OPINION PAPER

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Power toothbrushes: a critical review

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Abstract: Although the first toothbrush is thought to have been used in about 1000 AD, tooth brushing in America did not gain popularity until after 1945. The introduction of the powered toothbrush in 1960 has led to a large number of studies comparing the safety and efficacy of powered toothbrushes to manual toothbrushes. There is a general agreement that powered toothbrushes are as safe as manual toothbrushes; however, studies show significantly differing conclusions regarding the efficacy of power toothbrushes for the removal of plaque. The recent amendment of the Cochrane report on this subject concluded that the only type of powered toothbrush that removes more plaque than a manual toothbrush is one with rotational oscillation movement. Their conclusion was based on the review of 29 published studies, conducted between 1964 and 2001, with a total of 2547 participants. All these studies used similar research design criteria. The Cochrane conclusion is in agreement with a 1996 study carried out in the Netherlands. Many of the conflicting study conclusions, to date, on powered toothbrushes, are the result of using differing study design criteria. While the dental profession desires evidence-based research, it is clear that dental schools will need to increase the level of attention in their curriculum to address disciplined techniques for research design in order to reconcile the large variances in reported research results.

Key words: toothbrush; power toothbrush; electric toothbrush; manual toothbrush; plaque; gingival abrasion

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History of toothbrushes

The very earliest implements for cleaning teeth were simply small twigs that were eventually mashed at one end to increase their cleaning surface (1). According to Travers (editor of *World of Inventions*), ancient Roman patricians engaged special slaves to clean their teeth as part of a religious ritual (2). The first toothbrush,

thought to have been invented in China in 1000 AD, had an ivory handle and bristles made from a horse's mane (1, 2). Other early toothbrushes used bristles from the necks of cold climate pigs. The bristle brush came to Europe during the 17th century and soon was widely used. French dentists, who were the most advanced in Europe at the time, advocated the use of toothbrushes in the 17th and early 18th centuries. At the same time, prerevolutionary American dentists were encouraging the use of bristle toothbrushes in America (2).

Toothbrushes were first mass-produced by William Addis of Clerkenwald, England. H.N. Wadsworth patented the first American toothbrush, and companies began to mass produce toothbrushes in America around 1885. The Pro-phy-lac-tic brush, made by the Florence Manufacturing Company of Massachusetts, is a good example of an early American-made toothbrush. The same company was also the first to sell toothbrushes packaged in boxes. Nylon replaced the natural bristles in modern brushes in 1938. Although hard to believe, most Americans did not brush their teeth until soldiers brought the Army's enforced habit back home from World War II. Today, manual toothbrushes are commercially available across the globe in a myriad of designs.

Advent of the power toothbrush

It is an accepted knowledge among dental professionals that four basic habits are necessary to insure good dental hygiene. These include two times daily brushing lasting for 2 min, daily flossing, the use of a fluoridated toothpaste and regular visits to the dentist. Most dentists find that their patients do not brush correctly, either because of improper brushing technique or for not brushing long enough. The power toothbrush was introduced to address these two concerns.

The first power toothbrush was marketed in 1880 as Dr Scott's electric toothbrush. Dr Scott claimed that his toothbrush was 'permanently charged with electro-magnetic current.' While Dr Scott's toothbrush was not really a power toothbrush, as we know them today, the first toothbrush powered by electricity was developed in Switzerland after World War II. This power-corded electric toothbrush was introduced to the United States market in 1960 by Squibb under the name Broxodent. Although it was an oddity at the time, the power toothbrush was an immediate success. General Electric quickly followed by introducing a rechargeable cordless toothbrush in 1961. Interplak was the first rotary action power toothbrush for home use, introduced in 1987 (3).

Early commercially available power toothbrushes maintained a clear lack of superiority compared with manual toothbrushes, and problems with mechanical breakdowns caused their sales to decrease significantly following their initial introduction. Despite this, dentists continued to recommend them for use in special populations with diminished manual dexterity and cognition problems (4, 5).

Since the introduction of power toothbrushes in the early 1960s, they have undergone many technological advances in design and bristle motion, including rotation, oscillation and sonic vibration (6). Even though these products had been available for many years, it was not until the 1990s that they became a common household item for dental hygiene self-care and a primary preventive tool. By 2001, power toothbrushes accounted for 7% of all toothbrushes sold, compared to just 2% in 1999.

Types of power toothbrushes

A wide selection of powered brushes is currently in the marketplace. These products vary in relation to brush head configuration and size, mechanism of action and speed, as well as overall design. Some brushes have added convenience features such as timers. The mechanism of action of today's power toothbrushes can be categorised as *mechanical*, *sonic* or *ionic*.

