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TOOTH BRUSHING

Canadian Dental Hygienists Association Position Statement

Research is scarce on several aspects of tooth brushing, disallowing firm conclusions and providing many opportunities for future dental hygiene research. Frequency and duration data are equivocal, and neither ideal bristle stiffness nor tooth-brushing method has been determined. Re-chargeable toothbrushes with oscillating, rotating (with or without pulsating action) mode of action have been shown to be more effective in removing plaque and improving gingival outcomes than manual toothbrushes currently available. Due to the length of the clinical trials that assessed mode of action, only the clinical significance of plaque and gingivitis reduction could be assessed, not the impact on reduction of periodontal destruction. While the ideal force of tooth brushing has not been determined, excessive force may be linked with gingival trauma. Gingival recession and hard-tissue cervical abrasion have multi-factorial etiologies and tooth brushing is considered contributory. Worn toothbrushes have not been shown to be less effective than unworn brushes; therefore, no ideal replacement interval is evident. Toothbrushes support a variety of micro-organisms, but research is lacking that shows a relationship between a contaminated toothbrush and oral/systemic clinical manifestations.

Keywords: Dental devices, home care; dental plaque; gingival recession; gingivitis; health behavior; periodontitis; toothbrushing

CDHA Position Paper on Tooth Brushing

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EXECUTIVE SUMMARY

Purpose: Tooth brushing is the most commonly recommended and performed oral hygiene behaviour by North Americans and is done ubiquitously in developed nations. It is the primary mechanical means for removing dental plaque, thereby assisting in the prevention of oral diseases including gingivitis and dental caries. The aim of this paper is to report on an investigation of the current state of the science on tooth brushing for the control of plaque and periodontal diseases, particularly gingivitis, and in order to develop a Canadian Dental Hygienists Association (CDHA) position statement.

Methods: Using previously published reviews and analyses as a departure point, a comprehensive review and analysis of the literature was conducted. The search was guided by the development of several PICO questions on tooth brushing and included the following databases: MedLine, CINAHL (Cumulative Index of Nursing a Allied Health Literature), and the Cochrane Controlled Trials Register. Salient websites were also examined. Subsequent to the review and analysis, input was solicited from recognized experts and researchers in relevant fields of inquiry.

Results: A total of 238 papers were identified and retrieved in full text. Data on tooth-brushing frequency and duration, ideal bristle stiffness, and tooth-brushing method were found to be equivocal. Worn toothbrushes were not shown to be less effective than unworn brushes, and no ideal toothbrush replacement interval is evident. Re-chargeable power toothbrushes with an oscillating, rotating (with or without pulsating action) mode of action have been shown to be more effective in removing plaque and improving gingival outcomes than manual toothbrushes. Ideal tooth-brushing force has yet to be determined, but excessive force may be associated with gingival trauma. While gingival recession and hard-tissue cervical abrasion are recognized as having multi-factorial etiologies, tooth brushing is considered contributory. Toothbrushes have been shown to support a variety of micro-organisms, but research showing a relationship between a contaminated toothbrush and oral/systemic clinical manifestations is not evident.

Conclusions: Seven recommendations were developed representing the current understanding surrounding toothbrush use, based on the best available evidence. While considerable research into tooth brushing has been conducted, it was found that there is a paucity of research on several aspects of tooth brushing; thus many firm conclusions could not made. This lack of conclusive data in several areas about tooth brushing limits dental hygienists' ability to provide evidence-based recommendations for their clients. In these cases, dental hygienists will need to rely on their clinical experience along with the specific conditions of their clients. It is apparent that many opportunities exist for future dental hygiene research in several areas of tooth brushing.

Déclaration de L'ACHD sur le brossage des dents

Il y a un manque d'études sur plusieurs aspects du brossage des dents, ce qui empêche de tirer des conclusions fermes et offre de nombreuses possibilités pour la recherche future en hygiène dentaire. Les données sur la fréquence et la durée sont équivoques. Ni la rigidité des soies ni la méthode de brossage idéales n'ont été déterminées. Toutefois, il y a quelques études qui indiquent qu'une technique de frottage est moins efficace pour l'enlèvement de la plaque que d'autres techniques ou méthodes. Il a été démontré que les brosses à dents à piles rechargeables oscillantes, rotatives (avec ou sans action pulsatoire) étaient plus efficaces pour l'enlèvement de la plaque et l'amélioration de l'état gingival que les brosses à dents manuelles actuellement offertes. Étant donné la durée des essais cliniques évaluant le mode d'action, seule la portée clinique de la réduction de la plaque et de la gingivite pouvait être mesurée. L'effet sur la réduction de la destruction parodontale n'a donc pas été mesuré. Bien que la force idéale de brossage n'ait pas été déterminée, une force excessive peut causer un traumatisme gingival. La récession gingivale et l'abrasion des tissus durs cervicaux ont des étiologies multifactorielles et le brossage de dents est considéré comme un facteur contributoire. Il n'a pas été démontré que les brosses à dents usées étaient moins efficaces que les brosses qui ne l'étaient pas ; par conséquent, aucun intervalle de remplacement idéal n'est évident. Les brosses à dents favorisent le développement d'une multitude de microorganismes, mais peu d'études démontrent qu'il y a une relation entre une brosse à dents contaminée et les manifestations cliniques systémiques et buccales.

