivary gland function accelerate the development of caries.^{5,7,20} Among individuals with MCI and in the early stages of dementia, their poorer oral health may also be due to an inability to perform self-care.²¹

Sarcopenia and impaired fine motors skills are associated with cognitive impairment²⁰ and present difficulties in adequately performing self-care. Besides, the inability to remember to brush the

teeth increases with the development of the disease. Accordingly, it is crucial to develop good oral hygiene routines for patients with MCI.²²

Using a powered toothbrush has in several studies shown to be more effective in removing plaque and reducing gingival inflammation than a manual toothbrush.²³⁻²⁵ In addition, the powered toothbrush design makes it easier to hold, and its use requires less motor skill. Therefore, introducing a powered toothbrush as part of oral hygiene measures may benefit individuals with MCI. This study aimed to investigate whether the use of a powered toothbrush could maintain oral health by reducing the dental plaque (PI), bleeding on probing (BOP) and periodontal pocket depth (PPD) ≥ 4 mm in a group of individuals with MCI and also if changes in oral health affect various aspects of quality of life.

2 | METHODS

For this study, 213 individuals were recruited through a consecutive offer of participation to participants in the Swedish site of the multicentre project Support Monitoring and Reminder Technology for Mild Dementia (SMART4MD). The project was financed under the European Union Framework Program for Research and Innovation—Horizon 2020 (project ID: 643399). The Swedish site in SMART4MD was a collaboration between Blekinge Institute of Technology (BTH), Karlskrona municipality and Blekinge County council.

All residents in the municipalities of Karlskrona, Ronneby and Karlshamn over the age of 70 received a personal invitation by mail. Furthermore, they were recruited via exhibitions for older and from memory clinics. Inclusion criteria for the SMART4MD project were being 55 years or older, having experienced memory problems in the last 6 months before inclusion, a Mini-Mental State Examination (MMSE) score of 20-28, and not receiving any formal care. When screening for this study, the same inclusion criteria were used as for SMART4MD, with the addition that the participants should have at least ten teeth of their own.

All participants were given verbal and written information about the study design and the possibility of terminating their participation at any time without giving any reason. In addition, all participants provided written informed consent before entering the study.

The study period run from June 2018 to October 2020. The procedure involved a combined screening and baseline oral examination, followed by re-examinations at 6 and 12 months. All visits were to a university research clinic and included both medical and oral

examinations. The oral examinations were performed by a dentist with more than 30 years of experience as a general practitioner and 3 years of experience in clinical research examinations and a licensed hygienist, also with 30 years of experience from general dental care and for the past 10 years part-time at a research clinic conducting clinical research examinations. The first 10 examinations were conducted jointly by the two investigators to calibrate the examination routines and the completion of protocols. After that, regular joint reviews have been carried out both in doubtful and randomly selected cases. The visits were booked randomly, so the participants did not meet the same examiner at all visits. Nine participants did not meet the inclusion criteria of at least ten teeth and were excluded. In total, 34 participants did not present for follow-up and so were excluded from the current analysis.

During the study, all participants received their usual medical and dental care. At baseline, each participant received a powered toothbrush (Oral-B Genius 9000 Proctor & Gamble, www.oralb.de). Participants were carefully instructed in the powered toothbrush operation and were asked to brush for at least 2 minutes in the morning and evening. No restrictions were given against the use of other oral care products. Compliance with the use of the electric toothbrush was followed by a participant survey conducted at each examination.

2.1 | Dental examination

A dentist or a licensed dental hygienist performed a dental examination at baseline, 6- and 12-month visits. The examination recorded the number of remaining teeth, PI, BOP and PPD \geq 4 mm. PI was measured on four surfaces, mesially, distally, buccally and lingually for each tooth.²⁶ BOP and PPD \geq 4 mm were measured at four sites on each tooth (mesiobuccal, distobuccal, mesiolingual/palatal and distolingual/palatal). In this study, for PI and BOP, dichotomous registration has been used.²⁷ Intra-oral lesions, if present, were diagnosed and stimulated saliva secretion was measured for 2 minutes while chewing a piece of paraffin. The volume obtained was measured and divided by two to obtain the number of millilitres of stimulated saliva per minute.²⁸

2.2 | Medical examination

Medical examinations were carried out by licensed research nurses and included gathering information about all medications and over-the-counter (OTC) drugs, a questionnaire on demographic data and living conditions, a cognitive test, the MMSE and QoL tests, described below.

