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The impact of powered toothbrushing on patients with Diabetes

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The Impact of Powered Toothbrushing on Patients with Diabetes

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by

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The Impact of Powered Toothbrushing on Patients with Diabetes

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The Impact of Powered Toothbrushing on Patients with Diabetes

Human Subjects Approvals

TO: Kristian Carrasco - Masters of Dental Hygiene program

FROM: Dr. Theresa J. Martin, Chair – EWU IRB Human Subjects

DATE: Feb 16, 2021

SUBJECT: IRB approval of Effect of Powered Toothbrushing on Blood Glucose (HS-5985)

Human subjects protocol HS-5985 entitled "Effect of Powered Toothbrushing on Blood Glucose" has been approved as a non-exempt research project from federal regulations under 45 CFR Part 46.104 per our email discussions regarding appropriate edits to the original application.

The Impact of Powered Toothbrushing on Patients with Diabetes

Abstract

Purpose: Studies have shown that periodontal therapy can help manage diabetes and that powered toothbrushes promote better home care. However, there is no literature making the connection whether powered toothbrushes could assist in blood glucose management in diabetic patients. The primary aim for this study was to evaluate the efficacy of brushing with a powered toothbrush in patients with diabetes mellitus.

Methods: This clinical study included 8 ($N = 8$) adult participants from Willamette Dental group in Richland, WA. The individuals were asked to participate in a 6-week study testing whether brushing with a powered toothbrush affected their blood glucose levels and their perception on diabetes self-management. Each person in the study brushed with a manual toothbrush for one week and then brushed with a powered toothbrush for five weeks. Participants were asked pre- and post-questions on their diabetes management, brushing habits and on questions related to their blood glucose. Submissions were anonymously entered using an online survey software known as SurveyMonkey.

Results: There was no statistically significant difference in blood sugar week-to-week or between week 1 and week 6 according to the p values. The p values resulted in $p > .05$ for all weeks analyzed. The findings for this study regarding the pre- and post-self-management survey indicated no statistical significance as well. The perception of brushing twice daily was the closest to having significance with a p value of $p = 0.59$ from the pre to the post Diabetes Self-Management Questionnaire.

Conclusion: Results of the study showed no significance effect in using a powered toothbrush for oral home care in attempting to manage blood glucose readings for

diabetic patients. However, there was perceived improvement in self-management of diabetes. Future research is needed to determine the correlation between powered toothbrushes and diabetes.

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The Impact of Powered Toothbrushing on Patients with Diabetes

Table of Contents

List of Figures

Figures

List of Tables

Tables

Introduction/Literature Review

Introduction to the Research Question

Diabetes Mellitus (DM) is a group of metabolic disorders that is characterized by elevated levels of glucose in blood (hyperglycemia) and insufficiency in production or actions of insulin produced by the pancreas inside the body (Maritim et al., 2003). Diabetes can be divided into two different categories Type 1 and Type 2.

Type 1 Diabetes Mellitus (T1DM) is caused by an absolute deficiency of insulin secretion (American Diabetes Association [ADA], 2013). Type 1 Diabetes Mellitus results from a cellular-mediated autoimmune destruction of beta cells in the pancreas. This form of diabetes has a variable rate on beta-cell destruction (American Diabetes Association, 2013).

Type 2 Diabetes Mellitus (T2DM) is more prevalent. The cause of T2DM is a combination of resistance to insulin action and an inadequate compensatory insulin secretory response (American Diabetes Association, 2013). The World Health Organization (WHO) estimates that there are almost 200 million people with diabetes and approximately 85% of those have T2DM (Cinar et al., 2012). Type 2 Diabetes Mellitus (T2DM) is referred to as non-insulin dependent diabetes (American Diabetes Association, 2013). Most patients with T2DM are obese unlike with T1DM, where autoimmune destruction of beta-cells does not occur (American Diabetes Association, 2013). Type 2 Diabetes Mellitus (T2DM) is typically diagnosed in obese, middle-aged individuals, and it is characterized by progressively worsening hyperglycemia accompanied by disturbances of carbohydrate, fat, and protein metabolism

(Kallikazaros, 2013). In T2DM, insulin secretion is defective and insufficient to compensate for insulin resistance. Insulin resistance can improve with weight reduction and/or pharmacological treatment of hyperglycemia. Common risks for developing T2DM are age, obesity, and lack of physical activity (American Diabetes Association, 2013).

Established patient self-management tools, such as self-monitoring blood glucose, are now being used in tandem with information technology and telecommunications to prove a more integrated management of the disease (Chow et al., 2016). Diabetes treatment includes lifelong insulin use, blood sugar monitoring, diet, and exercising (Whiteman, 2019). Treatment for T1DM also includes monitoring diet and exercising while T2DM involves medication. Metformin is one of the most popular oral glucose-lowering medications, widely considered to be the optimal initial therapy for patients with T2DM (Sanchez-Rangel & Inzucchi, 2017).

Periodontal disease is a disease of the periodontal tissues that results in attachment loss and destruction of alveolar bone (Highfield, 2009). Periodontal disease typically involves inflammatory response to dental plaque (Ccahuana-Vaszquez et al., 2019). Ccahuana-Vaszquez et al. (2019) also states that gingivitis is prevalent in approximately 80% of the population; gingivitis is the earliest stage of periodontal disease.

Poor oral health and poor diabetes management both negatively contribute to glycemic control (Cinar et al., 2012). Ultimately, this proposed study aimed to decrease diabetes complications by providing empirical data on how proper oral home care with a powered toothbrush may assist in maintaining or lowering blood sugar levels. This study

will attempted to establish whether proper oral home care with a powered toothbrush had a clinical effect on blood sugar and self-management in adults with diabetes.

Statement of Problem

Studies have been conducted in relation to diabetes and periodontal health; however, there have not been studies on the correlation between oral home care and glucose levels in diabetic patients. Diabetic management may be improved by using powered toothbrushes; however further research is needed. Monitoring blood glucose is vital to a person with diabetes. Diabetes is managed in many ways including medications, diet, and exercise. Longitudinal studies have been conducted showing a relationship between periodontal disease and diabetes. Results of these studies show poorer glycemic control in diabetics with periodontal disease (Llambes et al., 2015). Evidence has shown that several risk factors such as diabetes and poor oral hygiene are related to periodontal diseases (Llambes et al., 2015). Periodontal therapy has been shown to improve glycemic control in T2DM subjects (Nazir, 2017). Therefore, proper oral home care may assist in maintaining healthy blood glucose levels.

The terms “electric” and “powered” are used interchangeably in regard to toothbrushes. A powered toothbrush consists of an electromotor handle that converts electricity into a mechanical action that is transferred to a shaft that propels the brush head (Elkerbout et al., 2020). Previous studies have been conducted on manual toothbrushing versus powered toothbrushing to show which reduces plaque the best to improve oral health. Kurtz et al. (2016) conducted a randomized clinical trial comparing the plaque removal efficacy of an oscillating-rotating power toothbrush to that of a manual toothbrush. The results of this study showed that powered toothbrushes with a

rotation-oscillation action removed plaque and reduced gingivitis more effectively than manual toothbrushes in the short-term and reduced gingivitis scores in studies over 3 months.

Jain et al. (2019) conducted a meta-analysis from two databases MEDLINE and EMBASE. The analysis aimed to explore the effect of non-surgical periodontal therapy on glycemic control in patients with T2DM. Based on the findings, scaling and root planning treatment resulted in a decrease in HbA1c by 0.26% ($P = 0.17$) at 3–4 months compared to the control group. Patients who have periodontal disease and receive periodontal treatment such as Scaling and Root Planing have shown improved blood sugar readings. There is a gap in the research regarding the relationship of blood glucose in diabetic patients and the use of a powered toothbrush. In order to address this deficiency, this study sought to answer the following question: Will using a powered toothbrush have an effect on blood glucose levels and self-management in adults with Type I and Type II Diabetes Mellitus?

Overview of Research

Diabetes

Diabetes Mellitus is a group of metabolic diseases characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both (Kharroubi & Darwish, 2015). The prevalence of diabetes in adults according to a report published in 2013 was 382 million people with 198 million being men and 184 million being women (Kharroubi & Darwich, 2015). There are several types of diabetes but only two will be evaluated for the purpose of this study. According to the American Diabetes Association (ADA) (2020) diabetes can be classified as Type 1 and Type 2. Type 1

diabetes is due to autoimmune beta cell destruction that usually leads to absolute insulin deficiency. Type 2 diabetes is due to a progressive loss of adequate beta cell insulin secretion frequently on the background of insulin resistance.

The ADA (2020) also states that T1DM and T2DM classification is very important to determine therapy. Diabetes can be diagnosed in three methods which involve plasma glucose criteria. The first method involves a fasting plasma glucose for eight hours with no caloric intake and diagnostic reading is fasting plasma glucose of lesser or equal to 126 mg/dL (7.0 mmol/L). The next test can be a two-hour plasma glycose value during a 75-g oral glucose tolerance test, test result should be less are equal to 200 mg/dL (11.1 mmol/L). The last test is the A1C test which is performed in a laboratory; results for diabetes are if the A1C is less or equal to 6.5% (48 mmol/mol).

Type 1 diabetes accounts for 5-10% of all diabetes (ADA, 2020). Type 1 diabetes is mainly due to an autoimmune destruction of the pancreatic beta cells through T-cell mediated inflammatory response as well as humoral response (Kharroubi & Darwish, 2015). Symptoms that develop with T1DM include polydipsia, polyuria, enuresis, lack of energy, extreme tiredness, polyphagia, sudden weight loss, slow-healing wounds, recurrent infections and Blurred vision (Kharroubi & Darwish, 2015).

