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Oscillating-rotating powered toothbrushes are more effective than manual toothbrushes. (Photo courtesy of Procter & Gamble)

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The effectiveness of toothbrushing

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Plaque control is the cornerstone of the prevention and control of periodontal disease and caries. However, although salivary flow has some limited potential in cleaning debris from interproximal spaces and occlusal pits, it is less effective in removing and/or washing out plaque, and natural cleaning of the dentition by physiological forces—that is movement of the tongue and cheeks—is virtually non-existent. [1]

Therefore, to be controlled, plaque must be removed frequently by active methods, and evidence from large cohort studies has demonstrated that high standards of oral hygiene will ensure effective plaque removal. [2] There is substantial evidence that toothbrushing can control plaque, provided that cleaning is sufficiently thorough and performed at appropriate intervals. The underlying factors that influence the effectiveness of toothbrushing include toothbrush design, its action, ease of use and patient compliance.

Systematic reviews

Evidence-based dentistry is an approach to oral health care that requires judicious integration of systematic assessment of clinically relevant scientific evidence with the dental professional's clinical expertise, the patient's treatment needs and preferences, and the available tools. At present, systematic reviews are considered to provide the highest level of evidence and to be the primary tool for summarising the existing evidence in a reproducible and systematic way. As such, they are crucial for evidence-based decision-making.

Systematic reviews differ from traditional reviews in that they are usually confined to a single focused question that serves as the basis for systematic searches, selection and clinical evaluation of the relevant research. Systematic reviews minimise bias and provide a comprehensive and contemporary overview. Such analyses are objective in their appraisal of quality and transparent in their assessment of heterogeneity, allowing others to appraise the methodology and quality of the review itself. By performing a meta-analysis on sufficiently similar studies, a pooled estimate of the common mean can be calculated, the range of results limited and the strength of the results increased. The Cochrane Handbook for Systematic Reviews of Interventions [3] declares that reviews are needed to help ensure that healthcare decisions can be based on informed, high-quality, timely research evidence. In addition, the American Dental Association has launched the Center for Evidence-Based Dentistry website, which currently contains over 1,600 clinically relevant systematic reviews.

PICO(S) rule

The protocol for a systematic review is developed beginning with a carefully formulated question using the PICO(S)rule—patient, intervention, comparison, outcome parameters and study design. The manner in which this question is formulated is decisive for interpretation of the results of the review. After the research protocol has been written, an objective literature search is undertaken to find the relevant literature, while minimising the possibility of overlooking any research. The parameters used to evaluate the results are also important for the conclusions that will be drawn. An example of the parameters used is the reduction in plaque and gingivitis associated with the use of different types of toothbrushes.

Toothbrushing
The use of mechanical devices for the routine cleaning of teeth dates back to the ancient Egyptians, who made a brush by chewing on the end of a twig to fray it. Today, there are literally hundreds of manual toothbrush designs, including bristle patterns that are designed to enhance plaque removal inhard-to-reach areas of the dentition, particularly proximal areas. Much emphasis has also been placed on new ergonomic designs, for example handle sizes adapted to the hand size of the prospective user. Nonetheless, even adults, despite their apparent efforts, appear not to be as effective in their plaque removal as might be expected.

The effectiveness of manual toothbrushes in a systematic review
Brushing-exercise studies, commonly used for toothbrush evaluations, serve as a useful indication of the ability of a toothbrush to remove plaque and facilitate the control of confounding variables such as compliance. A recent systematic review evaluated the efficacy of manual toothbrushing with respect to toothbrush design and brushing duration following such exercises. [4] In this review, a literature search yielded 2,079 titles and abstracts, of which 59 studies, with 212 brushing exercises as separate legs of the experiments and with 10,806 participants, met the eligibility criteria for inclusion.The mean pre- and post-brushing plaque scores found in the studies were used to calculate an overall weighted mean reduction in plaque score (42 per cent).

The sheer magnitude of the number of participants and the heterogeneity observed in the various study designs give the results particular value, as they reflect what may be generally expected from routine oral hygiene. In the studies with data assessed according to the Quigley–Hein plaque index, [5] the weighted mean reduction in plaque score was 30 per cent (95 per cent CI: 27 to 33 per cent), while in the studies using the Navy plaque index a weighted mean reduction in plaque score of 53 per cent (95 per cent CI: 50 to 56 per cent) was observed. Sub-analysis of the different bristle tuft configurations illustrated variation in ability to remove plaque (24 to 61 per cent), with the angled bristle design demonstrating the highest overall weighted mean reduction in plaque score with either index. A sub-analysis of the influence of the duration of brushing revealed an overall weighted mean reduction in plaque score of 27 per cent after one minute of brushing and 41 per cent after two minutes.

Therefore, it was concluded that the efficacy of plaque removal resulted in an overall weighted mean reduction in plaque score from baseline of 42 per cent, with a range of 30 to 53 per cent depending on the plaque index used. The available evidence indicates that bristle tuft arrangement (flat-trim, multi-level, angled) and brushing duration are variables relevant to efficacy. Irrespective of the index used, it appears that there is room for improvement regarding the efficacy of manual toothbrushes.

Powered (electric) toothbrushes
The first successful powered toothbrush (the Broxodent) was conceived in Switzerland in 1954 by Dr Philippe-Guy Woog, and the first generation of powered toothbrushes had a brush head like that of a manual toothbrush and designed to have a (combined) horizontal and vertical action. Since the 1980s, tremendous advances have been made and various powered toothbrushes have been developed to improve the efficiency of plaque removal.