2.3 | Cognitive test

The MMSE test focuses on memory, learning and orientation and has a score scale from 0 to 30 points.²⁹ In the present study, we use the terms MMSE high and MMSE low. The definition of MMSE high

is an MMSE score higher than 26 or that the baseline score does not decrease two steps or more during 12 months.

The MMSE low group is defined by an MMSE score of 26 and lower or a score decreasing two steps or more during 12 months.

2.4 | Quality of life assessment

Quality of life was measured using a Swedish translation of the quality of life Alzheimer disease examination (QoL-AD),³⁰ a 13-item instrument. The score can range from 13 to 52, the same as in the English version, and includes assessments of the individual's relationships with friends, family, financial situation, physical condition, mood and an overall evaluation of life quality. A higher score indicates a higher perceived quality of life. Oral health-related quality of life (OHRQoL) was assessed using the short-form Oral Health Impact Profile (OHIP-14). The OHIP-14 aims to assess seven dimensions of oral conditions' impacts on people's OHRQoL, including functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap.^{31,32} In the current study, a Swedish translation of OHIP-14 was used.³³ Unlike the English-language version,³⁴ which has a maximum score of 56, this version, and the "question does not apply to me" answer option, has six options from 1 to 6. They are always, very often, quite often, sometimes, quite rarely and never. In this version, the maximum score is 84. The fact that the survey contained an additional response option should be noted. However, an increased score indicates a higher perceived quality of life.

2.5 | Statistical analysis

All statistical analyses used the Statistical Package for Social Science, version 26.0 (SPSS Inc). The collected data were analysed using descriptive and comparative statistics. Paired samples t-tests and independent samples t-tests were used for calculations of significance. The results are presented as relative frequency (%). Pocket has been reported as the number of PPD \geq 4 mm in per cent of the total number of probed sites.

3 | RESULTS

The baseline demographic data for participants are shown in Table 1.

Out of a total of 170 participants, 84.1% belong to the MMSE high group (score of more than 26 or an MMSE score not decreasing two steps or more during 12 months) and 15.9% to the MMSE low group (score 26 or lower or a decreasing MMSE score two steps or more during 12 months). More individuals in the MMSE high group (61.1%) had a powered toothbrush experience than in the MMSE low group (38.9%).

Thirty-four individuals (16.3%) of the screened sample were lost to follow up. Sixteen participants returned the toothbrush because

TABLE 1 Study characteristics at baseline by sex (Brackets contain standard deviations)

	Individuals total M/FM		Male	Female	Total
Age y, mean	170 108/62		75.1 (4.7)	75.7 (4.9)	75.3 (4.8)
MMSE score mean	170 108/62		26.8 (1.6)	26.9 (1.5)	26.8 (1.6)
Diagnosis of dementia %	167 105/62		2.1 (0.8)	2.1 (0.8)	2.1 (0.8)
Education %	170 108/62	Elementary school	35.2 (0.5)	40.3 (0.5)	37.0 (0.5)
		Secondary school	22.2 (0.4)	30.6 (0.5)	25.3 (0.4)
		Higher education	42.6 (0.5)	29.0 (0.4)	37.6 (0.5)
Living arrangement %	170 108/62	Single	13.0 (0.1)	41.9 (0.5)	23.5 (0.4)
		Spouse/common law	87.0(0.3)	56.4 (0.5)	75.9 (0.4)
		With children	0. 0 (0.0)	1.6(0.1)	0.5(0.1)
Number of teeth mean	170 108/62		23.6 (4.8)	24.5 (3.3)	23.9 (4.3)
Removable prosthesis %	170 108/62		4.6 (0.2)	3.2 (0.2)	4.1 (0.2)
Number of daily used drugs %	170 108/62	0	15.7 (0.4)	19.4 (0.4)	17.1 (0.4)
		1-4	50.0 (0.5)	46.8 (0.5)	48.8 (0.5)
		≥5	34.3 (0.5)	33.9 (0.5)	34.1 (0.5)
A feeling of dry mouth %	162 103/59	Often	5.8 (0.2)	15.3 (0.4)	9.3 (0.3)
		Sometimes	44.7 (0.5)	47.5 (0.5)	45.7 (0.5)
		No never	49.5 (0.5)	37.3 (0.5)	45.1 (0.5)
Smoker %	164 105/57	Never smoked or stopped	95.2 (0.3)	96.6 (0.3)	92.4 (0.3)
		Regular or sometime smoker	4.6(0.2)	3.2 (0.2)	4.1 (0.2)
Snuff user %	156 88/53	No	85.4 (0.4)	100 (0.0)	90.4 (0.3)
		Yes	14.6 (0.3)	0.0 (0.0)	9.6 (0.3)