RÉSUMÉ

Le but : Le brossage des dents est le comportement d'hygiène buccale le plus couramment recommandé et adopté par les Nord-Américains et est fait de façon systématique dans les nations développées. C'est le principal moyen mécanique d'enlever la plaque dentaire, aidant ainsi à prévenir les affections buccales, incluant la gingivite et la carie dentaire. Le but de cet article est de faire rapport sur une investigation de la position actuelle de la science sur le brossage des dents comme moyen de contrôle de la plaque et des affections parodontales, particulièrement la gingivite et d'en arriver à formuler une déclaration de l'Association canadienne des hygiénistes dentaires (ACHD).

Les méthodes : En utilisant les études et analyses publiées antérieurement comme point de départ, une étude et une analyse approfondie de la littérature a été faite. La recherche était guidée par le développement de plusieurs questions PICO sur le brossage des dents et incluaient l'utilisation des bases de données suivantes : MedLine, CINAHL (Cumulative Index of Nursing a Allied Health Literature) et le Cochrane Controlled Trials Register. Des sites Web sérieux ont également été vérifiés. À la suite de l'étude et de l'analyse, des commentaires ont été sollicités auprès d'experts et de chercheurs reconnus oeuvrant dans des domaines pertinents d'investigations.

Les résultats : Au total, 238 articles ont été identifiés et récupérés en texte intégral. Les données sur la fréquence et la durée du brossage des dents, sur la rigidité des soies et la méthode de brossage idéales se sont révélées équivoques. Il n'a pas été démontré que les brosses à dents usées étaient moins efficaces et aucun intervalle de remplacement idéal n'est évident. Il a été démontré que les brosses à dents à piles rechargeables avec action oscillante, rotative (avec ou sans action pulsatoire) sont plus efficaces pour l'enlèvement de la plaque et l'amélioration de l'état gingival que les brosses à dents manuelles. La force idéale de brossage n'a pas encore été déterminée, mais la force excessive peut être associée à un traumatisme gingival. Bien que la récession gingivale et l'abrasion des tissus durs cervicaux sont reconnues comme ayant des étiologies multifactorielles, le brossage de dents est considéré comme un facteur contributoire. Il a été démontré que les brosses à dents favorisent le développement d'une multitude de microorganismes, mais les études montrant une relation entre une brosse à dents contaminée et les manifestations cliniques systématiques et buccales ne sont pas évidentes.

Les conclusions : Basées sur les meilleures données probantes disponibles, sept recommandations, représentant la vision commune actuelle concernant l'utilisation de la brosse à dents, ont été développées. Bien qu'une recherche considérable ait été réalisée sur le brossage de dents, il a été démontré qu'il y a un manque d'études sur plusieurs aspects du brossage de dents ; par conséquent, il n'a pas été possible de tirer plusieurs conclusions fermes. Ce manque de données concluantes dans plusieurs aspects du brossage de dents limite la capacité des hygiénistes dentaires de faire des recommandations basées sur des données probantes à leurs clients. Dans ces cas, les hygiénistes dentaires devront s'en remettre à leur expérience clinique en tenant compte de l'état spécifique de leurs clients. Il est évident que de nombreuses possibilités existent pour la recherche future en hygiène dentaire dans plusieurs aspects du brossage des dents.

RECOMMANDATIONS

1. Les brosses à dents manuelles sont une option viable pour le contrôle de la plaque.
2. Il a été démontré que le seul type de brosse à dents électrique à être cliniquement supérieur aux brosses à dents manuelles en ce qui concerne l'élimination accrue de la plaque dentaire et la réduction des risques de gingivite est celui qui incorpore une action oscillante, rotative (avec ou sans action pulsatoire) dans un modèle à pile rechargeable ; les autres types de brosses à dents électriques se sont révélés aussi efficaces que les brosses à dents manuelles.

3. L'utilisation d'une brosse à dents électrique n'est pas plus dommageable pour les tissus buccaux que l'utilisation d'une brosse à dents manuelle et peut être moins dommageable.
4. En ce qui concerne l'efficacité d'une technique de brossage de dents, aucune méthode ne s'est révélée clairement supérieure. Cependant la technique de frottage peut être moins efficace que les autres méthodes.
5. Il n'y a pas d'éléments probants qu'une brosse à dent aux soies usées est moins efficace qu'une brosse à dents aux soies non usées. Par conséquent, aucun intervalle de remplacement idéal n'a encore été déterminé.
6. Les clients montrant une récession gingivale et/ou des lésions des tissus durs cervicaux non carieuses devraient être conseillés, sur une base individuelle, concernant les interventions et les recommandations devraient inclure de l'information sur l'étiologie multifactorielle de ces manifestations.
7. Bien que la recherche démontre que les brosses à dents favorisent le développement d'une multitude de microorganismes, il n'a pas été démontré que cela se traduisait en manifestations cliniques systémiques et buccales.