Type 2 diabetes accounts or 90-95% of all diabetes (ADA, 2020). Prevention of T2DM includes early identification of impaired glucose tolerance, coupled with weight loss and physical interventions (Fonseca et al., 2012). A diabetes prevention program sponsored by the National Institute of Diabetes and Digestive and Kidney Disease demonstrated that lifestyle modification or treatment with Metformin could delay the incidence of developing diabetes by 58% and 31% (Fonseca et al., 2012). The same

program also indicated that modest weight loss could minimize the risk. According to Fukunaga et al. (2011) in 2007, the estimated national cost of diabetes exceeded one hundred and seventy-four billion. This data included $116 billion in diabetes related medical cost and $58 billion in reduced production due to employee being absent, disabled or deceased.

One of the important oral signs of diabetes is gingivitis and periodontitis. Patients with undiagnosed or poorly controlled T1DM or T2DM are at higher risk for periodontal disease. There are many studies that demonstrate an association between diabetes and an increased susceptibility to oral infections including periodontal disease. Periodontitis also progresses more rapidly in poorly controlled diabetics, and early onset of the disease is seen as a risk factor for more severe diseases. Conversely, most well-controlled diabetic patients can maintain periodontal health and will respond favorably to periodontal therapy (AlJehani, 2014).

Pihlstrom et al. (2005) state that people who have T1DM at all ages and T2DM in adults have more widespread or severe periodontal disease versus people who are non-diabetic. There are modifiable and non-modifiable risk factors associated with the development of periodontal disease. Diabetes and periodontal disease are not curable but can be controlled or maintained. A review of the literature by Kinane and Chestnutt (1997) found considerable evidence to suggest that diabetes and periodontitis have a direct relationship. According to Tervonen and Karjalainen (1997) plaque and oral hygiene are also modifiable risk factors for the progression of periodontal disease. Tervonen and Karialainen (1997) also confirm a close relationship between plaque and gingivitis.

The Impact of Powered Toothbrushing on Patients with Diabetes

Periodontal Disease

Periodontal disease is referred to as common inflammatory disorders known as gingivitis and periodontitis, which are caused by a pathogenic microbiota in the subgingival biofilm. These microbiota include *Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans ,Tannerella forsythia* and *Treponema denticola* that trigger innate, inflammatory, and adaptive immune responses (Silvia et al., 2015). The process of periodontal disease results in destruction of tissues surrounding and supporting teeth.

According to Preshaw (2015) periodontal disease is regarded as a non-resolving chronic inflammation that is initiated and perpetuated by the subgingival bacteria and that gingivitis is a reversible condition. Preshaw (2015) also states that inflammation can be controlled by improving oral hygiene and reducing the bacterial biofilm. The results of not improving oral hygiene is periodontitis. Loss of attachment is what differentiates periodontitis and gingivitis. Periodontitis results in increased probing depths, resorption of alveolar bone, and the tissue damage that is irreversible (Preshaw, 2015). Prevalence according to Preshaw (2015) estimated that 5-15% of adults in have severe chronic periodontitis, moderate periodontitis within the range of 30-50% of adults, and gingivitis affecting the great majority (e.g. >75%) of people. Cases of periodontitis are defined in Figure 1.

According to Silvia et al. (2015) the first line of defense against periodontal disease is the innate immune response. To summarize, the immune response is triggered when invading microorganisms are identified as non-self. Innate immunity does not work alone as they also involve adaptive immunity cells and characteristic cytokines

have a factor in periodontal disease pathogenesis. T cell-mediated adaptive immunity is dependent on innate immunity antigen presenting cells which then undergo maturation and migrate towards lymph nodes. Once at the lymph nodes, they produce cytokines that ultimately polarize and activate specific T CD4+ lymphocytes.

Figure 1

Periodontal Case Definitions

Case definitions for denoting periodontitis in epidemiological studies

Authors/context	Case severity	Case definition
Tonetti & Claffey, 2005. Consensus report of the 5th European Workshop on Periodontology [28]	Mild/incipient cases	Presence of proximal attachment loss of ≥ 3 mm in ≥ 2 non-adjacent teeth
	Severe cases	Presence of proximal attachment loss of ≥ 5 mm in ≥ 30% of teeth present
Page & Eke, 2007. US Centre for Diseases Control and Prevention (CDC) and American Academy of Periodontology (AAP) [27,29]	Mild periodontitis	Two or more interproximal sites with attachment loss ≥ 3 mm and two or more interproximal sites with probing depths ≥ 4 mm, not on the same tooth, or one site with probing depth ≥ 5 mm
	Moderate periodontitis	Two or more interproximal sites with attachment loss ≥ 4 mm, not on the same tooth, or two or more interproximal sites with probing depths ≥ 5 mm, not on the same tooth
	Severe periodontitis	Two or more interproximal sites with attachment loss ≥ 6 mm, not on the same tooth, and one or more interproximal sites with probing depth ≥ 5 mm

Note. Cases of periodontitis from mild to severe (Preshaw, 2015).

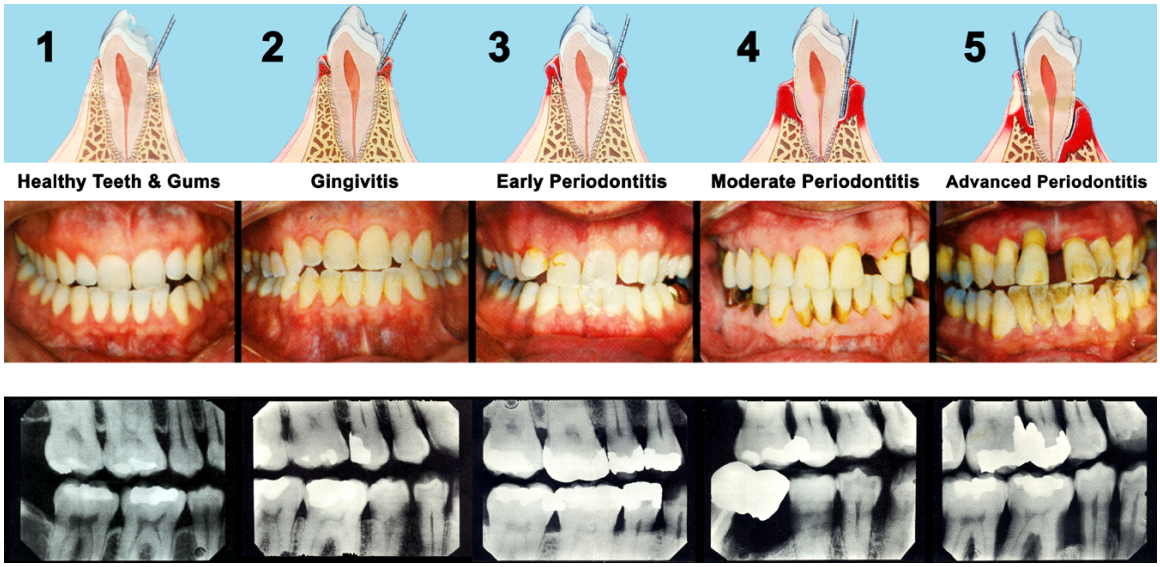
Silvia et al. (2015) discussed that the etiology of periodontal disease includes pathogenic microbiota in the subgingival biofilm. Cytokines and chemokines are then produced by the epithelium which then results in adhesion molecules, increase in the permeability of the gingival capillaries and chemotaxis of polymorphonuclear neutrophils through the junction epithelium and into the gingival sulcus. The periodontal pocket forms when this process is continued where the inflammation extends deep into the tissues and causes loss of supporting connective tissues and alveolar bone.

Dental plaque is the primary cause of gingivitis, which is recognized by redness of the gingiva at the junction with the teeth, together with slight swelling and bleeding

from the gingival margin (Yaacob et al., 2014). Gingivitis is generally regarded as a site-specific inflammatory condition initiated by dental biofilm accumulation and characterized by gingival redness, edema, with no periodontal attachment loss (Trombelli et al., 2018). Gingivitis can be reversed once the dental biofilm is removed. The process of healthy periodontium to advanced periodontitis can be seen here (see Figure 2).

Figure 2

Stages of Periodontitis



Note. Healthy gingiva to advanced periodontitis from left to right (https://gpdentalpartners.com.au/education/gum-disease/) .

Periodontal diseases are a diverse family of oral health conditions affecting the periodontium. Gingivitis can progress to involve the periodontal membrane called periodontitis. A pocket between the gingiva and the tooth forms, and with further destruction bone supporting the tooth is eroded (Yaacob et al., 2014). There are modifiable and non-modifiable risk factors associated with periodontal disease. AlJehani (2014) points out that the oral bacterial microbiome includes over 700 different phylotypes, with approximately 400 species found in subgingival plaque. The subgingival

microflora in periodontitis can harbor hundreds of bacterial species but only a small number has been associated with the progression of disease and is considered etiologically important. Subgingival plaque from deepened periodontal pockets is dominated by gram-negative anaerobic rods and spirochetes. Strong evidence has implicated *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* in the pathogenesis of adult periodontitis. In addition, *Bacteroides forsythus*, *Prevotella intermedia, Peptostreptococcus micros,* and *Fusobacterium nucleatum* have been strongly linked with the progression of adult periodontitis (AlJehani, 2014).

AljeHani (2014) found several studies that show the prevalence and severity of periodontal disease increase with age. Papapanou et al. (1989) demonstrated that the mean annual rate of bone loss among the initially 70-year-old subjects was 0.28 mm compared to 0.07 on the 25-year-old individuals. Papapanou et al. (1989) also state that the increased severity of periodontal disease and bone loss with age is probably related to the length of time for which the periodontal tissues have been exposed to bacterial plaque. More studies carried out in some of the developed countries show changing patterns of periodontal disease progression. These studies found by Papapanou et al. (1989) have shown that advanced periodontal destruction and bone loss are seldom seen in individuals under the age of 40. A similar finding has been observed even in the elderly population. Studies among the elderly have shown that advanced periodontal disease affects only a small fraction of this age group. However, among those with advanced disease, further breakdown does occur with increasing age.