Abbreviations: FM, Female; M, Male; MMSE, Mini-Mental State Examination.

TABLE 2 PI at baseline, 6 and 12 mo and change form baseline to 6 mo and change from baseline to 12 mo for the entire group, and for the high^a and low^b MMSE groups

	Baseline PI (SD)	6 mo PI % (SD)	Change baseline to 6 mo P < .050	12 mo PI % (SD)	Change 6-12 mo P < .050	Change baseline-12 mo P < .050
Total N 170	41.1 (20.3)	30.9 (19.1)	.000	31.5 (18.4)	.688	.000
MMSE high ^a N 143	39.7 (19.4)	29.5 (18.7)	.000	29.5 (18.0)	.983	.000
MMSE low ^b N 27	48.3 (23.3)	38.3 (19.5)	.037	42.0 (17.3)	.305	.162

Note: P values for change baseline to 6 mo, change 6-12 mo and change baseline to 12 mo are presented.

^aMMSE high = score of more than 26 or a not decreasing MMSE score two steps or more during 12 mo.

^bMMSE low = score 26 or lower or a decreasing MMSE score two steps or more during 12 mo.

they did not want to use it or participate any longer. Two individuals became too ill to continue, another one died, and one thought it was too far to travel for continued participation. Fourteen individuals left the study without giving any reason. The MMSE mean score of the dropout group was slightly higher than the mean score of the remaining study group at baseline. Among the ten individuals dropping out

after the six-month examination, a deterioration in PI and BOP was observed. There was no significant reduction in the number of periodontal pockets ≤4 mm.

The per cent sites for PI, at baseline, 6 and 12 months are presented in Table 2 and for POB and probing pocket depths ≥4 mm in Table 3.

TABLE 3 The per cent of sites with BOP and PPD ≥ 4 mm, at baseline, 6 and 12 mo for the entire group, and the high^a and low^b MMSE groups

	Baseline		6 mo		12 mo		Change baseline to 6 mo P value		Change 6-12 mo P value		Change baseline to 12 mo P value	
	BOP % (SD)	PPD ≥ 4 mm % (SD)	BOP % (SD)	PPD ≥ 4 mm % (SD)	BOP % (SD)	PPD ≥ 4 mm % (SD)	BOP	PPD	BOP	PPD	BOP	PPD
Total N:70	15.1 (17.9)	11.5 (15.7)	10.1 (16.8)	9.6 (12.9)	9.9 (16.0)	8.4 (14.3)	0.000	0.043	0.897	0.122	0.000	0.004
MMSE high ^a N:143	14.9 (17.3)	11.9 (16.5)	8.6 (13.9)	8.9 (12.4)	9.7 (16.1)	8.7 (15.2)	0.000	0.002	0.420	0.717	0.000	0.012
MMSE low ^b N:27	16.2 (21.2)	9.9 (10.5)	17.8 (26.4)	13.7 (15.2)	11.1 (15.5)	7.0 (8.4)	0.715	0.343	0.054	0.008	0.130	0.212

Note: P values for change baseline to 6 mo, change 6-12 mo and change baseline to 12.

^aMMSE high = score of more than 26 or a not decreasing MMSE score two steps or more during 12 mo.

^bMMSE low = score 26 or lower or a decreasing MMSE score two steps or more during 12 mo.

