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Effectiveness of oral self-care among adult Gullah-speaking African Americans with diabetes

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Abstract

We investigated the efficacy of plaque removal after an oral self-care demonstration among adult Gullah-speaking African Americans with diabetes. Fiftyfour adults with diabetes completed an observed, uninstructed oral self-care demonstration with their normal mode of oral self-care. Before and after the oral self-care demonstration, the plaque levels of six test teeth were assessed using the Plaque Index. The mean percentage of plaque removal after the oral self-care demonstration was 27.4%. The mandibular teeth and the lingual surface had less plaque removal compared with the maxillary teeth and buccal surfaces. Only approximately 10% of participants achieved 50% or more plaque removal after the oral self-care demonstration. Thus, the majority of the participants did not achieve an acceptable level of plaque removal. Dental health professionals should emphasize better oral home care for people with diabetes and teach them how to access the lingual surfaces, especially of the mandibular teeth.

Plaque removal from all tooth surfaces through regular oral self-care, including toothbrushing and flossing, is essential to prevent the onset or development of inflammatory periodontal diseases and dental caries.^{1,2} However, oral self-care among adults with diabetes is inadequate, particularly when considering their high risk for periodontal diseases.^{3,4} Self-reported twice-a-day toothbrushing among adults with diabetes was less common compared with the general population.^{3,4} Several studies^{5–7} have suggested that adults with diabetes had either no better or worse oral hygiene than the general population. Infrequent interdental cleaning has been shown to contribute to periodontal diseases among adults with diabetes.⁸ Manipulation of a manual toothbrush or floss string to perform thorough oral self-care requires a fair amount of hand dexterity.⁹ Diabetes mellitus has been shown to be associated with hand abnormalities such as Dupuytren's contracture, limited joint mobility, adhesive capsulitis, and flexor tenosynovitis, which are present in 40% to 50% of adults with diabetes.^{10–12} These hand abnormalities were about four times more frequent in diabetic than in nondiabetic individuals.¹⁰ The prevalence of hand abnormalities in individuals with diabetes increases with the duration of diabetes and increasing age.^{11,12} In addition, peripheral neuropathy can also affect the hands

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of diabetic individuals.¹³ Consequently, hand function (such as dexterity, grip, and pinch strength) was significantly decreased in older individuals with diabetes, which may affect their oral self-care such as brushing and flossing.^{14–16}

Based on a meta-analysis conducted by van der Weijden and Hioe,¹⁷ the aim of the majority of the oral self-care studies has been to evaluate the effectiveness of plaque removal ability of different types of toothbrushes. These studies included a homogeneous group of nondisabled young and middle-aged adults (mean age $\approx$ 40 years) with good general and oral health, no physical limitation or restriction to carry out normal oral hygiene procedures, a minimum of 18 to 20 teeth, and no oral prostheses or orthodontic appliances. Few studies have investigated the effectiveness of oral self-care of a specific medical diagnostic group who are prone to oral diseases and hand abnormalities.¹⁸ Given the importance of good oral hygiene among individuals with diabetes and the possibility that hand abnormalities may affect their ability to efficiently remove plaque, the purpose of this pilot study was to investigate the efficacy of plaque removal after an observed, uninstructed routine oral self-care demonstration among adults with diabetes.

Methods

Participants

A convenience sample of 54 (9 male and 45 female) individuals participated in this oral self-care study. The sample was drawn from a pool of 300 Gullah-speaking African American adults who had been diagnosed with diabetes and were part of an epidemiological study.¹⁹ The Gullah language (Sea Island Creole English, Geechee) is a creole language spoken by the Gullah people (also called “Geechees”). They are an African American population living on the Sea Islands and the coastal region of the U.S. states of South Carolina and Georgia. Gullah is based on English, with strong influences from West and Central African languages such as Mandinka, Wolof, Bambara, Fula, Mende, Vai, Akan, Ewe, Yoruba, Igbo, Hausa, Kongo, Umbundu, and Kimbundu. This population is characterized by high rates of type 2 diabetes and diabetic complications.¹⁹

To be eligible for our study, the individuals with diabetes had to be older than 18 years of age, had to have at least one tooth, were cognitively alert (i.e., oriented to time, place, person, and purpose), and were functionally communicative (able to carry on daily conversation). Individuals who required premedication such as antibiotics prior to a dental procedure, were blind, had an upper extremity amputation, or had a history of stroke were excluded. The protocol was approved by the institutional review board and General Clinical Research Center at the Medical University of South Carolina (MUSC). A written, informed consent was obtained from all participants before initiation into the study.