Powered toothbrushes currently available vary in their action. Oscillating-rotating toothbrushes are designed with a round head that moves back and forth, with alternating turns clockwise and counter-clockwise. In contrast, toothbrushes with a circular action rotate in one direction only, counter-oscillating toothbrushes have tufts of bristles that rotate back and forth independent of the directions of other tufts, and other toothbrushes move from side to side (including sonic toothbrushes). At different times, individual studies have been conducted on the efficacy and safety of these powered toothbrushes categories and the collective evidence has been summarised in systematic reviews.

Powered versus manual toothbrushes
An early dental systematic review, performed in collaboration with the Cochrane Oral Health Group, compared powered and manual toothbrushes in everyday use, principally in relation to plaque removal and gingival health. [6] In this review, five electronic databases were searched to identify randomised controlled trials that compared powered and manual toothbrushes (up to the middle of 2002) in which the participants were members of the public with uncompromised manual dexterity who brushed unsupervised for at least four weeks. The review was first updated by Robinson et al. (2005) and the most recent update of this review was published by Yacoob et al. (2011). [7,8] In total, 50 eligible trials involving 4,326 participants, with no evidence of publication bias, were included in the review.

Oscillating-rotating powered toothbrushes resulted in greater plaque and gingivitis reduction compared with manual toothbrushes, with standard mean differences (SMD) for plaque and gingivitis reduction of 0.53 (95 per cent CI: -0.74 to -0.31) and 0.49 (95 per cent CI: -0.73 to -0.26), respectively, in the short term (one to three months). Significantly greater plaque and gingivitis reduction was also found in the long term (i.e. beyond three months), with approximately 27 per cent fewer sites with bleeding on probing.

The conclusion of this last systematic review was that only for oscillating-rotating toothbrushes is there consistent evidence of their clinical superiority to manual toothbrushes and greater ability to reduce plaque and gingivitis. These results confirm the findings and conclusions of the earlier reviews that compared powered and manual toothbrushes.

Comparison of different powered toothbrushes
The most recent Cochrane review assessed the comparative efficacy of powered toothbrushes with differing action and their effect on oral health. [9] Five electronic databases were searched for studies conducted up to July 2010, resulting in a total of 17 eligible trials, with more than 1,300

total participants. The criteria for selection were that the studies were randomised, compared at least two powered toothbrushes with differing action and involved at least four weeks of unsupervised brushing, and that their participants had uncompromised manual dexterity. The action of the toothbrushes in these trials was oscillating-rotating, counter-oscillating, side-to-side, circular, ultrasonic, multidimensional and ionic (electrically active).

Based on seven trials of up to three months in duration, with no significant heterogeneity, oscillating-rotating toothbrushes were found to result in statistically significantly greater plaque reduction in the short term (one to three months) compared with side-to-side powered toothbrushes. The SMD for plaque reduction was calculated as 0.24 (95 per cent CI: 0.02 to 0.46). Clinically, the relative superiority of the oscillating-rotating action to the side-to-side action equated to a 7 per cent reduction in the Turesky modified Quigley–Hein plaque score. The SMD for short-term gingivitis reduction of 0.35 (95 per cent CI: -0.04 to 0.74) was not statistically significant. As only one trial of more than three months in duration was available, and with only a limited number of participants, no firm long-term conclusions could be drawn.

The safety of powered toothbrushes
A systematic review was recently conducted on the safety of oscillating-rotating toothbrushes compared with manual toothbrushes regarding hard and soft tissue. [10] After searching several electronic databases, 35 original papers were selected for inclusion and grouped by research design (randomised controlled trials with safety as the primary outcome, trials in which safety was a secondary outcome, studies that used a surrogate marker of safety, and laboratory-based studies).

The review authors concluded that “this systematic review of a large body of published research in the preceding two decades consistently showed oscillating-rotating toothbrushes to be safe when compared with manual toothbrushes, and collectively indicated that they do not pose a clinically relevant concern to either hard or soft tissues”.The outcome is consistent with the observations of the Robinson et al. (2005) and Yacoob et al. (2011) reviews, supporting the safety of oscillating-rotating powered toothbrushes. [7,8] There are at present no systematic reviews on safety for any other powered toothbrush.

Other considerations
Evidence-based dentistry is important for decision-making; however, it has to be noted that clinical outcome may not be the only decisive factor. For instance, while a powered toothbrush may offer ease of use and improve patient compliance with brushing, the increased cost of powered toothbrushes may affect a patient’s toothbrush choice. It is the manner in which the user brushes that determines the efficacy of plaque removal. The role of the dental professional is to coach and motivate the patient. Features such as a timer and visual signals on a toothbrush help to increase engagement of the user while brushing, and have been found to result in improved brushing and patient compliance.

Conclusion
Based on the available evidence, oscillating-rotating toothbrushes have been shown to result in greater plaque and gingivitis reduction compared with manual toothbrushes. Additionally, based on short-term data, oscillating-rotating toothbrushes compare favourably to powered toothbrushes with a side-to-side action, while insufficient evidence is available for other powered toothbrushes. Systematic reviews also provide evidence of the safety of oscillating-rotating toothbrushes.

Summary of findings: The bristle tuft configuration is an important parameter for manual toothbrushes. Oscillating-rotating powered toothbrushes are more effective than manual toothbrushes. The safety and efficacy of oscillating-rotating toothbrushes have been established.

A complete list of references is available from the publisher.

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