There was a significant reduction for the MMSE high group in pockets ≥ 4 mm between the baseline and the 6-month examination. Also, a significant reduction was found between the 6-month and 12-month examination for the MMSE low group. PI decreased during the first 6 months in the MMSE high group, and BOP decreased from baseline to 12 months. Both changes were statistically significant. For the MMSE low group individuals, the PI's reduction was statistically significant for the first 6 months. Sites with BOP also decreased but not significantly between 6 and 12 months. Comparisons of BOP and PI between MMSE high and MMSE low groups are presented in Table 4. There was no significant difference in the BOP. Individuals in the MMSE high group had a statistically significant lower PI score at all time points compared with individuals in the MMSE low group. When comparing BOP and PI between the individuals who reported to have prior experience of using a powered toothbrush (61.1%) and prior users of only a manual toothbrush (38.9%), no significant differences were found between the groups at any timepoint.

In Tables 5 and 6, changes over time for QoL-AD and OHIP-14 is presented. QoL-AD significantly decreased from baseline to 6 months and from 6 to 12 months for the MMSE high group $P = 0.004$ and $P = 0.035$ respectively. For the MMSE low group, the decrease in QoL-AD was significant from 6 to 12 months ($P = 0.018$). On the contrary, the OHRQoL instrument OHIP-14 shows significant improvements for the MMSE high group between baseline and 6 months ($P = 0.035$) and the MMSE low group between 6 and 12 months ($P = 0.006$).

In the present study, the participants were asked to use a powered toothbrush for at least 2 minutes morning and evening and no restrictions were given against the use of other oral care products. The participant survey conducted at each examination demonstrated that the powered toothbrush was used daily or several times daily by 61.2% of participants at baseline, 95.4% at 6 months and 95% after 12 months. At the same time, the use of manual toothbrushes dropped from 73.3% to 44.7% from baseline to the 12-month check-up. This shows that several participants continue to use the manual toothbrush in parallel with the powered toothbrush, but that there is a shift towards increased use of the powered toothbrush.

4 | DISCUSSION

The present study found that using a powered toothbrush significantly reduced BOP, PI and PPD ≥ 4 mm for individuals with mild cognitive impairment. In addition, QoL-AD decreased significantly during the 12-month study period for both MMSE groups, while OHIP-14 improved significantly for the MMSE high group at 6 months and for the MMSE low group between 6 and 12 months.

Several studies have demonstrated that a powered toothbrush is superior to a manual toothbrush in reducing BOP and PI.²³⁻²⁵ In the present study, no significant differences in BOP or PI were observed at baseline between individuals who reported to have experience of how to use a powered toothbrush (61.1%) and those who only used a manual toothbrush (38.9%). No data regarding prevalence or

TABLE 4 Per cent BOP and PI at baseline, 6 and 12 mo. Comparison between the groups MMSE high and MMSE low

	Timepoint	MMSE high ^a N = 143	MMSE low ^b N = 27	SE diff	95% CI	Sign (two-tailed)
BOP %	Baseline	14.9	16.2	3.76	-8.66 to 6.19	0.742
	6 mo	8.6	17.8	5.22	-19.86 to 1.49	0.089
	12 mo	9.7	11.1	3.36	-8.04 to 5.24	0.678
PI %	Baseline	39.7	48.3	4.21	-16.90 to -0.27	0.043
	6 mo	29.5	38.3	3.96	-16.58 to -0.95	0.028
	12 mo	29.5	42.0	3.76	-19.87 to 5.02	0.001

Abbreviations: BOP, Bleeding on probing; PI, Plaque index.

^aMMSE high = score of more than 26 or a not decreasing MMSE score two steps or more during 12 mo.

^bMMSE low = score 26 or lower or a decreasing MMSE score two steps or more during 12 mo.

TABLE 5 QoL-AD mean scores at baseline, 6 and 12 mo for the entire group and for the high^a and low^b MMSE groups separately

	Baseline	6 mo	12 mo	Change baseline to 6 mo P values	Change 6-12 mo P values
	QoL-AD % (SD)	QoL-AD % (SD)	QoL-AD % (SD)	QoL-AD	QoL-AD
Total Mean	40.8 (5.2) ^{N 170}	39.7 (5.0) ^{N 170}	39.0 (5.1) ^{N 170}	0.001	0.014
MMSE high ^a	41.1 (5.0) ^{N 143}	40.0 (4.8) ^{N 143}	39.6 (4.9) ^{N 142}	0.004	0.035
MMSE low ^b	39.2 (6.0) ^{N 27}	37.9 (5.7) ^{N 27}	36.0 (4.7) ^{N 27}	0.145	0.018

Note: P values for change between baseline and 6 mo and change between 6 and 12 mo.