Procedure

One to two days before the study appointment, the participants were contacted by phone and instructed to refrain from doing any oral self-care procedures or using chewing gum for at least 16 hours before the appointment to allow for overnight plaque to build up and to refrain from smoking in the morning of their appointment. The participants were asked to bring to the appointment the toothbrush that they currently used at home. The study was conducted at the research dental clinic within MUSC’s General Clinical Research Center. At the study clinic, the participants completed a questionnaire related to their sociodemographic characteristics, diabetes history, dental care needs, dental utilization, and oral hygiene habits.

The study involved an observation of participants’ oral self-care with an assessment of their dental plaque before and after the demonstration. To measure dental plaque before the

participants' oral self-care demonstration, a dental hygienist dried the participants' teeth with compressed air and then used a cotton swab to apply an erythrosine red disclosing solution to the crowns of the teeth. The dental hygienist then directed the participant to spread the solution over all surfaces of the teeth with the tongue. Plaque was scored using the Plaque Index (PII) 20 that evaluated four tooth surfaces (distal, buccal, mesial, and lingual) of the following six teeth: the maxillary right first molar (tooth 3), the maxillary right lateral incisor (tooth 7), the maxillary left first bicuspid (tooth 12), the mandibular left first molar (tooth 19), the mandibular left lateral incisor (tooth 23), and the mandibular right first bicuspid (tooth 28). Missing teeth were not substituted.²⁰

After the plaque from the six test teeth were scored, the participants were told to carry out their oral self-care as they normally did at home, which may have included brushing with toothpaste and dental flossing. This was done in the dental clinic that had a sink and a mirror above the sink. No instruction in oral self-care procedures or techniques or the amount of time to do the oral self-care was given. Bristles of the toothbrush that the participants brought from home were assessed. Toothbrushes with soft bristles were given to participants who either did not bring a toothbrush or who had toothbrushes with worn bristles. Fluoride toothpaste and floss string in a floss holder were provided to the participants if they requested these items. The dental hygienist observed the participants' oral self-care and recorded whether they used toothpaste and/or flossed their teeth as well as the length of time they brushed. In addition, physical assistance required to perform oral selfcare was documented.

Upon completion of the observed, uninstructed oral self-care demonstration, the participants were reassessed for the remaining plaque on the same six test teeth with the reapplication of the disclosing solution. For consistency, the same trained dental hygienist, familiar with the PII, performed the scoring of plaque in both the pre- and the postoral self-care assessments.²¹ The dental hygienist (examiner) was trained and had completed several pilot trials before conducting the study. An intraexaminer reliability rating was not measured.

Dental Plaque Index

PII was used to record the amount of plaque on each tooth.²⁰ Each of the four surfaces of the teeth (buccal, lingual, mesial, and distal) was given a score from 0 to 3: 0 = no plaque; 1 = a film of plaque adhering to the free gingival margin and adjacent area of the tooth; 2 = moderate accumulation of soft deposit within the gingival pocket or the tooth and gingival margin, which can be seen with the naked eye; 3 = abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin. For a qualitative description of the overall score for the PII, the criteria excellent = 0; good = 0.1 to 0.9; fair = 1.0 to 1.9; and poor = 2.0 to 3.0 were used.

Data analysis

For tooth-surface analysis, the PII scores for the distal and mesial surfaces were pooled for each tooth to obtain the score for the approximal surface. The mean tooth surface PII scores along with its standard deviation (SD) for the three surfaces (buccal, lingual, and approximal) at pre- and postoral self-care demonstrations were then computed from the six test teeth. Pair-wise comparisons among the PII scores for the three tooth surfaces were performed via three two-sided paired *t*-tests.

For individual tooth analysis, the PII scores from the four tooth surfaces were added and divided by 4 to give the mean PII scores for the tooth. The PII scores for teeth 3, 7, and 12 were pooled and averaged to form the mean PII score for the maxillary teeth, and the PII scores for teeth 19, 23, and 28 were pooled and averaged to form the mean PII score for the mandibular teeth.

