The effectiveness of toothbrushing
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Plaque control is the cornerstone for 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 – ie, movement of the tongue and cheeks – is virtually non-existent (Lindhe & Wicén, 1969). 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 (Van der Weijden & Slot, 2011). There is substantial evidence showing that toothbrushing can control plaque, provided that cleaning is sufficiently thorough and performed at appropriate intervals. The underlying factors influencing the effectiveness of toothbrushing include toothbrush design, its mode of 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 assessments of clinically relevant scientific evidence, with the dental professional’s clinical expertise and the patient’s treatment needs, 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 which 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 average can be calculated, the range of results limited and the strength of the results increased. The Cochrane Handbook for Systematic Reviews (http://www.cochrane.org/training/cochrane-handbook) 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 (ADA) has launched a website called ‘Center for Evidence-Based Dentistry’ (http://ebd.ada.org/SystematicReviews.aspx) that currently contains more than 1600 clinically relevant systematic reviews.

PICO(S)-question
The protocol for a systematic review is developed beginning with a carefully formulated question using the ‘PICO(S)’ rule – patient, intervention, comparison, outcome and study design. The manner in which this question is formulated is

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The results are also important for the conclusions that will be drawn. An example of parameters used would be the reductions 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 from hard-to-reach areas of the dentition, particularly proximal areas. Much emphasis has also been placed on new ergonomic designs, for example handle sizes appropriate for the hand size of the prospective user. Nevertheless, 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 of brushing exercise studies are commonly used for toothbrush evaluations, serve as a useful indication of the plaque removal ability of a toothbrush 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 (Slot et al, 2012). The literature search yielded 2079 titles and abstracts, of which 59 papers with 212 brushing exercises (as separate legs of the experiments, and including 10,806 participants, met the eligibility criteria for inclusion. The mean pre- and post-brushing plaque scores found in the papers were used to calculate an overall weighted mean percentage plaque score reduction. The sheer magnitude of the number of participants and the heterogeneity observed in the various studies designs gives the results particular value, because they reflect what may be generally expected from routine oral hygiene. For the studies with data assessed according to the Quigley & Hein plaque index, the weighted mean reduction in plaque scores was 50 per cent (95 per cent CI: 27 per cent to 55 per cent), while in the studies using the Navy plaque index a weighted mean plaque score reduction of 55 per cent (95 per cent CI: 50 per cent to 56 per cent) was observed. Sub-analyses between the different bristle tuft configurations illustrated variation in plaque removal ability (24 per cent to 61 per cent), with the angled bristle design demonstrating the highest mean plaque reduction with either index. A sub-analysis on the influence of the duration of brushing revealed a mean plaque reduction 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 average plaque score reduction from baseline of 50 per cent, with a range of 30 per cent to 55 per cent depending on the plaque index used. The available evidence indicates that bristle tuft arrangement (flat-trim, multi-arrangement), and brushing duration are variables contributing to efficacy. Irrespective of the index used, it appears that there is room for improvement for the efficacy of manual toothbrushes.

The first successful electric toothbrush (the Broxo SA) was...
conceived in Switzerland in 1954 by Dr. Philippe-Guy Woog, and the first generation of electric toothbrushes had a brush head designed as a manual toothbrush that moved a (combined) horizontal and vertical motion. Since the 1980s, tremendous advances have been made with various electronic toothbrushes have been developed to improve the efficiency of plaque removal. Powered brushes currently available vary in their mode-of-action. Oscillating-rotating brushes are designed with a round head that moves back and forth, with alternating turns clockwise and counter-clockwise. In contrast, brushes with a circular mode-of-action rotate in one direction only, counter-oscillation brushes have tufts of bristles that rotate back and forth independent of the directions of other tufts, and other brushes move from side-to-side (including sonic brushes). At different times, individual studies have been conducted on the efficacy and safety of these powered brush categories and the collective evidence has been summarised in systematic reviews.