^aMMSE high = score of more than 26 or a not decreasing MMSE score two steps or more during 12 mo.

^bMMSE low = score 26 or lower or a decreasing MMSE score two steps or more during 12 mo.

TABLE 6 OHIP-14 mean scores at baseline, 6 and 12 mo for the entire group and for the high^a and low^b MMSE groups separately

	Baseline	6 mo	12 mo	Change baseline to 6 mo P values	Change 6-12 mo P values
	OHIP-14 % (SD)	OHIP-14 % (SD)	OHIP-14 % (SD)	OHIP-14	OHIP-14
Total Mean	77.8 (6.9) ^{N 158}	78.1 (7.6) ^{N 150}	78.2 (7.2) ^{N 154}	0.860	0.648
MMSE high ^a	78.0 (6.6) ^{N 118}	79.2 (5.6) ^{N 118}	78.2 (7.3) ^{N 117}	0.035	0.315
MMSE low ^b	77.1 (8.9) ^{N 24}	72.3 (12.7) ^{N 24}	78.8 (6.4) ^{N 21}	0.062	0.006

Note: P values for change between baseline and 6 mo and change between 6 and 12 mo.

^aMMSE high = score of more than 26 or a not decreasing MMSE score two steps or more during 12 mo.

^bMMSE low = score 26 or lower or a decreasing MMSE score two steps or more during 12 mo.

duration of prior use are available. Both groups demonstrated similar improvement, and the achieved results were maintained over the study period.

At baseline, 90.8% of the participants stated that they visit professional dental care one or more times a year. At the 12-month visit, the corresponding data are 88.3% for visits once or several times a year. This is a slightly higher value than for Blekinge County, Sweden, where 77.1% of all residents between 75 and 79 years old stated that they 2019 visited dental care during the year.⁸ The small changes between baseline and 12-month examination for the study sample do

not indicate that participation in the study led to a change in habits regarding dental care.

Many factors besides presence and composition of the oral biofilm may affect the presence of deepened periodontal pockets. Smoking and diabetes are correlated to periodontitis. Among the participants in this study, at M12, only 2.3% smoked regularly and 1% stated that they smoked occasionally. The low prevalence of smokers in the present study is considered to have limited effect on the result. The impact and prevalence of diseases associated with periodontitis have not been assessed in this study.

Lack of saliva may influence the oral microflora. In the present study, the stimulated saliva secretion was measured at each examination and demonstrated a slight increase over time. No significant correlation was found between the amount of plaque surfaces and saliva secretion in M12, ($r = -.103$, $N = 169$, $P = .180$). However, 7.6% of the participants had a saliva secretion <0.7 mL/min at M12, which is a factor to take into account when considering the results.

A significant reduction in PI from baseline to 6 months was found even for the MMSE low group in the present study. At the same time, BOP increased.

BOP is an inflammatory response initiated by the biofilm³⁵ and is the long-term result of biofilm accumulation at the gingival margin. In contrast, PI is more a snapshot of the individual's oral hygiene performance at a specific time point, possibly explaining the seeming contradiction between BOP and PI values. For example, an intensified oral hygiene before the examination would result in low PI scores but would not affect the BOP scores.

One of the present study's limitations is that it is not a randomised clinical trial.

The present study was planned to last for 24 months. Unfortunately, due to the Covid-19 pandemic, the study had to be discontinued after 12 months. However, over a 12-month period the present study demonstrated that using a powered toothbrush could improve oral health parameters among individuals with MCI.