AlJehani (2014) states that numerous studies reported higher periodontal destruction among males compared to the female population. The reasons for these sex

differences are not clear. However, the relationship observed between sex and the disease is not apparent and is not considered strong nor consistent. Thus, sex may be a demographic factor, which may interfere with the effects of other factors and, it must be controlled for investigating the disease.

Oral Home Care

There have been many debates on oral home care when it comes to manual toothbrushing versus powered toothbrushing. According to recent studies, powered toothbrushes have overwhelmingly proven to be more effective in plaque removal than manual toothbrushes (Petker et al., 2019). A variety of powered toothbrushes that use different types of head movements are available which include side-to-side, counter oscillation, rotation oscillation, circular, and ultrasonic (ADA, 2019).

In 2019, Petker et al. (2019) conducted a six-month cross-sectional study to evaluate oral cleanliness in daily users of powered versus manual toothbrushes. For the study, (N = 115) University students were asked to clean their teeth to the best of their abilities by using their own devices. This included n = 55 students using powered toothbrushes and n = 60 students using manual toothbrushes. Plaque was assessed prior to and immediately after brushing. No differences between groups were found with respect to plaque before and after brushing, clinical parameters and overall brushing duration (all $p > .05$, all $d < .156$).

In contrast to the study conducted by Petker et al. (2019), a systematic review and meta-analysis of single brushing exercises was conducted by Elkerbout et al. (2020) to see how effective a powered toothbrush was compared to a manual toothbrush. Elkerbout et al. (2020) searched MEDLINE-PubMed and Cochrane-CENTRAL for studies.

The Impact of Powered Toothbrushing on Patients with Diabetes

Inclusion criteria included adults 18 years of age and older in good general health and without periodontitis, orthodontic treatment, implants and/or removable prosthesis. Studies evaluating a powered toothbrush compared with a manual toothbrush in a single brushing exercise were included. Plaque scores were assessed according to the Quigley-Hein plaque index (Q&HPI) or Rustogi modified Navy plaque index (RMNPI). Independent screening of 3450 unique papers resulted in 17 eligible publications presenting 36 comparisons. In total, 28 comparisons assessed toothbrushing efficacy according to the Q&HPI and eight comparisons used the RMNPI. Results showed a significant effect in favor of the powered toothbrush. The difference of Means (DiffM) was −0.14 ($p < .001$; 95% CI [−0.19; −0.09]) for the Q&HPI and −0.10 ($p < .001$; 95% CI [−0.14; −0.06]) for the RMNPI, respectively. The sub analysis on the oscillating-rotating mode of action showed a DiffM −0.16 ($p < .001$; 95% CI [−0.22, −0.10]) for the Q&HPI. For the side-by-side mode of action using RMNPI, the DiffM showed −0.10 ($p < .001$; 95% CI [−0.15; −0.05]). The sub analysis for brands showed for the P&G oscillating-rotating powered toothbrush using the Q&HPI a DiffM of −0.15 ($p < 0.001$; 95% CI [−0.22; −0.08]) and the Colgate side by side for RMNPI showed a DiffM of −0.15 ($p < .001$; 95% CI [−0.18; −0.12]). Results indicate that the use of a powered toothbrush was more effective than the manual toothbrush with respect to plaque removal following a single brushing exercise.

Ccahuana-Vasquez et al. (2018) conducted a five-week randomized clinical evaluation of a novel electric toothbrush head with regular and tapered bristles versus a manual toothbrush for reduction of gingivitis and plaque. Ccahuana-Vasquez et al. (2018) conducted a randomized, examiner-blind, parallel group, five-week study where

participants with mild-to-moderate plaque and gingivitis received an oral examination and were evaluated for baseline plaque. Qualifying participants were randomly assigned to the novel Oral-B sensitive brush head on an Oral-B Vitality oscillating-rotating handle or an ADA manual toothbrush. Participants brushed twice daily with the assigned brush and a standard fluoride dentifrice for 5 weeks before returning for an oral examination and plaque evaluation. The study had $N = 150$ participants with an average age of 45.7 years. Both brushes demonstrated a statistically significant reduction versus baseline using the RMNPI ($p < .001$).

Kurts et al. (2016) completed a replicate-use, single brushing, examiner-blind, randomized, two-treatment, four-period crossover clinical trial involving four examiners. The study aimed to determine whether multiple examiners could demonstrate consistent removal advantages for an oscillating-rotating powered toothbrush versus a manual toothbrush. This study included 95 ($N = 95$) subjects between the ages of 18-70. At each of the four visits, subjects arrived having abstained from oral hygiene for 24 hours prior, and brushed with their assigned toothbrush marketed fluoride dentifrice under supervision unaided by a mirror. Plaque was assessed by each examiner using the Turesky-Modified Quigley-Hein Plaque Index at each study period before and after brushing. Data was analyzed separately for each examiner using the analysis of covariance for crossover design. Out of the 95, only 87 subjects completed all four periods of the study. Both toothbrushes resulted in significant plaque reduction when compared to baseline. Significant treatment differences were observed for all four examiners ranging from 0.10 to 0.16 in favor of the oscillating-rotating brush ($p < .001$).

The Impact of Powered Toothbrushing on Patients with Diabetes

A randomized controlled trial was conducted by Vibhute and Vandana (2012) on comparing manual and powered toothbrushes. The result from Vibhute and Vandana (2012) identified three trials with full articles. In the first study, Oral-B powered toothbrushes showed 86 % (1.77+/- 0.39 SD) reduction of plaque index and 95% reduction in bleeding index whereas a manual toothbrush showed 85% (1.72 +/- SD) of reduction in plaque index and 90% reduction in bleeding index. The second study compared ultrasonic and manual brushes. In this study findings reported significant reduction of plaque index (50% and 60%) and bleeding index (35% and 26%). In the last study, ionic and manual brushes were compared. In this study findings reported significant reduction of plaque index (83% and 17%) and bleeding index (97% and 33%).

A meta-analysis was conducted by Yaacob et al. (2014) to compare manual and powered toothbrushes in everyday use. Electronic databases that were searched included the Cochrane Oral Health Group's Trials Register, the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE and CINAHL. Selection criteria included finding randomized controlled trials of at least four weeks of unsupervised powered toothbrushing versus manual toothbrushing for oral health in children and adults. Fifty-six trials were used and 4,624 (N = 4,624) participants were involved in these trials. Trials were separated into short term (follow-up between 28 days and three months) and long term (follow-up beyond three months). There was moderate quality evidence that powered toothbrushes provided a statistically significant benefit compared to manual toothbrushes regarding the reduction of plaque in both the short term and long term. Short term (standardized mean difference (SMD) -0.50 (95% confidence interval (CI) -0.70 to -0.31); 40 trials, n = 2871) and long term (SMD -0.47 (95% CI -0.82 to -0.11; 14

trials, n = 978) (Yaacob et al., 2014). These results correspond to an 11% reduction in plaque for the Quigley Hein index (Turesky) in the short term and 21% reduction long term.

Ccahuana-Vaszquez et al. (2019) conducted a 5-week study to evaluate reduction of gingivitis and plaque using comparisons of an electric toothbrush versus a manual toothbrush. The result of the study concluded that the electric toothbrush creates significantly greater reductions in gingival inflammation, number of bleeding sites, and plaque.

Self-care & Diabetes

Patients with diabetes have a three to fourfold increased prevalence of severe periodontitis, and the severity of periodontitis is associated with poor glycemic control (Dale et al., 2014). The most recent Adult Dental Health Survey (2009) reported that 75% of dentate adults aged 55–64 years had signs of periodontitis (pocket depth or loss of attachment of ≥4 mm), and this increased to 82% in the 75–84 years group. Dale et al. (2014) discusses the importance of considering oral health, and in particular the prevention of moderate to severe periodontitis, as part of diabetes management, which includes self-performed plaque control, such as brushing, flossing, and attending the dentist for regular dental check-ups. Oral manifestations of type T2DM can be prevented through several approaches that are aimed at ensuring proper brushing and flossing behaviors, encouraging patients to visit the dentist for a routine check-up and controlling blood glucose levels (Nazir et al., 2018).

The Impact of Powered Toothbrushing on Patients with Diabetes

Summary

Powered toothbrushes have shown to be beneficial in the removal of plaque and improving oral health. Although diabetes management has been improved by using lifestyle changes such as diet, exercise, or medications, there are still other factors such as oral home care that have not yet been studied. There are no studies connecting the relationship between homecare and diabetes and that is the goal for this study. This study will attempt to determine the efficacy of brushing with powered toothbrushes and concluding if blood sugar in diabetic patients decreased.

Methodology

Research Method or Design

Research methodology for this pilot study was from a quantitative perspective utilizing a convenience sampling of volunteers from patients at Willamette Dental Group located in Richland, WA. The relationship between blood glucose and proper oral home care using powered toothbrushing was explored through a non-randomized experimental study design. This pilot study was conducted to monitor blood sugar changes and diabetes self-management in adult participants with the use of a powered toothbrush. This study included 8 ($N = 8$) adult T1DM or T2DM patients who currently only use manual toothbrushes and the study was six weeks in length.