The *mechanical* action power toothbrush comes with rotating or oscillating heads. The heads are self-powered and work much like a wax polisher works on the floor or your car. As the bristles are pressed against teeth and gums, the rapid, constant movement removes plaque and food particles.

The *sonic* toothbrush has a rotating head and bristles, but, in addition, it emits sound waves. The manufacturer claims that the sound waves create a vibration that helps in conjunction with the bristles to loosen plaque and food particles. This is the same technology used in the dental office for ultrasonic plaque removal. However, the efficacy of sonic technology in power toothbrushes for the removal of plaque has not been substantiated by clinical data.

Ionic toothbrushes are alleged to work by reversing the polarity of the teeth. Teeth naturally have a negative ionic charge and, conversely, food particles naturally have a positive ionic charge. These opposite charges are attracted to each other causing food particles to stick to the teeth. The ionic toothbrush temporarily changes the tooth's negative ionic charge to a positive charge. Then, another part of the toothbrush is positively charged, attracting the plaque and food particles away from the tooth. The bristles brush the loosened particles away. Again, the effectiveness of this mechanism for the removal of plaque has not been substantiated by clinical data.

Plaque removal

Specific oral bacteria, generically known as 'dental plaque', are the primary cause of gingivitis (gum disease) and caries. The

removal of dental plaque plays an important role in the maintenance of oral health. There is conflicting evidence regarding the efficacy of power toothbrushes as compared to manual toothbrushes for the removal of plaque.

Some research indicates that power toothbrushes can be more effective in the removal of plaque than a manual toothbrush (7–9). This increased efficacy is mainly because of superior interproximal cleansing abilities. Despite significant developments and improvements in the design of the manual toothbrush, they only remove about 50% of the plaque on smooth surfaces of the teeth, and even less interproximally. Several independent studies have reported a definite reduction in plaque levels in both adult and children groups using power toothbrushes when compared with manual brushes. Some of these studies report that power toothbrushes reduce plaque by as much as 60% more than manual brushes and result in a greater reduction in gingivitis (6, 10, 11).

Contrary to some research that indicates the superiority of power toothbrushes to manual toothbrushes, a recently published analysis of selected studies by Heanue *et al.* (12) found that only one type of power toothbrush was more effective at removing plaque and decreasing gum disease than manual brushes. The study, whose findings were published in early 2003 in the *Cochrane Library*, was conducted by a British-based non-profit health research group called the Cochrane Collaboration. This group subjects long-standing health procedures to rigorous scientific scrutiny. The Cochrane Collaboration's Oral Health Group, based at the University of Manchester's Dental Hospital, involved researchers from the Universities of Birmingham, Edinburgh, Manchester and Sheffield.

Heanue *et al.* (12; the Cochrane study) compared manual and power toothbrushes in relation to the removal of plaque, the health of the gingivae, staining and calculus. The reviewers used data from 29 trials conducted between 1964 and 2001, involving 2547 participants. In order to obtain a fair comparison of cleaning efficacy, only clinical trials that met the following criteria were selected for analysis: design – random allocation of participants, participants – general public with uncompromised manual dexterity, intervention – unsupervised manual and power tooth brushing for at least 4 weeks and primary outcomes – the change in plaque and gingivitis over that period. Cochrane researchers clustered power toothbrushes into six categories, depending on how they operated. For example, there were side-to-side, counter-oscillation and circular-action toothbrushes.

Heanue *et al.* (12) concluded that the only category of power toothbrushes that cleaned better than manual toothbrushes were those that worked with *rotation–oscillation action*, with brush heads that rotate in one direction and then the other. This type of power toothbrush was shown to remove more plaque and reduce gingivitis more effectively than manual brushes. No other powered brush designs were consistently superior to manual toothbrushes. The Braun Oral-B Plaque Remover, made by the Gillette Co., is among the leading products in the rotational oscillation category.

In addition, Clinical Research Associates (CRA), a non-profit organisation dedicated to serving dentists by evaluating dental materials, devices and concepts for efficacy and clinical usefulness, published a July 1998 study in which six toothbrushes were evaluated to determine if toothbrushes with sonic or ultrasonic capabilities reduce dental plaque more effectively than manual or other automated toothbrushes. They concluded that no automated toothbrush was substantially better than the conventional manual brush in removing plaque. However, of all the brushes tested, the Braun Oral-B Ultra Plaque Remover Personal left the smallest percentage of plaque on teeth after brushing (13). An earlier study conducted in the Netherlands in 1996 reported that the oscillating/rotating toothbrush (Braun/Oral-B Plak Control) is more effective in plaque removal than the sonic-powered toothbrush (Sonicare; 14).