A longer observation time would have been advantageous to further evaluation of the long-term effect of using a powered toothbrush in this particular patient population. Despite this limitation, it should be highlighted that the present study consists of a relatively large group of individuals with MCI followed for 12 months and that two experienced calibrated examiners performed all examinations. In the present study, the participants received detailed information and instructions on how to handle the powered toothbrush and were motivated to use it regularly. The information, instructions and motivation to use the powered toothbrush combined with twice-yearly examinations may have been essential components for the obtained results. The obtained results in the present study are in line with previously published research³⁶ where participants received repeated instructions on how to use their toothbrushes, resulted in a faster learning curve for a powered toothbrush vs a manual toothbrush. In the present study, the PI and BOP score was higher in the MMSE low group than in the MMSE high group. The higher BOP scores and PI scores found in the MMSE low group are in line with the results from a recent study¹⁷ demonstrating a significant deterioration of BOP and PI scores with an increasing degree of cognitive disease. Even in individuals with MCI, a significant increase in PI was demonstrated compared with a healthy control group. It was also found that toothbrushing decreased following the initial stages of cognitive change, regardless of age, gender, level of education, tobacco or alcohol habits. The present study found that deterioration of oral hygiene could be postponed at least for 12 months when introduced to a powered toothbrush. BOP was also improved, indicating that the introduction

of a powered toothbrush is beneficial for individuals with different grades of MCI and moderate cognitive impairment. For this group of individuals with impaired fine motor skills and sarcopenia, a powered toothbrush may be easier to use than a manual toothbrush with a thin handle. Also, the introduction of new equipment may increase the interest in oral hygiene measures. However, being part of a scientific study may have affected the results, even though it is unlikely to have a long-term effect.

The individuals participating in this study were diagnosed with mild cognitive impairment, and their QoL-AD score significantly decreased during the 12 months. MCI is a transitional period in the borderline between normal cognitive ageing and early dementia. The cognitive, behavioural and functional symptoms seen in dementia can significantly affect individuals QoL and general well-being. Since the symptoms of early dementia are also seen in MCI, one can expect a decrease in QoL also in this group.³⁷ The present study results that even early changes in cognition result in deterioration of QoL is in agreement with other studies results.^{38,39} However, the existing research is disparate, and some studies do not show any difference in QoL in individuals with and without MCI.^{40,41} A recently published literature review⁴² demonstrated that all the included studies showed different associations between cognitive impairment, oral health and QoL. Previous research is sparse in the area, and the available studies are often carried out on participants in institutional living. In the present study, we used two different instruments which measure different dimensions of QoL.

In contrast to QoL-AD, the OHRQoL instrument OHIP-14 indicated an experience of improved quality of life for MMSE high at 6 months and MMSE low at 12 months. Poor oral health has in several studies been associated with low QoL.^{15,43,44} In the present study, despite lower MMSE scores indicating MCI and a decline in QoL-AD score, the obtained improvements in BOP, PI and PPD were associated with improvements in OHRQoL measured by OHIP-14 and is in line with a previous study.⁴⁵ In that study, the experimental group underwent a six-month oral health promotion project, resulting in significant improvements of both BOP and QoL compared with their control group.

In this study, the result obtained after 6 months was maintained for an additional 6 months indicating the long-term effects of introducing a powered toothbrush to individuals with MCI.

Future research and randomised controlled trials are needed to clarify further the impact of using a powered toothbrush among the older population to improve oral health in the long-term perspective.

5 | CONCLUSION

The use of a powered toothbrush was associated with a reduction in PI, BOP and PPD over 12 months even among individuals with low or declining MMSE score. An adequately used powered toothbrush maintain factors that affect oral health and oral health-related quality of life in people with mild cognitive impairment.

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CONFLICT OF INTEREST

Prof. Renvert declares that he has been part of the European Advisory board for Procter & Gamble. The authors declare that there is no conflict of interest regarding the publication of this paper.

AUTHOR CONTRIBUTIONS

Prof. Renvert and Prof. Sanmartin Berglund were involved in planning the project. Dr Flyborg performed the data collection and managed the data collected. All authors analysed the data. Dr Flyborg led the writing. Prof. Renvert, Prof. Sanmartin Berglund and Prof. Anderberg participated in the final manuscript production. All authors revised and accepted the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

There are no visible risks for the participants to take part in the study, and all participants provided written informed consent before entering the study. The participants' identity is coded so that all incoming data is de-personalised, and the code key is stored on a server at BTH. Analysis of the material will take place at the group level. Therefore, no individual participant will be identified when presenting the results. The ethical principles of the research described in the World Medical Association Declaration of Helsinki (WMA, 2013) were followed. The Regional Ethical Review Board in Lund approved the study (Dnr 2018/28).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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