Procedures

Human Subjects Protection/Informed Consent

Approval from Eastern Washington University (EWU) Internal Review Board (IRB) was obtained prior to beginning the study (HS-5985). Willamette Dental Group (WDG) accepted EWU IRB. After IRB approval was obtained, the Principal Investigator (PI) began recruiting participants for the study. During the screening process, an informed consent document (Appendix A) was given to each potential participant. Participants agreed to record daily blood glucose readings on their weekly log (Appendix B) which was a paper that was self-developed by the PI. A total of six weekly logs were provided to patients and they were asked to place in their bathroom mirror as a reminder to take blood glucose readings. The weekly log was provided to participants with their Oral-B powered toothbrush. This weekly log was then reported to

the PI via SurveyMonkey each week on Sunday. Participants received a link via email that they could click each Sunday to input required weekly data from the provided questionnaire (Appendix C). Prior to program implementation, participants self-developed identification numbers to be Health Insurance Portability and Accountability Act (HIPAA) compliant. Instructions on how to develop identification numbers included combining the participants street address with the year they were born. Participants were required to enter identification numbers, dates, answer questions on toothbrush method and time, enter daily blood glucose readings, answer when they took their readings, and when the last time they ate a meal or had a snack on their weekly logs. Participants completed a pre and post questionnaire on Diabetes Self-Management (Appendix D). Participation was voluntary, and participants were informed they could drop out of the study at any time. All data collected was kept on SurveyMonkey with only the PI having the password for the account.

Informed consent included any possible risks for participants, although the use of a powered toothbrush was the only change in daily lives for these diabetic patients. Diabetic patients chosen for the study were potentially already taking daily blood glucose readings. All participants who began the study received an Oral-B powered toothbrush. Oral-B Powered toothbrushes were donated by Bernadette Schlaefer, RDH, BS who is the Scientific Relations Manager for Oral-B. As an incentive to complete the study, all participants who provided all required data and did not miss any surveys, were entered in a raffle for a gift basket. The gift basket contained oral home care products and a year supply of brush head replacements for their Oral B powered toothbrush.

The Impact of Powered Toothbrushing on Patients with Diabetes

Sample source, plan, sample size, description of setting.

Moore et al. (2011) recommended at least 12 participants for pilot studies whose primary focus is estimating average values and variability for planning larger subsequent studies. Moore et al. (2011) stated that size is quite practical for most early-stage investigators to conduct within single centers while still providing valuable preliminary information. A comparable pilot study on children with asthma was conducted using 12 (N = 12) participants who showed great participation percentages (Shields et al., 2018).

Participants were patients from WDG in Richland, WA and were recruited using a flyer (Appendix E) that was self-developed by the PI, who is a dental hygienist at WDG. The flyer was placed at the check-in desk in the front office and all providers assisted in promoting the study. The PI also recruited participants by speaking to patients directly when they came in for their routine dental appointments. A convenience sample was used due to participants being easily accessible for the PI. Only those participants who met the inclusion criteria were eligible for the study. Participants who met criteria had a detailed conversation with the PI to go over the procedures. Inclusion criteria included: patients who have been diagnosed with either T1DM or T2DM, have internet access and an electronic device, have a glucometer, be able to take their blood glucose daily, are currently only using a manual toothbrush, and are 18 years of age or older. Exclusion criteria was defined as non-diabetic patients, no internet access, no electronic device, not able to take daily blood glucose readings, and those patients who already use powered toothbrushes.

Once all the participants agreed and signed consent, a date was determined to begin the study. Participants received their powered toothbrush, weekly paper log, and an

instruction sheet for the study that included brushing instructions (Appendix F) one week prior to implementation. The study was six weeks in length. Baseline glucose readings were provided to the PI on the first weekly log via Survey Monkey. Participants used their manual toothbrush for week one so the PI could have baseline readings from the participants. For the next five weeks, all participants transitioned to the Oral-B powered toothbrush. Participants reported data from the questionnaire on the weekly log provided by the PI, which was then submitted at the end of each week on Sunday via SurveyMonkey to the PI.

The total number of participants was 8 ($N = 8$). The study was conducted at the participants' homes. Participants' homes was the best route for study since they were able to take their own blood glucose readings daily and report via SurveyMonkey as long as they had internet access and an electronic device.

Variables

The independent variable for the study was the use of a powered toothbrush that was provided to participants as well as the manual toothbrush that patients already have been using. The independent variable was also the number of times patients brushed their teeth, and if they remember to take their blood glucose readings. The dependent variables were the participants' blood glucose readings and diabetes self-management. Possible confounding variables in the study included smoking, diet, and what type of medication patients were taking.

Instruments

Quantitative data was collected with a questionnaire that was developed by the PI. Participants included their weekly logs containing all data required. Data included on the

questionnaire were identification numbers, dates, blood glucose readings, and if they brushed in the morning and night for a minimum of two minutes. Data collected by the participants on their paper log was transferred by the participants online via SurveyMonkey weekly so the PI had electronic access. Data was also collected for the pre and post Diabetes Self-Management Questionnaire via SurveyMonkey. Electronic mode of delivery was preferred to avoid additional in-person visits and protect patient health during the current pandemic.

Equipment

SurveyMonkey was used to distribute the survey and collect patient responses. Data collected from the questionnaire was then analyzed to determine if powered toothbrushes had any effect in blood glucose readings and if the participants had different perceptions on their diabetes management before and after the study. Oral-B Genius X powered toothbrushes were provided to participants prior to implementation of the study. Weekly logs and the Diabetes Self-Management pre and post questionnaire were provided to participants prior to implementation, these weekly logs and questionnaires contained areas to input identification numbers, dates, blood glucose readings, brushing, and diabetes self-management questionnaires. Participants used some sort of electronic means such as a computer or mobile device to complete weekly surveys. Patients used their glucometers once every morning to document their glucose readings on their weekly log.

Steps to Implementation

In the first phase, approval was obtained from WDG and EWU IRB. During the second phase, the PI recruited patients that were eligible for the study. In the third phase,

participants were informed of the purpose of the survey and how they were selected. Informed consent was discussed during this phase. Once participants were selected, each participant had a discussion with the PI to go over the study process in detail and answer any questions that that may arise.

In the fourth stage, participants followed the toothbrush type weekly schedule (Appendix F). Participants used manual toothbrushes for the first week of the study which served as the baseline. During week 2-6, participants replaced their manual toothbrush with their Oral-B powered toothbrush. Participants received a link each week from the PI via email on Sundays. This link was sent from SurveyMonkey and was used to report daily blood glucose readings for the weekly log that were taken by the participants first thing every morning. The pre and post Diabetes Self-Management Questionnaire also had links that were sent prior to Week 1 and after Week 6 when the study ended. Once the study was complete, data was evaluated and analyzed by the PI. The PI offered to send all participants the study results once the study was complete.

Summary

This study focused on diabetic patients that currently receive dental treatment at WDG in Richland, WA. Patients were recruited as they came in for routine dental visits with the PI as well as a flyer that was placed upon check in. Data were self-reported from the questionnaire provided via Survey Monkey. The PI examined the use of a powered toothbrush and the effect it had on daily blood glucose and on diabetes self-management.

Results

Description of Sample

The PI recruited participants for the study from Willamette Dental Group located in Richland, WA. Originally 18 ($N = 18$) participants were recruited but it was determined only eight were compliant with submitting data. The data analysis focused on those 8 participants ($N = 8$). These participants consisted of five ($n = 5$) females and three ($n = 3$) males. This study was conducted at the participants' homes. All 8 ($N = 8$) participants completed consent forms and gave permission for the PI to include data obtained in this study for this thesis paper. There were two different categories for ethnicity in the study. From the eight participants, seven participants were Caucasian/white and one participant was from two or more races. This study included patient ages ranging from 47 to 64 years old, the mean age being 57.1 and the SD 6.29.

A1C. All participants reported having A1C readings taken prior to beginning the study on the pre-Diabetes Self-Management Questionnaire. A1C is a simple blood test that measures your average blood sugar levels over the past 3 months (CDC, n.d.). A1C readings from the participants ranged from 6.4 to 12. The target A1C goal percentage is 7% for a patient with diabetes (CDC). The average A1C score for the participants were 7.83% which indicates healthy ranges. Only ($n = 2$) participants had greater percentages than 7% A1C at 9.1% and 12%.

Statistical Analysis

This study sought to answer the following questions: Will using a powered toothbrush have an effect on blood glucose levels in adults with Type I and Type II

The Impact of Powered Toothbrushing on Patients with Diabetes

Diabetes Mellitus? Will the use of a powered toothbrush have any effect on the perception of diabetes self-management? This study hypothesized that brushing with a powered toothbrush would result in improvement in blood glucose for participants with DM. All participants had either T1DM or T2DM and did not currently use a powered toothbrush. The study also hypothesized improvement in the perception of diabetes self-management.

Quantitative data was collected on a daily log: daily blood glucose readings, whether participants brushed for a minimum of two minutes every morning and night, what time patients took their blood glucose readings, and also the length of time after eating a meal or snack before taking blood glucose readings. For the blood glucose readings that were taken daily for 6 weeks a repeated-measures *t*-test or "within subjects" *t*-test was conducted, in which each subject was compared to him or herself to reveal change over time (if any). For the pre and post Diabetes Self-Management Questionnaire a Wilcoxon signed-rank test was completed since the data was nonparametric. Data from participants was submitted using SurveyMonkey. Analysis was performed using SPSS statistical software, version 25.

Effect of Powered Toothbrushing on Blood Glucose Weekly Log

Blood glucose readings were taken daily for 6-weeks. For the weekly blood glucose logs the PI reverse coded yes as "1" and no as "2." For the time of day, "a.m." was coded as "1" and "p.m." was coded as "2." Blood glucose reading logs were provided to all individuals in the study. The following questions were asked: "Did you brush for a minimum of 2 minutes in the a.m.?"; "Did you brush for a minimum of 2 minutes in the p.m.?"; "What was your daily blood glucose reading?"; What time did you

take your blood glucose reading?"; and "What time was your last meal or snack?" Out of 84 potential brushing opportunities (2 brushings x 7 days x 6 weeks = 84 opportunities), only twice did a participant report not brushing (82/84 compliant brushings = 97.6% brushing compliance).