A two-sided, paired *t*-test for testing the null hypothesis of no difference in the means of the PII scores for the maxillary and mandibular teeth was performed.

To calculate the PII scores for an individual, the PII scores for each of the test teeth were added and divided by the number of teeth assessed (i.e., a value of six, if no teeth were missing). The method of calculation was based on the weighted Toothbrushing Skill Achievement Index score described by Niederman and Sullivan,²² accounting for participants who did not have all six teeth present. The mean PII score along with its SD (pooled from the scores of the four tooth surfaces for each of the six test teeth) for each participant before and after the oral self-care demonstration were calculated. A one-sided, paired *t*-test was performed to test the hypothesis that the postoral self-care PII scores were significantly lower than the preoral self-care PII scores. All statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC), and the type I error rate was set at 0.05.

Since the PII was ranked from 0 (best) to 3 (worst), a participant with an average PII score of 1 on preoral self-care could only improve, at most, by one point, whereas a participant with an average PII score of 3 on preoral self-care could improve by several points. To account for this, the percentage of plaque removal was calculated as the difference in the pre- and postoral self-care PII scores divided by the preoral self-care PII score and multiplied by 100.

Results

Forty-seven participants reported being diagnosed with type 2 diabetes, two with type 1, and five did not know the type of diabetes they had. The mean ($\pm$ SD) years that the participants had been diagnosed with diabetes was 11.8 ± 10.2 years, ranging from less than 1 year to 39 years. The mean ($\pm$ SD) age for the participants was 56.1 ± 11.1 years (range 35 to 87 years). Twenty-one (38.9%) participants were married, 16 (29.7%) had some college education, 23 (42.6%) were employed, with 86.9% of them working full-time, 37 (68.5%) had an annual household income below \$25,000, and 28 (51.9%) reported having private dental health insurance.

Twenty-five (46.3%) participants reported having had a dental cleaning at least once a year. Forty-six (85.2%) participants reported that they had a need for dental care now, of which 28 wanted a dental cleaning. Seventeen (31.5%) participants had less than half the number of natural teeth either in their upper or in their lower jaw. Only 13 (24.1%) participants had all six test teeth. Twenty (37.0%) participants brushed their teeth once a day, and 31 (57.4%) brushed twice or more often a day. Twenty-four (44.4%) participants reported either never flossing or flossing less than once a week, and 21 (38.9%) reported flossing at least once a day, two participants did not bring their toothbrush to the study clinic. Twelve participants claimed to use a medium- (7 participants) or firm- (5 participants) bristled toothbrush at home.

Twenty-one (38.9%) participants' toothbrushes were judged to be worn. Twenty-seven participants were given a new toothbrush, of which eight used a medium- or firm-bristled toothbrush at home. During the study, all participants used toothpaste when brushing their teeth. Eight participants required physical assistance to perform oral self-care (including help to open toothpaste cap and squeezing toothpaste onto toothbrush), and none of these participants flossed. Only two participants reported using an electric toothbrush at home. However, these two participants did not require any assistance in using a manual toothbrush and regular dental floss during the study.

The mean ($\pm$ SD) duration of brushing time was 1 minute and 19 ± 27 seconds, ranging from 30 seconds to 2 minute and 10 seconds, with about 70% of participants brushing for 1 minute and 30 seconds or less. Twentyfour (44.4%) participants did not floss during the observed oral self-care demonstration, which was the same number as those who reported less than once a

week flossing or never flossing in the questionnaire. Table 1 shows the demographic characteristics and oral hygiene habits of the participants divided into three age groups—young adults (≤ 44 years old, $n = 10$), middle-aged adults (45 to 64 years old, $n = 33$), and older adults (≥ 65 years old, $n = 11$). Surface- and tooth-based analyses The mean and SD of the pre- and postoral self-care PII scores for the three surfaces and the percentages of plaque removal are listed in Table 2. The buccal surface had the lowest preoral self-care PII score, followed by the lingual and approximal surfaces. For the percentage of plaque removal, the buccal surface was the highest (38%), with the lingual displaying the least change (22%). The results of the three paired *t*-tests are displayed in Table 3. The percentage of plaque removal on the buccal surface after the oral self-care was significantly different from that on the lingual and approximal surfaces ($p < .001$), whereas the percentage of plaque removal on the lingual and approximal surfaces was not significantly different from each other ($p = .09$). The mean and SD for the pre- and postoral self-care PII scores along with the percentage of plaque removal for each of the six teeth examined are listed in Table 4. Teeth 3, 7, and 12 (the three maxillary teeth) had the three lowest mean PII scores at preoral self-care and the three lowest mean PII scores at postoral self-care. Even though the three maxillary teeth (teeth 3, 7, and 12) had a lower PII score at both pre- and postoral self-care than the three mandibular teeth (teeth 19, 23, and 28), the mean percentages of plaque removal were similar ($t_{39}, 0.05 = 1.40, p = .17$). Teeth 3 and 7 had the highest mean percentage of plaque removal (30%), and tooth 19 had the lowest (22%).