**Powered brushes versus manual toothbrushes**

An early dental systematic review, performed in collaboration with the Cochrane Oral Health Group, compared manual and powered toothbrushes in everyday use, principally in relation to plaque removal and gingival health (Heanue et al., 2002). Five electronic databases were searched to identify randomised controlled trials comparing powered and manual toothbrushes (up to the middle of 2002) where 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. in 2005 and the most recent update of this review was published by Ya-coub et al. in 2011. In total, 50 eligible trials involving 4,326 participants, with no evidence of publication bias, were included in the review. Oscillating-rotating powered brushes resulted in greater plaque and gingivitis reductions compared to manual brushes, with standard mean differences (SMD) for plaque and gingivitis reductions of SMD=0.55 (95 per cent CI; -0.74 to -0.31) and SMD=0.49 (95 per cent CI; -0.75 to -0.26) respectively in the short-term (one–three months). Significantly greater plaque and gingivitis reductions were also found in the long-term beyond three months, with approximately 27 per cent fewer sites with bleeding-on-probing.

The conclusion from this last systematic review was that only for oscillating-rotating brushes is there consistent evidence to consider them clinically superior to manual brushes and to offer greater plaque and gingivitis reductions. These results confirm the findings and conclusions from the earlier reviews comparing manual and powered brushes.

**Comparison of different powered toothbrushes**

The most recent Cochrane review assessed the comparative efficacy of powered brushes with different modes of action and their effect on oral health (Deacon et al., 2011). Five electronic databases were searched up to July 2010, resulting in a total of 17 eligible trials, with more than 1,500 total participants. The criteria for selection were that the studies were randomised, compared at least two powered brushes with different modes of action, involved at least four weeks of unsupervised brushing and where the participants had no impairment of manual dexterity. The toothbrush modes-of-action represented by these trials were: oscillating-rotating, counter-oscillating, side-to-side, circular ultrasonic, multidimensional and ionic (electrically active).

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Based on seven trials of up to three months duration, with no significant heterogeneity, oscillating-rotating brushes were found to result in statistically significantly greater plaque reductions in the short term (one-three months) compared to side-to-side powered brushes. The standard mean difference (SMD) for plaque reduction was calculated to be SMD=-0.24 (95% CI; 0.02 to 0.46). Clinically, the relative superiority of the oscillating-rotating mode of action to the side to side motion of action would equate to a seven per cent reduction in the Turesky modified Quigley-Hein plaque score. The short-term gingivitis reduction of SMD=-0.55 (95% CI; -0.04 to 0.74) missed being statistically significant. As only one trial was available of more than three months duration, 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 and, finally, 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 brushes, 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 Deacon et al., 2011 reviews supporting the safety of oscillating-rotated powered brushes. There are at present no systematic reviews on safety for any other powered brush.

Other considerations

Evidence-based dentistry is important for decision making, however it has to be noted that clinical outcomes may not be the only decisive factor to come into play. For instance, the increased cost of powered toothbrushes may play a role in a patient’s toothbrush choice, while a powered toothbrush may offer ease-of-use and improve patient compliance with brushing. It is the toothbrush in the hands of the user 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 brush help to increase engagement of the user to perform an adequate job and have been found to result in improved brushing and patient compliance.

Conclusions

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

References


Dr. Fridus van der Weijden graduated in 1984 from the State University Dental School in Utrecht, The Netherlands where he also received his training as a periodontist and was accredited by the Dutch Society of Periodontology in 1990. He defended his thesis entitled, ‘The use of models and indices in plaque and gingivitis trials’ in 1995 and received accreditation as a ‘senior investigator’ by the Netherlands Institute for Dental Sciences in 2000. In 2005 he received accreditation as an ‘implant-specialist’ by the Dutch Society of Oral Implantology. Since 1990 Fridus van der Weijden divides his time between the Clinic for Periodontology, Erasmus and the Academic Centre for Dentistry Amsterdam. Furthermore he works on regular occasions as an implant dentist in a practice devoted to implantology in Drachten. He is a board examiner in postgraduate courses and the author of the book entitled, ‘The Power of Ultrasounds’ and the co-author and editor of the book ‘Preservation Dentistry’. He has also authored and co-authored approximately 60 national and 150 international publications. The Ivory Cross, awarded him early 2010 with the Carl Wittlowski Medal of honor for his work on prevention and propagation of oral health. Early 2010 he has been appointed a chair as professor at the University of Amsterdam with ‘Prevention of Oral and Systemic infections’ as main focus for his research. This chair has been an initiative of the Dutch Society of Periodontology.