Table 1 displays the mean blood sugar readings ranges. There was no significant difference in blood sugar week-to-week or between Week 1 and Week 6. Participants were asked to take their blood glucose readings first thing every morning. There was a total of eight surveys possible and data collection from eight total participants. A paired t-test was conducted to study the effects of using a powered toothbrush on blood sugar. The results showed that brushing with a powered toothbrush did not have any effects on blood sugar levels. A paired *t*-test was conducted and results are displayed in Table 2. Table 2 also presents an overall analysis including p values. The *p* values as seen on the column farthest to the right shows no statistical significance in any of the 6 weeks of the study.

Table 1

Weekly Blood Sugar

	Mean	Range	N
Week 1	156.1	107.8-216.9	6
Week 2	161.1	99.6-237.6	6
Week 3	164.7	111.6-261.9	7
Week 4	164.1	107.1-289.1	7
Week 5	151.4	113.4-202.7	6
Week 6	143.5	114.7-191.1	5

Note. Statistics on weekly blood sugars.

Table 2

Weekly Blood Glucose Data Analysis

Week	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)	*p*
1 to 2	-5.86	10.52	4.29	-1.36	5	0.231	$p < 0.2$
2 to 3	-3.79	16.41	6.69	-0.57	5	0.596	$p < 0.59$
3 to 4	0.60	18.04	6.81	0.09	6	0.934	$p < .93$
4 to 5	19.29	35.48	14.49	1.33	5	0.241	$p < .24$
5 to 6	-2.46	4.23	1.89	-1.30	4	0.264	$p < .26$
1 to 6	0.40	7.38	3.29	0.12	4	0.909	$p < .9$

Note. Blood glucose analysis from the 6-week study analysis.

Pre and Post Diabetes Self-Management Questionnaire.

A pre and post Diabetes Self-Management Questionnaire was conducted so that the PI could evaluate participant perceptions regarding their diabetes self-management. It was hypothesized that there might be some statistically significant changes in behavior, or at least changes in how participants perceived their behaviors, since these questions were asked on a Likert scale shown on Table 3.

The four level responses on the pre and post Diabetes Self-Management Questionnaire were reversed coded so that “4” is the score for “Applies to me very much,” while “1” codes for “Does not apply to me.” The purpose of the reverse coding was to better understand data for readers. Higher scores were better to use to indicate "positive responses.” The individuals selected how they perceived their own behavior.

Table 3

Diabetes Self-Management Questionnaire

The following statements describe self-care activities related to your diabetes. Thinking about your self-care over the last 6 weeks, please specify the extent to which each statement applies to you.
1. Does not apply to me
2. Applies to me to some degree
3. Apples to me to a considerable degree
4. Applies to me very much

Note. Likert scale survey used for participants to self-report perceptions on their diabetes management.

A Wilcoxon sign rank test was used on each of the questions to measure the differences in the means of the score before and after on each question. The answers to each individual question were pooled (via the mean). Pooling all the questions together was used to create an "overall mean".

Table 4 shows the mean scores and one can observe if the means increased, decreased or stayed the same. Table 4 interpretation is as followed: ranks - the negative refers to how many cases had lower scores post than pretest, positives are how many cases marked higher scores post than pre, and ties mean cases that marked it the same, pre and post.

Table 4

Wilcoxon Sign Rank Test on Diabetes Self-Management

		N	Mean Rank	Sum of Ranks
Check Blood Sugar (post) - Check Blood Sugar (pre)	Negative Ranks	0	0.00	0.00
	Positive Ranks	3	2.00	6.00
	Ties	5		
	Total	8		
Diet (post) – Diet (pre)	Negative Ranks	0	0.00	0.00
	Positive Ranks	3	2.00	6.00
	Ties	5		
	Total	8		
Appointments (post) – Appointments (pre)	Negative Ranks	2	1.50	3.00
	Positive Ranks	0	0.00	0.00
	Ties	6		
	Total	8		
Medications (post) – Medications (pre)	Negative Ranks	0	0.00	0.00
	Positive Ranks	0	0.00	0.00
	Ties	8		
	Total	8		
Physical Activity (post) – Physical Activity (pre)	Negative Ranks	1	1.50	1.50
	Positive Ranks	4	3.38	13.50
	Ties	3		
	Total	8		
Brush Twice Daily (post) – Brush Twice Daily (pre)	Negative Ranks	0	0.00	0.00
	Positive Ranks	4	2.50	10.00
	Ties	4		
	Total	8		

Notes. Data analysis on pre and post Diabetes Self-Management Questionnaire.

Checking blood sugar levels daily. A Wilcoxon Signed-Ranks test indicated that the "checking blood sugar levels daily post" (mean rank = 0.00) was not rated more

favorably than the "checking blood sugar levels daily pre" (mean rank = 2.0), $Z = -1.60$, $p < .109$. There was a positive increase in the mean ranks in regards to participants checking their blood sugar readings daily, as shown on Table 4. The results indicated that there were three more positive ranks and zero negative ranks, which translated to individuals believing that they checked their blood sugar readings more on a daily basis post they study.

Diet. A Wilcoxon Signed-Ranks test indicated that the "diet post" (mean rank = 0.00) was not rated more favorably than the "diet pre" (mean rank = 2.0), $Z = -1.63$, $p < .102$. The ranks for the food that the participants chose to eat to achieve optimal blood sugar levels included three positive and zero negative rankings. These results interpret to participants perceiving choosing better diet to achieve optimal blood sugar levels.

Appointment Compliance. A Wilcoxon Signed-Ranks test indicated that the "appointments post" (mean rank = 1.50) was not rated more favorably than the "appointments pre" (mean rank = 0.0), $Z = -1.41$, $p < .157$. The only mean rank that had a negative rank was the question asking if participants kept all doctors' appointments recommended for their diabetes treatment. Table 4 shows that there were two negative ranks and zero positive ranks indicating a perception by the participants that compliance with doctor appointments decreased.

Diabetes Medication. A Wilcoxon Signed-Ranks test indicated that the "medications post" (mean rank = 0.00) was not rated more favorably than the "medications pre" (mean rank = 0.0), $Z = 0.00$, $p = 1.00$. Table 4 shows that there were no changes in the pre and post questionnaire in the question asking if participants take their diabetes medication routinely. Table 4 shows that there were zero positive and

negative rankings. This data indicates that all participants perceived that they take their medications as recommended.

Physical Activity. A Wilcoxon Signed-Ranks test indicated that the "physical activity post" (mean rank = 1.50) was not rated more favorably than the "physical activity pre" (mean rank = 3.38), $Z = -1.63$, $p < .102$. The mean rankings for the question related to participants completing physical activity regularly to achieve optimal blood sugar levels increased. Table 4 shows that there were one negative ranking and four positive rankings.

Brushing. As shown in Table 4, a Wilcoxon Signed-Ranks test indicated that the "brushing teeth post" (mean rank = 2.50) was not rated more favorably than the "brushing teeth pre" (mean rank = 0.0), Z = -1.89, p = .059. There were four positive rankings and zero negative rankings. There were more positive rankings which would indicate that participants perceived more brushing compliance during the study.

The Wilcoxon test answers the question if the difference in ranks pre to post is significantly different from zero (that is, a significant change in scores occurred). Table 5 displays statistics: *Z* is the test value. The bottom row on Table 5 presents the *p*-values. Table 5 shows the result of the Wilcoxon signed rank test for each question. Table 5 shows the observed difference between each question's measurement pre and post which resulted in no statistical significance. This would indicate for this sample that the intervention did not cause any statistical significance in the change of self-reported behaviors.

Table 5

Analysis on Diabetes Self-Management Questionnaire

	Blood Sugar	Diet	Appointments	Medications	Physical Activity	Brushing
Z	-1.604	-1.63	-1.414	.000	-1.633	-1.890
Asymp. Sig. (2-tailed) (*p* value)	.109	.102	.157	1.00	.102	.059

Note. P values on all questions in the Diabetes Self-Management Questionnaire.

Table 6 also shows the mean and standard deviation for each question, pre and post-test. Looking at the means for questions 1, 2, 5 and 6, one can observe there was a slight increase in the selection of higher numbers (more agreement/better behaviors) on the post-survey. This would indicate that patients' perceived improvement in checking blood sugars daily, choosing the food they eat to achieve optimal blood sugar levels, completing physical activity to achieve optimal blood sugar levels, and brushing teeth twice daily. However, there was a slight decrease in the mean score for question 3 for participants keeping their doctors' appointments recommended for diabetes treatment. For question 4 on whether patients took their medication routinely for diabetes treatment there was no change; participants all selected "4" as their response both pre and post Paired sample t-tests were developed on all questions except 4, to determine if any of the changes were significant.

Table 6

Descriptive Statistics on the pre and post Questionnaire

	N	Mean	Std. Deviation	Minimum	Maximum
Blood Sugar (pre)	8	3.13	1.24	1	4
Diet (pre)	8	2.13	0.641	1	3
Appointments (pre)	8	4.00	0.00	4	4
Medications (pre)	8	4.00	0.00	4.00	4.00
Physical Activity (pre)	8	1.87	0.640	1.00	3.00
Daily Brushing (pre)	8	3.12	0.834	2.00	4.00
Blood Sugar (post)	8	3.87	0.353	3.00	4.00
Diet (post)	8	2.62	0.916	2.00	4.00
Appointments (post)	8	3.75	0.462	3.00	4.00
Medications (post)	8	4.00	0.00	4.00	4.00
Physical Activity (post)	8	2.75	1.164	1.00	4.00
Daily Brushing (post)	8	3.75	0.462	3.00	4.00

Note. Descriptive statistics on the pre and post Diabetes Self-Management Questionnaire.

Discussion

Summary of Major Findings

Although there were initially 18 participants only 8 ($N = 8$) were used in the final analysis comparing their data, since they completed all surveys required. Eight individuals completed both the pre and post Diabetes Self-Management Questionnaire as well as the weekly blood glucose logs.