Subject-based analyses

A plot of the mean preoral self-care PII score versus the mean postoral self-care PII score for each participant is shown in Figure 1. The Pearson product-moment correlation coefficient between the pre- and postoral self-care PII scores was 0.89 ($p < .001$). The means ($\pm$ SDs) of the PII scores for the participants at pre- and postoral self-care demonstrations were 1.87 ± 0.52 and 1.39 ± 0.55 , respectively. The mean ($\pm$ SD) of the differences between pre- and postoral self-care PII scores was 0.48 ± 0.25 , with a 95% confidence interval (CI) of 0.42 to 0.55, which was significantly greater than 0 ($t_{53}, 0.05 = 13.91, p < .001$). Qualitatively, the PII score remained in the category of “fair” after the oral self-care demonstration. The percentage of plaque removal among all participants ranged from 0% to 75%, with a mean ($\pm$ SD) of $27.43 \pm 15.97\%$ (95% CI of 1% to 54%). Two participants had no improvement after the oral self-care, and six (11%) had at least 50% of plaque removal, with only one reaching 75% improvement. There was no significant difference in the percentage of improvement in plaque removal between participants who used their own toothbrush and those who used a toothbrush supplied by the study clinic ($t_{52}, 0.05 = 0.15, p = .882$).

Discussion

As expected, statistically significantly lower dental plaque scores were recorded immediately after the oral self-care demonstration. However, the mean percentage of plaque removal was only 27.4% after the oral self-care demonstration in our study compared with the 40% to 55% plaque removal after 1 minute of brushing with a manual brush in the general (young or middle-aged) healthy, nondisabled population, as reported in the meta-analysis study.¹⁷ In addition, the PII score remained in the category of “fair” after the oral self-care demonstration. Clinically, most of the participants did not achieve sufficient plaque removal after the oral self-care demonstration—only approximately 10% of them had 50% or more plaque removal. In our study, plaque removal during observed oral self-care was relatively low.

The percentage of plaque removal would be even smaller when the participants completed their oral self-care at home. The percentage of plaque removal on the buccal surface was higher than that of the approximal and lingual surfaces after the self-care demonstration, with the lingual surface having the least improvement, which is consistent with a previously reported study.

²³ Even though the percentage of plaque removal on each of the three mandibular teeth was lower than that of each of the three maxillary teeth, no significant difference was observed in the percentage of plaque removal between the mandibular and the maxillary teeth. This may have been due to 37 (68.5%) participants with missing tooth 19, which had the lowest percentage of plaque removal. The mean percentage of plaque removal for the three mandibular teeth was therefore weighted more heavily on tooth 23, which had the highest percentage of plaque removal among the three mandibular teeth.

Since both the mandibular teeth and the lingual surface were recorded as having a smaller improvement in plaque removal among these adults with diabetes, dental health professionals need to emphasize better home care for this population. These patients need to be taught how to thoroughly remove plaque from their mandibular teeth and the lingual surfaces by providing instruction/education of proper brushing and flossing techniques when using a regular toothbrush and dental floss.

Limitations

There are several limitations in the research design that may have affected the validity of the study results. First, despite the fact that the dental hygienist (examiner) was trained and had completed several pilot trials before conducting this study, the validity of the study would improve if one examiner scored the PII and a different dental hygienist evaluated the participants' skill performance in oral self-care. Second, the intrarater reliability for the examiner to score the PII was not determined. Third, including another PII measure, such as Turesky's modification of the Quigley–Hein Plaque Index²⁴ or the Modified Navy Index,²⁵ may have enabled comparison of the results of this study to a larger selection of results in the literature. Fourth, this study lacked a control, as it was a one-group, pre-post observational design without a comparison group of age-matched adult Gullah-speaking African Americans who did not have diabetes.

