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Exploration of Two Toothbrush Technologies for More Predictable Plaque Control

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ABSTRACT

A tooth brush is a critical tool for mechanical plaque removal. Plaque is one of the etiological factors responsible for the development of dental caries and periodontal disease. Even though this information is well documented and understood, the literature points out that most patients still suffer from preventable dental disease largely due to inadequate home care. As a result, consistent development and modification of toothbrushes to improve cleaning efficacy continues. One of particular interest is three-sided brushing where bristles are configured to clean buccal, occlusal and lingual surfaces simultaneously. Another modification is adding a battery-powered motor to the bristle component such as sonic vibration. This literature review aims to collate the evidence on three sided and sonic brushing to evaluate if the combination of these two technologies offer patients an alternative and possibly more effective method to predictably remove plaque.

Keywords: Toothbrush; Triple-headed design; Sonic toothbrush; Plaque removal; Gingivitis

INTRODUCTION

Current literature has shown the prevalence of periodontitis in US individuals, 30 years or older as 47% and it is about 70% in individuals over 65. It is also accepted that most individuals do not brush teeth properly even when professional instructions are given to them. The European workshop on mechanical plaque control in 1998 has proposed the attributes for an ideal toothbrush. Some suggestions are to generate higher efficacy in plaque control with a three-sided brush design. Other modifications can include the addition of a battery-powered motor to the bristle component such as sonic vibration. A variety of literature will be investigated to understand the potential utility of these two technologies when it comes to providing patients with options for predictable home care [1,2].

Mechanical Plaque Control for the Prevention of Periodontal Disease

Periodontal diseases can be classified as gingivitis *i.e.,* inflammation of gums and periodontitis where the inflammation has spread to the periodontal apparatus resulting in the deterioration in the supporting structures of the tooth [3,4]. A classic study by has shown that there is a causal link between supragingival plaque and development of gingivitis. When students with clinically healthy gingiva abstained from performing daily oral hygiene for 2-3 weeks, plaque accumulated and gingivitis commenced [5]. The gingival condition was reversed after students restarted performing mechanical plaque control. While gingivitis is reversible, periodontitis is not. If plaque continues to pool at the gingival margin, tissue edema can increase and subgingival microbiota increasingly becomes full of gram-

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negative anaerobic rods. The result is gradual destruction of the supporting structures of the teeth [6].

LITERATURE REVIEW

Oral Hygiene Compliance

Tooth brushing plays an important role in mechanical plaque control. Traditionally, dental professionals advocate brushing twice daily for two minutes. Patient compliance has not been consistent with health care recommendations. About 30%-60% of the healthcare information is usually forgotten within an hour of the appointment and about 50% of health advice is not followed [7]. Studies have shown adults tend to brush only for about 30-60 seconds and children's brushing time is even lower. A study conducted on oral hygiene practices among adults showed that about 18%-32% of participants brushed only once a day [8].

Two-Sided Toothbrush *vs.* Conventional Design

The double-headed toothbrush was a design improvement made to better control plaque. Conducted a study in 39 patients by comparing the efficacy of double-headed and single-headed toothbrushes. All the patients were instructed to use the bass brushing technique for one week and it was shown that double-headed brushes were superior in efficacy in the lingual surface with no significant differences in the buccal aspect. Conducted a study on 27 patients of which 23 were recall patients with poor plaque control and compared the efficacy between the double-headed and single-headed conventional brush. It was shown that the double-headed brush was efficacious in cleaning the lingual and palatal surfaces [9,10].

Three-Headed Toothbrush *vs.* Conventional Design

A further design modification led to the development of triple-headed toothbrushes that were intended to clean the buccal, occlusal and lingual/palatal surfaces simultaneously. There are numerous studies that have shown the efficacy of this novel design when compared to the conventional toothbrush. Even though most people still use a single sided manual toothbrush, it is inferior in terms of its plaque removal efficacy. A variety of three-sided toothbrushes have been studied to investigate efficacy of plaque removal compared to a conventional toothbrush design [11,12].

Children

In 2004, a study conducted with twenty-nine pre-school children observed that three-sided brushing yielded a significant reduction in the number of tooth surfaces with plaque. Plaque scores decreased in maxillary and mandibular posterior and anterior teeth. Another study, which used a tooth brushing performance index, found that parents who assisted their children with brushing were more effective at plaque control with a three-sided brush than with a single sided brush [13,14].

Adolescents

A clinical trial focusing on patients undergoing fixed orthodontic treatment (n=60) observed that those using triple-headed toothbrushes had significantly lower mean plaque scores than those who used traditional brushes. A similar study on patients with fixed lingual orthodontic appliances (n=26) found that plaque scores along with gingival and bleeding indexes were drastically lower post brushing with a triple-headed toothbrush [15].

Adults

A study conducted on 200 adults who received tooth brushing instructions found that plaque scores were relatively lower for the triple-headed toothbrush. Patients who didn't receive professional brushing instruction had dramatically higher tooth-brushing performance index scores after using a triple-headed brush. A study conducted on mentally retarded patients aged between 18 to 40 years found that manipulation of the triple-headed brush was far easier when compared to the conventional brushes. In 2018, a systematic review was conducted and from the analysis of 15 studies, it was observed that the triple-headed toothbrush was efficacious in plaque removal. It ensured lower plaque scores and helped care-dependent individuals whose tooth brushing was performed by care-givers.