During this study, the mean blood sugar for each participant was analyzed using a paired *t*-test to analyze week to week mean glucose readings as shown in Table 2. This data concluded no statistical significant differences week to week or compared from Week 1 to Week 6. A Wilcoxon Sign Rank Test was conducted to analyze the pre and post Diabetes Self-Management Questionnaire which also did not have any significance in *p* values although brushing two times daily was close with *p* value of $p = 0.59$.

Discussion

Effect of Powered Toothbrushing on Blood Glucose Weekly Log

Unfortunately, there was no significant change in weekly blood glucose readings between the participants throughout the 6-week study. There are many factors that could have affected this outcome. The study could have benefited more if participants had diabetes that was not controlled versus controlled. If a patient were to have controlled diabetes they possibly would not have had any change in glucose readings. If patients had uncontrolled diabetes, then that would have allowed for greater chance for change in a positive manner. Another factor for the results of no statistical significant change could have been the time of day when the patient took their blood glucose reading. Fasting state

is not well defined; the WHO recommends an 8–14 hour fast, whereas the American Diabetes Association (ADA) defines fasting as "no caloric intake for at least 8 hours or an overnight 8 to 10 hour fast" (Moebus et al., 2011). If the study had a more specific timeframe for all participants to take their blood sugar readings then there may have been a change. The lack of statistical significant change in blood glucose readings may have also been due to some participants taking their readings after they ate breakfast instead of before they ate breakfast. As noted in Table 7, there is a major difference in what the blood glucose reading is prior to eating versus after eating.

Table 7

Blood Sugar Level Interpretation

Time of check	Blood sugar level
Fasting or before breakfast	60–90 mg/dl
Before meals	60–90 mg/dl
1 hour after meal	100–120 mg/dl

Note. Blood sugar levels are displayed in accordance to the time a meal is eaten (Huizen, 2019)

Pre and post Diabetes Self-Management Questionnaire

Checking blood sugar levels daily. Regular testing of blood glucose is critical to effectively manage type 1 diabetes and type 2 diabetes requiring intensive insulin therapy to keep their blood glucose levels in the target range (Ontario Health, 2019). In this study, participants were tasked with taking blood sugar levels once daily. It was recommended that participants take their blood sugar readings first thing every morning. For people with type 1 diabetes, frequent testing is the only way to safely and effectively manage blood sugar levels, with most people needing to take their readings at least four times per

day (Weinstock, 2021). If a person has type 2 diabetes and takes insulin or medications that can cause hypoglycemia then it is recommended to take blood glucose readings based on recommendations from their healthcare provider (Weinstock, 2021). The PI was unable to verify and group when the participants took their blood glucose readings resulting in no statistical significance in the data.

Diet. Dietary intake and physical exercise are the two main determinants of the energy balance, and they are considered as a basic base in the treatment of patients with diabetes (Marín-Peñalver et al., 2016). Figure 3 shows which foods may impact glycemic control. Depending on what type of food the participant last ate, the blood glucose could have been impacted resulting in no statistical significant change in the data. Participants were not given requirements on what diet to follow during the 6-week study but simply asked before and after the study if their perception regarding their diet changed. The PI believes that nutrition could have been a part of the study to assist in blood glucose management. The PI hypothesized better blood glucose readings may have been noted if a healthier diet would have been incorporated into the study.

Figure 3

Glycemic Impact

Low Glycemic Impact *Choose **most** often*	Medium Glycemic Impact *Choose **more** often*	High Glycemic Impact *Choose **least** often*
Breads, Cereals, Grains, and Pasta		
• Hearty whole-grain specialty breads such as whole-meal wheat, rye, and pumpernickel • Sourdough bread • All-Bran cereal • Steel-cut oats/oatmeal • Barley, bulgur wheat	• Whole-wheat bread • White pita bread • Tortilla • Shredded wheat • Raisin bran • Brown rice, long-grain rice • Couscous, quinoa, pasta	• Bagel • English muffin • White bread • Cornflakes • Instant oatmeal • Instant rice, short-grain rice • Frozen waffles
Fruit, Vegetables, and Legumes		
• Lentils, dried beans • Apples, peaches, oranges • Strawberries, blueberries • Carrots, green peas • Spinach, broccoli* • Lettuce, cucumbers*	• Cantaloupe, pineapple • Bananas, raisins • Watermelons • Corn, sweet potatoes • Plantains	• Potatoes, baked or boiled • Instant mashed potatoes
Dairy, Beverages, Other		
• Milk, yogurt • Frozen desserts (ice milk, ice cream) • Nuts, seeds, peanut butter* • Eggs, low-fat cheeses* • Lean meats, fish* • Heart-healthy oils, vinegar*		Sweetened soft drinks, sports beverages
**These items contain very little carbohydrate. Therefore, they have very little effect on blood glucose.*		

Note. Categories of food and their levels of impact on blood glucose (Clinical Diabetes, 2011)

Appointment Compliance. Participants were asked whether they kept their doctors' appointments recommended for their diabetes treatment. Although there was no statistically significant change in the pre and post self-management questionnaire, the PI hypothesized that their A1C averages reflected good health and diabetes treatment compliance. Successful diabetes disease management involves routine medical care with individualized patient goals, self-management education and on-going support to reduce complications (Nuti et al., 2015). In order for a patient to know where they stand with their health, routine checkups are important. There is a lot that goes into diabetes management such as weight management, medications, A1C tests, and also other health

behaviors. A patient will not know if their diabetes is controlled or not if they are not actively getting their A1C tested every 3-months.

Diabetes Medication. To achieve good metabolic control in diabetes and maintain long term, a combination of changes in lifestyle and pharmacological treatment is necessary (Marín-Peñalver et al. 2016). Sanchez-Rangel & Inzucchi (2017) state that Metformin is one of the most popular oral glucose-lowering medications, widely considered to be the optimal initial therapy for patients with T2DM. The results from the study indicated that all participants felt it "applies to me very much" when asked if they were following the medication regime provided by their primary care doctor. Medication regime is not always followed by patients. According to Polonsky and Henry (2012) poor medication adherence is linked to key nonpatient factors such as patient demographics, critical patient beliefs about their medications and perceived patient burden regarding obtaining and taking their medications. The PI believes these patients have access to obtaining their medications if needed for their diabetes. The PI hypothesized this because all participants were seen at the dental office. If the participants were seen at the private dental office that means they likely had dental insurance which means that they most likely have medical insurance to help with diabetes medication.

Physical Activity. Daily physical activity is vital for someone diagnosed with Diabetes Mellitus. The American Diabetes Association (2013) states that the common risks for developing T2DM are age, obesity, and lack of physical activity. The data analyzed did not reflect a statistically significant change from pre to post on the Diabetes Self-Management Questionnaire regarding regular physical activity. There are many

benefits to exercise for patients diagnosed with Diabetes which include increased insulin sensitivity in tissues and improvement of glycemic control (Marín-Peñalver et al. 2016).

Brushing. Perception of brushing twice daily was the closest to having significance with a *p* value of $p = 0.59$ from the pre to the post Diabetes Self-Management Questionnaire. The PI predicts the reason for this positive impact was due to accountability and eagerness to change. As stated before by Cinar et al. (2012), poor oral health and poor diabetes management both negatively contribute to glycemic control. The PI believes that the Hawthorne effect may have had a factor in the results. A study on the Hawthorne effect showed an increase in productivity among a selected group of workers who were supervised intensively by managers under the auspices of a research program (Mcambridge et al., 2014). The indirect monitoring of participants could have promoted better behavior. Participants were informed the purpose of the study was to examine if there may be a connection with the use of a powered toothbrush on their blood glucose readings. The PI hypothesized that the participants were eager to be a part of positive findings related to diabetes management.

Limitations

Limitations included a small sample size, technology issues, and length of study. Originally the goal was to recruit 24 participants for the study. Unfortunately, time had a major impact on recruitment as the PI only had a two-week time frame to recruit. All patients scheduled at the dental office were spoken to by the PI about the study during this two-week time frame. On the final day of recruitment 18 participants had been recruited and had signed informed consents. Full participation was low since only 8/18 participants completed all eight surveys required.

There are many factors that the PI believes had input on the low participation. The first factor was the utilization of only email for survey responses. Electronic surveys were used due to the current pandemic and the limitations of taking precautions to avoid exposing participants and the PI to COVID-19; however, the response rates were low. Using emails could have negatively affected participants due to the function of technology. Participant ages ranged from 47-64 years old and they could have had trouble with accessing and completing the surveys. Another factor would be errors with technology. A few participants emailed the PI that they had not received the surveys in certain weeks. Not receiving the survey reflects on the outcome of the total received survey and compliance which is a reason the PI had to dismiss the limited data from 10 out of the 18 participants.

The timeframe is also noted as a limitation as participants could have viewed this as too long of a study and too large of a commitment. A comparable pilot study on children with asthma was conducted using 12 participants who showed great participation percentages (Shields et al., 2018). The timeframe for this study was only two weeks which could have been the reason for the higher participation. Compliance could have been higher because the participants were all children from staff members at the university that they study was being conducted. The PI hypothesized there would be more compliance with a smaller sample size when in fact a larger sample size would result in more data to compare. Faber and Fonseca (2014) state that very small samples undermine the internal and external validity of a study. Very large samples tend to transform small differences – even when they are clinically insignificant.

The Impact of Powered Toothbrushing on Patients with Diabetes

Recommendations/Suggestions for Future Research

The PI recommends expanding the sample of participants in future research. Having a larger sample size would yield a larger data set. The PI also recommends completing surveys in person rather than online so that data can be collected free of technology errors. The PI recommends the use of a control group; although not essential for many aspects of the study, inclusion of a control group allows for a more realistic examination of recruitment, randomization, implementation of interventions, blinded assessment procedures, and retention in blinded interventions (Leon et. al., 2015). The PI recommends that a study be conducted using participants that have uncontrolled diabetes. A study on participants with uncontrolled diabetes would possibly yield more change since there is a higher chance of improvement in blood glucose with following study participation guidelines.