Gingival abrasion and safety

The safety of power toothbrushes has been clearly established, and research indicates that daily use of a power toothbrush is at least as safe as a manual toothbrush (15). It is widely believed that use of a powered toothbrush, which employs a mechanical action instead of a manual action, reduces brushing force and the incidence of gingival bleeding because of gum damage. In a study by Danser *et al.* (16), it was observed that brushing force was not influenced by the speed of the brush head and had no correlation with the incidence of gingival abrasion. In another study by Boyd *et al.* (17), it was determined that power toothbrushes were used with about one-third the force of a manual toothbrush.

In a Swiss study evaluating the clinical effects and gingival abrasion aspects of two power toothbrushes and one manual toothbrush, it was determined that in a group of dental students trained in manual brushing technique, where efficacy was similar with the three toothbrushes tested, there was no evidence of greater gingival abrasion with either powered toothbrush when compared with a manual brush (18).

The concerns of gingival abrasion associated with tooth brushing are influenced by the filament end-rounding of the brush on either manual or power toothbrushes. The results of the Danser *et al.* (16) study concluded that end rounding has no effect on plaque removal, but does affect the incidence of gingival abra-

sion. They showed that gingival abrasion is not influenced by brushing force, but is affected by filament end rounding.

Manual versus power toothbrushes

Power toothbrushes not only move bristles at a much faster speed than you could possibly achieve manually, but they also remove plaque more evenly in hard-to-reach places, such as between teeth and on back molars. Prof. Bill Shaw and Dr Helen Worthington, joint coordinating editors of the Cochrane Collaboration say, 'Persons who enjoy the feel of a power toothbrush and can afford one may be assured that it is at least as effective as traditional brushing and that there is no evidence that it will cause more injuries to the gum' (19). This is a pretty modest advantage for power brushes that can cost anywhere from $7 for a battery-powered model to $100 for a rechargeable model; considerably more than the manual toothbrushes that many people get free from their dentists.

Once people use a power toothbrush, they seldom go back to a manual brush. Power toothbrushes are often recommended by dental care professionals because they automatically create good brushing technique, are best for individuals with low manual dexterity, such as children and the handicapped, and are safe for orthodontic patients (6).

When commenting on the Cochrane Collaboration, Dr Kenneth Burrell, senior director of the Council on Scientific Affairs for the American Dental Association, said that the findings, if they prove accurate, could be useful in helping dentists make recommendations to their patients. 'Someone using the simplest manual toothbrush with good knowledge of how to brush and conscientious brushing can do just as well as somebody using a powered toothbrush, regardless of the design.' Burrell further commented: 'There are two parts that make up the effect of toothbrushing; one is the device you use and the other is the person attached to the device' (20).

Conclusion

The results of the Cochrane study support the use of power toothbrushes not only for people with manual dexterity problems or other physical limitations, but for the general population. Nonetheless, correct brushing technique is still more important than the choice of a certain toothbrush. The Cochrane study suggests that many expensive power toothbrushes are no more effective than a manual brush. And, while many research studies suggest that power toothbrushes are more effective in removing plaque, decreasing gingivitis and diminishing brushing force, not all power brushes are alike. Oscillating/rotating and counter-rotational action-powered toothbrushes have been found to be somewhat more effective in plaque removal with minimal gum abrasion when compared to rotary, vibrating or sonic-action brushes (6).

The Cochrane study represents a systematic review of research that had already been conducted on power toothbrushes. It sought to bring together all the relevant research evidence in order to be as reliable as possible. By using predetermined criteria for selecting studies for the review, the conclusion reaffirms that studies and trials that follow the same experimental design can produce supporting conclusions.

The Cochrane study also points out the necessity for dental researchers to carefully design the clinical trials and studies with accepted methodologies in order to reduce the contradictory results found in the literature to date. And perhaps, most importantly, it demonstrates the need for more long-term clinical trials and studies that are designed and executed with a specific set of predetermined and consistent criteria. While very short trial periods may be indicative of a particular result, they are rarely conclusive.

Clearly, there is a strong need for evidence-based medicine in the practice of dentistry. As the demand for research standards become more rigorous, dental schools need to increase attention for teaching the methodology of incorporating disciplined criteria in the design process before proceeding with clinical trials and studies.

In conclusion, the findings of the Cochrane study are so significant because this is the most comprehensive, independent review of power toothbrushes that has ever been conducted. and it shows conclusively that power toothbrushes with an oscillating, rotating mechanism, like the Oral-B 3D Excel, are more effective than manual toothbrushes and other power toothbrushes, including those with sonic technology, at removing plaque and reducing and reversing gingivitis (21).

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