In-vitro Study

Laboratory assessments were made to understand the Interproximal Access Efficacy (IAE), Gingival Margin Cleaning (GMC) and Subgingival Access (SA) for 6 types of toothbrush designs and it was observed that the triple-headed brush design was significantly superior in all the three aspects (IAE, GMC, SA) with p-values of <0.001 that denotes very high level of statistical significance.

Powered Toothbrushes

Powered toothbrushes utilize an AC-powered motor that is connected to a handle consisting of the brush head with bristles and it can produce a movement that can enhance mechanical. Plaque removal from the teeth and gums. The history of these toothbrushes dates back to the 18th century with designs of a novel brush by Swedish clockmaker and electric toothbrush by Dr. Scutt the range of motion in the powered toothbrushes include rotation, counter-oscillation, rotation oscillation, side-side, sonic and ultrasonic. This review will mention various technologies while focusing on one of the most popular ones sonic vibration.

Plaque Control Capabilities of Manual *vs.* Powered Brushes

The average person usually brushes for about 50 seconds. There are numerous studies that have investigated the effect of brushing time on plaque removal in both manual and powered brushes. Manual brushes are less effective in plaque removal within the same time frame as a powered toothbrush. In 1 minute, the manual toothbrush removed less

plaque when compared to powered brushes. It took the manual brush user about 6 minutes to remove the same amount of plaque removed by the powered brush within a minute. It is also notable that powered toothbrushes reach an optimum level of cleaning efficacy 84% at 2 minutes and about 93% at 6 minutes, so it is reasonable to suppose that with an increase in time, the cleaning efficacy can improve for the manual brush but not for the powered toothbrush. Powered toothbrushes also show drastic improvements over manual in terms of compliance with about 62% of patients using their brushes 36 months after purchase. A high-quality Study of Health in Pomerania (SHIP) observed that electric brushes had a significant effect on retention of teeth and reduction in periodontal disease and clinical attachment loss.

DISCUSSION

Sonic Powered Toothbrushes

The sonic toothbrush has a mechanism of action where the brush strokes per minute range between 20000 Hz-30000 Hz. They work through hydrodynamic action which causes cavitation, fluid streaming and acoustic vibrations that produce a high-speed scrubbing to effectively dislodge plaque from subgingival and interdental regions. It has been shown that the dynamic fluid motion in sonic brushes enhances removal of bacteria that adheres to saliva-coated hydroxyapatite. Two studies have shown that sonic brushes have a significant edge over manual brushes in reducing probing depths and gingival inflammation.

Sonic Brushes *vs.* Manual Toothbrush

There are various studies that have compared the efficacy of sonic and manual toothbrushes. A randomized clinical trial was conducted on 142 subjects with mild to moderate gingivitis and they were prescribed either a sonic or manual brush for home-use. The post-operative evaluation at 4-weeks observed that there was significantly reduced supragingival plaque, gingival inflammation and gingival bleeding with sonic brushes when compared to their manual counterparts. It was also concluded that both the products were safe for home usage. A similar result was observed in a study conducted on 40 young adults that showed that sonic brushes removed significantly greater amounts of plaque when compared to manual toothbrushes. A meta-analysis conducted in 2017 included 18 studies from various databases, and it observed significantly higher plaque removal and reduction in gingivitis at a 3-month follow up using sonic powered toothbrushes when compared to manual brushes. There was higher heterogeneity among the studies but the bias was not significant.

In 2014, a study conducted observed that a sonic powered toothbrush with the triple head design was more efficacious in removing supragingival plaque at the gingival margin, interproximal areas and in the whole mouth when compared to a manual flat trim brush design. The observations were noted after single usage and a follow-up of four weeks. A clinical trial conducted on 32 lichen planus patients with desquamative gingivitis, the clinical and biochemical (matrix metalloproteinase (MMP-1, MMP-9) efficacy of sonic and manual soft toothbrush was assessed. There was a significant improvement in the periodontal parameters and reduction in biochemical markers of inflammation such as MMP-1 and MMP-9 with sonic toothbrushes over a follow-up period of 8 weeks in these patients. There was also a notable increase in unstimulated salivary flow levels in patients with dry mouth with the usage of sonic powered toothbrushes. In 2016, a clinical trial assessed the efficacy of sonic powered toothbrushes and manual brushes in patients with mild to moderate Intellectual Disability (ID). It was observed that powered toothbrushes with a fluoridated toothpaste significantly reduced the plaque scores and alleviated gingivitis in these patients. It can be observed that the application of sonic brushes and its efficacy is not only limited to patients with gingivitis and it can be used in a plethora of conditions such as autoimmune diseases (lichen planus), xerostomia and intellectual disability.

CONCLUSION

Effective at-home plaque control is always on the top of every dental professional's mind because it often translates into long term periodontal health. Therefore, it is necessary to evaluate technologies that show the most promise in terms of providing predictable home-care for patients. The two technologies that have been consistently mentioned in the literature as superior to traditional manual brushing are sonic motor vibration and three-sided bristle configuration. Each of these technologies offer a significant reduction in brushing time and technique-sensitivity. They also offer consistent plaque-removal and reduction in gingival inflammation. It is worth exploring whether a cumulative effect can be achieved with a single toothbrush product that combines three-sided brushing with sonic vibration to amplify plaque control benefits.

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