Although it may impact patient compliance, this study was only 6-weeks in length and the PI recommends that a future study be at minimum 3 months long to be able to also evaluate and compare A1C levels. A1C levels are taken every 3 months to monitor average blood glucose levels. The PI recommends a crossover design where participants are grouped into two different groups. These two groups would receive Treatment A (manual toothbrush) for 1.5 months then Treatment B (powered toothbrush) for the remaining 1.5 months. The PI would also be more diligent in participant selection. Due to the time constraint the PI had to accept all participants who immediately qualified for the study to obtain a larger sample size. The PI also recommends a specific timeframe on when the participants should take their blood sugar such as 8:00-10:00 a.m. each day prior to their first meal. The PI recommends further

research into the relationship between the use of a powered toothbrush on blood glucose levels in DM patients including using different brands/models.

Conclusions

Unfortunately, due to the limited participation from the participants there was no clear statistical significance. The research studies reviewed while completing the literature review demonstrated the use of powered toothbrushes improves oral health. There is no research regarding the connection between the use of powered toothbrushes to improve home care and to improved management of blood glucose in DM patients. Further research regarding the use of powered toothbrushes for the treatment and management of DM should continue to be conducted to evaluate if an electric toothbrush can help patients better control their blood sugar and diabetes self-management.

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Appendix A

Informed Consent

Informed Consent

Effect of Powered Toothbrushing on Blood Glucose

Principal Investigator
Kristian Carrasco, Master in Dental Hygiene Student
509-820-1251
Responsible Project Investigator
Sarah Jackson, RDH, MSDH

Purpose and Benefits

This proposed study will include diabetic participants who are 18 years and older that will follow procedures provided by the principal investigator for the 6-week study. The study will have a minimum of 12 participants in which they will receive the treatment with the powered toothbrushing. Participants will take daily blood glucose readings via their glucometer and record their glucose readings every morning on their weekly paper log. They will submit weekly logs on Sunday mornings. Weekly logs will be provided to participants via an online link that will be provided to them by the principal investigator via email. Participants that will benefit from the study will be those who do not currently have a powered toothbrush and would like to get a free one. This research will fulfill the requirement for thesis completion in order to graduate from Eastern Washington University and the results of the study may become part of a presentation or publication.

Procedures

Participants will voluntarily participate in a 6-week study. Participation will not be compensated for the study, participants will receive an Oral-B Genius X toothbrush at the inception of the study. Participants will be provided with instructions on the study, how to document and submit weekly logs, and toothbrushing technique. Participants will have a Zoom call to share expectations with the principal investigator. The blood glucose readings will be documented at home by participants first thing every morning on their weekly log. Additionally, participants will also note if they brushed for a minimum of two minutes in the morning and at night. Participants will record on the weekly log the instrument used to brush either a manual or powered toothbrush depending on what week they are on. Participation in research is voluntary. You have the right to decline to be in this study, or to withdraw rom it at any point without penalty or loss of benefits which you are otherwise entitled.

The Impact of Powered Toothbrushing on Patients with Diabetes

Risk, Stress or Discomfort

Participation in this study will not impact your dental benefits at Willamette Dental Group. The researcher will not disclose any information about the participant status, findings or logs to Willamette Dental Group. There will be minimal risk since participants will be conducting daily readings at home via their glucometer and self-reporting the findings in a log. This study involves no more risk than what you would normally encounter in day-to-day activities. All face-to-face contacts involved in this research will be conducted using the COVID safety protocols for Willamette Dental Group and Eastern Washington University.

Other Information

All data collected by the participant will be confidential and anonymous by procedural steps to de-identified each participant with a code and a code key to the identity will be held in a secure locked space for the duration of the study. Upon completion of the study all material including code keys will be destroyed in accordance with WDG privacy policies.

Signature of Principal Investigator Date

Subject's Statement

"The study described above has been explained to me, and I voluntarily consent to participate in this study. "I have had an opportunity to ask questions and I give permission to collect and analyze data I will provide to the principal investigator in which I participate during this study. I understand that by signing this form I am not waiving my legal rights. I understand that I will receive a signed copy of this form."

Signature of Subject: Date:

Email: Phone number

Preferred method of contact: Phone or email (please circle)

If you have any concerns about your rights as a participant in this research or any complaints you wish to make, you may contact Charlene Alspach, Executive Director, Grant & Research Development, at (509) 359-2517 or calspach@ewu.edu or Sarah Jackson, RDH, MSDH, Professor, at Sarah.Jackson@ewu.edu.

Appendix B

Effect of Powered Toothbrushing on Blood Glucose Weekly Log

Participant Identification #

	Date: MM/DD /YYYY	Did you brush your teeth for a minimum of 2 minutes in the Am?	Did you brush your teeth for a minimum of 2 minutes in the Pm?	What was your blood sugar reading today?	Time glucose reading was taken?	Time of last meal or snack?
Sunday		Yes or No	Yes or No			
Monday		Yes or No	Yes or No			
Tuesday		Yes or No	Yes or No			
Wednesday		Yes or No	Yes or No			
Thursday		Yes or No	Yes or No			
Friday		Yes or No	Yes or No			
Saturday		Yes or No	Yes or No			

Appendix C

Weekly reporting using SurveyMonkey

Week 1: Participants will provide A1C

1. What is your identification number?
2. What is the date? MM/DD/YYYY

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

3. Did you brush your teeth in the AM for at least 2 minutes? (Enter “Yes” or “No”)

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

4. Did you brush your teeth in the PM for at least 2 minutes? (Enter "Yes" or "No")

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

5. What was your daily blood glucose reading?

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

6. What time did you take your blood glucose reading?

Sunday
Monday
Tuesday

Wednesday
Thursday
Friday
Saturday

7. What time was your last meal or snack?

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

Appendix D

Diabetes Self-Management Questionnaire (DSMQ)

Pre and Post questionnaire

The following statements describe self-care activities related to your diabetes. Thinking about your self-care over the last 5 weeks, please specify the extent to which each statement applies to you	Applies to me very much (3)	Applies to me to a consider-able degree (2)	Applies to me to some degree (1)	Does not apply to me (0)
I check my blood sugar levels daily				
The food I choose to eat makes it easy to achieve optimal blood sugar levels				
I keep all doctors' appointments recommended for my diabetes treatment				
I take my diabetes medication routinely				
I do regular physical activity to achieve optimal blood sugar levels				
I brush my teeth twice daily				

Appendix E

Recruiting Flyer

PARTICIPATE & RECIEVE A FREE POWERED TOOTHBRUSH!

Hello patients of Willamette Dental Group, P.C., my name is Kristian Carrasco and I am a dental hygienist here in Richland. I am also a master's student at Eastern Washington University and I am completing my thesis on the effects of powered toothbrushing on blood glucose in diabetic patients. Participants who are chosen for the study will brush with a manual toothbrush for one week and a powered toothbrush for 5 total weeks. Participants will report daily blood glucose readings at the end of each week on an electronic survey. If you are an adult with diabetes and currently NOT using a powered toothbrush and wish to participate, please ask for an Informed Consent and provide to any front desk staff member. If chosen to participate you will receive a free Oral-B Genius X toothbrush (not pictured). As an incentive to complete the study, all participants who provide all required data and do not miss any blood sugar readings, will be entered in a raffle for a gift basket. The gift basket will contain oral home care products and a year supply of brush head replacements for their Oral B powered toothbrush.

Sincerely, Kristian Carrasco, RDH, BASDH

Appendix F

Study Instructions & Oral-B Genius X Instructions (Braun, n.d.)

Hello and thank you so much for being part of my study in completing my thesis at Eastern Washington University. This study will provide information on the effects of using powered toothbrushes on blood glucose. Below will be instructions to follow during this 6 week study.

The following table indicates which type of toothbrush you will be utilizing for each week.

Week	Toothbrush
1	Manual
2	Powered
3	Powered
4	Powered
5	Powered
6	Powered

Manual toothbrush weeks instructions

Participants will brush with their **MANUAL** toothbrushes on **week 1.** Participants will brush with their manual toothbrushes every morning and night for a minimum of 2 minutes for these weeks. Participants are to document blood glucose readings first thing every morning and track on the weekly log provided.

Instructions on how to fill out weekly log.

The Impact of Powered Toothbrushing on Patients with Diabetes

- Enter identification # provided to you
- Enter date
- Circle yes or no if you brushed in the AM for a minimum of 2 minutes
- Circle yes or no if you brushed in the PM for a minimum of 2 minutes
- Enter blood glucose reading for that day
- Enter what time blood glucose was taken
- Enter time of last meal or snack

Each Sunday morning, you will receive a link via text message or by email depending on your chosen preference. This link will be from SurveyMonkey. There will be 5 questions to answer and once they are answered you will press submit (green button).

Powered toothbrush weeks instructions

Participants will brush with their **POWERED** toothbrushes on week **2, 3, 4, 5** and **6.** Participants will brush with their manual toothbrushes every morning and night for a minimum of 2 minutes for these weeks. Participants are to document blood glucose readings first thing every morning and track on the weekly log provided.

Instructions on how to fill out Weekly Log.

- Enter identification # provided to you
- Enter date
- Circle yes or no if you brushed in the AM for a minimum of 2 minutes
- Circle yes or no if you brushed in the PM for a minimum of 2 minutes
- Enter what time blood glucose was taken
- Enter time of last meal or snack

The Impact of Powered Toothbrushing on Patients with Diabetes

Each Sunday morning, you will receive a link via text message or by email depending on your chosen preference. This link will be from SurveyMonkey®. There will be 6 questions to answer and once they are answered you will press submit (green button).