Recommendations

For most individuals, brushing the lingual surfaces and flossing with regular dental floss require greater manual dexterity than brushing only the buccal surfaces. To confirm the impact of impaired manual dexterity (i.e., those needing physical assistance) among adults with diabetes on oral self-care efficacy (i.e., plaque removal), a larger sample size would be needed with a carefully matched comparison group of adult Gullah-speaking African Americans without diabetes. The inclusion of a standardized hand function assessment or an assessment of the participants' oral self-care, such as the Index of Activities of Daily Oral Hygiene, would also be essential.²⁶

We suggest that dental health professionals recommend electric toothbrushes with a builtin timer that allows brushing for 2 minutes for adults with diabetes who experience physical challenges in completing their oral self-care. The greatest benefit of powered brush has been reported to be on the mandibular and lingual surfaces.²⁷ Powered toothbrushes, which include rechargeable oscillating/ rotating or battery-operated models, are superior to manual toothbrushes for plaque removal.^{28,29} Even a batterypowered toothbrush (which is more affordable) has been shown to improve plaque removal scores by 32.8% when compared with a manual toothbrush.³⁰ An adapted interdental cleaning device such as a dental flosser and/or an oral irrigator could also be recommended because adults with diabetes who have manual dexterity deficits typically do not floss.

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Figure 1.
Plot of mean preoral self-care PII score versus mean postoral self-care PII score for each participant (n = 54).

Table 1
Demographic characteristics and oral hygiene habits of participants divided into three age groups.

	Young adults (≤44 years old, n = 10)	Middle-age adults (45–64 years old, n = 33)	Older adults (≥65 years old, n = 11)
Female	7 (70%)	28 (85%)	10 (91%)
Brush once a day	1 (10%)	16 (48%)	3 (27%)
Brush ≥2 times daily	8 (80%)	15 (45%)	8 (73%)
Never floss	4 (40%)	11 (33%)	4 (36%)
Floss >1 time daily	1 (10%)	18 (55%)	2 (18%)
Required physical assistance in oral hygiene	0 (0%)	5 (15%)	3 (27%)

Table 2

Mean and standard deviation of the plaque score (PII) for pre- and postoral self-care and percentage of plaque removal for each of the three surfaces of the teeth examined.

Tooth surface	Mean preoral self-care score (std. dev.)	Mean postoral self-care score (std. dev.)	Mean percentage of plaque removal (std. dev.)
B	1.60 (0.54)	1.06 (0.64)	37.91 (27.61)
A	1.98 (0.54)	1.49 (0.53)	25.13 (14.60)
L	1.90 (0.56)	1.49 (0.60)	22.28 (16.65)

B = buccal; A = approximal; L = lingual.

Table 3

Comparison of the mean difference in the percentage of plaque removal among the three tooth surfaces.

Tooth surface comparison	Mean difference (std. dev.)	<i>t</i> -value	df	<i>p</i> value
B vs. L	15.89 (24.86)	4.33	45	<.001
B vs. A	12.93 (24.67)	3.78	51	<.001
L vs. A	3.86 (15.06)	1.72	44	.09

B = buccal; A = approximal; L = lingual.

Table 4

Mean and standard deviation of the plaque score (PII) for pre- and postoral self-care and percentage of plaque removal for the teeth examined.

Tooth position(s)	n	Mean preoral self-care score (std. dev.)	Mean postoral self-care score (std. dev.)	Mean percentage of plaque removal (std. dev.)
3	28	1.74 (0.53)	1.21 (0.48)	30.01 (20.02)
7	43	1.56 (0.62)	1.11 (0.56)	29.96 (23.75)
12	38	1.68 (0.60)	1.22 (0.49)	26.80 (20.84)
19	17	1.91 (0.67)	1.46 (0.53)	22.23 (14.59)
23	48	2.00 (0.53)	1.49 (0.62)	27.02 (21.44)
28	45	2.08 (0.55)	1.57 (0.58)	24.58 (19.64)
Maxillary arch	45	1.68 (0.57)	1.21 (0.50)	28.39 (18.67)
Mandibular arch	49	2.03 (0.54)	1.52 (0.61)	27.22 (17.34)