How to brush your teeth

To brush your teeth correctly, spend at least two minutes, which includes 30 seconds brushing each section of your mouth (upper right, upper left, lower right and lower left), both morning and night.

Using a Manual Toothbrush Technique

Step 1: Place bristles along the gumline at a 45 degree angle. Bristles should contact both the tooth surface and the gumline.

Step 2: Gently brush the outer tooth surfaces of 2-3 teeth using a vibrating back, forth and rolling motion. Move brush to the next group of 2-3 teeth and repeat.

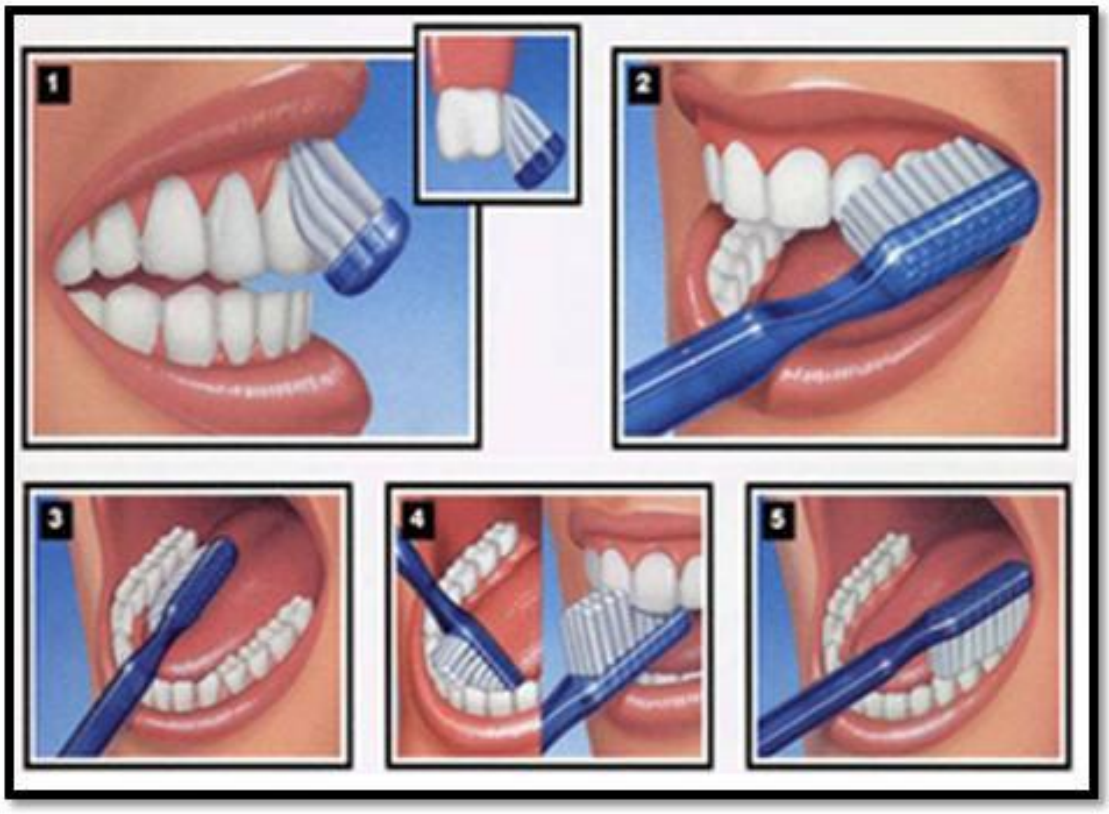
Step 3: Maintain a 45 degree angle with bristles contacting the tooth surface and gumline. Gently brush using back, forth and rolling motion along all of the inner tooth surfaces.

Step 4: Tilt brush vertically behind the front teeth. Make several up and down strokes using the front half of the toothbrush.

Step 5: Place the brush against the biting surface of the teeth and use gentle back and forth scrubbing motion.

Figure 4

Modified Bass Toothbrush



Note. Modified Bass manual toothbrushing technique from steps 1 to 5.

http://hrd472team5fall2014.weebly.com/brushing-techniques.html

Using Proper Electric Toothbrush Technique

Step 1: Make sure your toothbrush is charged. Many electric toothbrushes have charge level indicator lights, so you can actually see when the toothbrush is charged.

Step 2: Choose toothbrush head and insert.

Step 3: Start with the outside surfaces of the teeth. Guide the brush head slowly from tooth to tooth, holding the brush head in place for a few seconds against each tooth before

moving on to the next one. Follow along with the shape of each tooth and the curve of the gums.

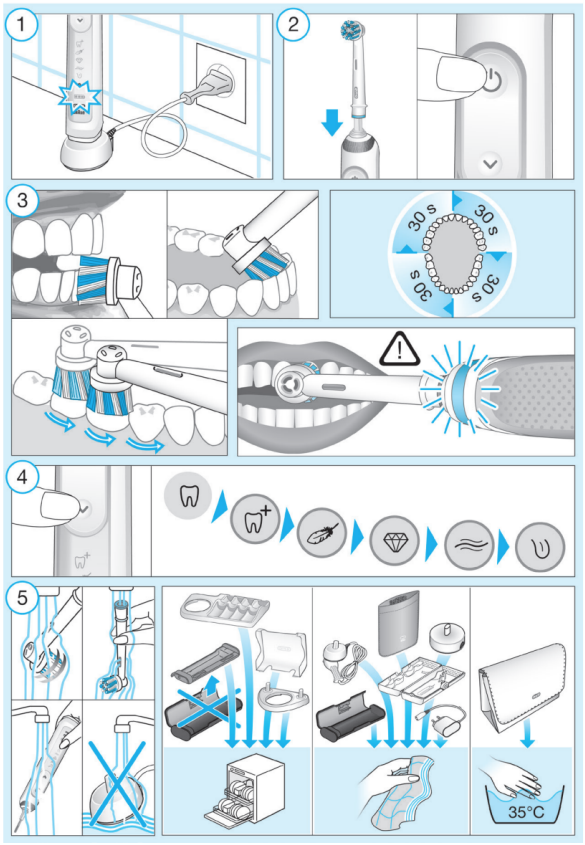
Step 4: Repeat Step 2 on the inside surfaces of the teeth.

Step 5: Repeat Step 2 on the chewing surfaces of the teeth as well as behind the back teeth.

Step 6: Direct the brush head along the gum line and upon the gums. Again, do not press hard or scrub.

Figure 5

Oral B Toothbrush Instructions



Note. Oral B® toothbrushing technique and handling (Braun, n.d.)

Curriculum Vita

Kristian Ariel Carrasco, RDH, BASDH

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Education

Graduate Education
Master of Science in Dental Hygiene — 2019-2021
Eastern Washington University
Cheney, Washington

Undergraduate Education
Bachelor of Applied Science in Dental Hygiene — 2016-2018
Yakima Valley College
Yakima, Washington

Associate in Arts — 2014-2016
Yakima Valley College
Yakima, Washington

Licensure

Dental Hygiene License
License #DH60878495
First issued:07/24/2018
Last issued: 02/05/2019

The Impact of Powered Toothbrushing on Patients with Diabetes

Current status: Active
Expiration date: 03/07/2020

Course Work

Master of Science in Dental Hygiene

Healthcare leadership

- Focusing on healthcare providers by building in the critical areas of leadership development. The content develops the leadership skills essential for achieving personal and organizational objectives.

Graduate Seminar in Healthcare Technology

- Focus on the advanced technology in dental healthcare.

Seminar on Concepts of Public Health and Health Promotion

- Students use current evidence to engage in discussion on topics related to the roles of advocate and health promoter.

Biostatistics

- Preparing students for their graduate research projects and to increase their ability to assess evidence, conduct research in an ethical manner, and utilize statistics.

Clinical Work

Willamette Dental Group 2018-Present
Richland, Washington

Title: Lead Registered Dental Hygienist
Traditional & Restorative hygiene duties, including but not limited to: Reviewing medical and dental history, periodontal probing, oral cancer screening, digital radiographs, removal of calculus, plaque and stain by the use of hand scaling and ultrasonic instrumentation, application of sealants, application of fluoride treatments, administration of local anesthetic, administration of Nitrous Oxide, periodontal scaling and root planing, smoking cessation, diet intervention, oral health education, and placement of permanent restorations. Lead responsibilities include chart auditing and team management.

Academic Experience

Releaf-Hands Free Dental suction 2018

- Hands on training on High vacuum suction options and education on the hands free dental suction. With this hands on experience we were able to demonstrate how effective we could suction without having to utilize our hands. Benefits include no risk of back flow versus traditional saliva ejector.

Zoom Whitening 2019

- Hands on training with a Zoom Whitening representative. In this 1-hour experience I was able to efficiently whiten up too three shades whiter on my

patient. I was able to use the Zoom equipment and whitening solution to maximize my patient's brightness.

Velscope-Oral Cancer Screening 2019

- Online training and hands n training on using Velscope to visualize the oral mucosa and identifying any abnormalities. I was able to learn and be able to put Velscope together and be able to disinfect and learn how to operate.

Scholarly Activities

Research interest

- Correlation between Diabetes and Hispanic population

Professional Associations

American Dental Hygienists' Association 2016-2018

Washington State Dental Hygienists' Association 2016-2018

Community Service

Grace clinic 2019
Kennewick, Washington - *Patient care on a Weekend*

Honors and Award

Colgate Student Total Achievement Recognition 2018
Offered to graduating dental hygiene students who show excellence and commitment to the hygiene profession by demonstrating:

- *Demonstrating true dedication to the profession*
- *Exhibiting extraordinary compassion in patient care*
- *Displaying enthusiasm and follow-through for community service*
- *Demonstrating outstanding patient education and motivation skills.*

Yakima Valley College Class Vice President 2016-2018

- Voted on by the Class of 2018
- Attend College Council meetings