INTRODUCTION

INADEQUATE PLAQUE CONTROL CAN LEAD TO AN INCREASE in pathogenic microflora, which is considered the primary cause of gingivitis and is certainly implicated in the progression of periodontitis although its relationship to the latter is more complex.[1,2]

Tooth brushing is the most commonly recommended and performed oral hygiene behaviour in North America and is done ubiquitously in developed nations.[3-5] It is considered a primary mechanical means of removing substantial amounts of plaque in order to prevent oral disease, including gingivitis and dental caries, while also maintaining dental aesthetics and preventing halitosis.[2] While the primary mechanism of action of tooth brushing is the mechanical removal of plaque, it is also used as a means of delivering chemotherapeutic agents via toothpaste.[6]

Though most people in developed countries use tooth brushing as part of their routine oral health interventions, the adequacy in controlling plaque through this means is considered sub-optimal, particularly in the gingival area, which is critical in preventing inflammation.[5,7,8] In an early review, it was reported that the average daily toothbrush cleaning of two minutes would remove only 50% of all plaque.[5] Factors affecting the efficacy of tooth brushing include the technique, frequency, duration, brush type and design, and the dentifrice used.[5,6]

Dental clients look to oral health professionals, particularly dental hygienists, for current and accurate information about oral health care behaviours. The influx of oral health care aids, including new designs of both manual and power toothbrushes, has contributed to much confusion for consumers surrounding the efficacy and safety of new models.[9] It is therefore critical that dental hygienists be knowledgeable about toothbrushes and tooth brushing in order to make evidence-based recommendations to their clients.[10] This task is equally confusing for oral health care professionals in that there have been international workshops and abundant research studies, sometimes presenting contradictory findings.[10]

The aim of this paper is to report on an investigation into the current state of the science on tooth brushing for the control of plaque and periodontal diseases, particularly gingivitis. This review will encompass traditional toothbrushes, both manual and power, but will exclude specialized toothbrushes designed for specific areas of the dentition. The outcome of the investigation is this position paper and accompanying position statement that will provide dental hygienists with a current knowledge base on the topic in order to provide evidence-based client education.

BACKGROUND

The toothbrush has been reported to have been invented in China in approximately 1000 AD.[11] This early configuration is reported to have had an ivory or oxen bone handle with either horse mane or hog bristles.[10,11] It was not until the 17th century that the toothbrush made its way to Europe, and it was the latter part of that century before American dentists were recommending its use.[11] In 1885, it is reported toothbrushes were being mass produced[11] and, as a result, were more commonly in use, albeit often shared among family members due to the expense.[6] In the late 1930s, nylon bristles had largely replaced natural ones.[6,11,12] Improvements in manufacturing also allowed for the development of plastic handles and a subsequent decrease in price, making toothbrushes more readily accessible.[6] Interestingly, it was a result of a mandatory tooth-brushing protocol for American soldiers in the Second World War and subsequent bringing the habit back home that gave the impetus for widespread use of tooth brushing.[11]

It is therefore critical that dental hygienists be knowledgeable about toothbrushes and tooth brushing in order to make evidence-based recommendations to their clients.

Powered toothbrushes were first developed in Switzerland after the Second World War and were powered by electricity.[11] Introduced to the United States market in 1960, powered toothbrushes were an immediate success, but these early versions were not superior to manual toothbrushes and suffered from mechanical failure.[11] These first powered toothbrushes were designed simply to mimic the manual tooth-brushing motions, some up and down and others side to side.[13] Continuous developments have occurred since these initial models.[14,15] However, the second generation of powered toothbrushes did not emerge until the 1990s and they have increasingly become a household item ever since.[1,6,11]

MATERIALS AND METHODS

This position paper, commissioned by the Canadian Dental Hygienists Association (CDHA), represents a comprehensive review of the literature on tooth brushing in order to develop a position statement about the practice of tooth brushing as a preventive oral health behaviour. The first step in the investigation was to develop several PICO questions that subsequently guided the literature search and this report. In this case, more than one PICO question was deemed essential due to the multi-dimensional facets of tooth brushing. The following questions were developed:

1. For an adult client with plaque and/or gingivitis *(Population)*, will powered tooth brushing *(Intervention)* as compared to manual tooth brushing *(Comparison)* better reduce plaque and/or reduce bleeding and/or gingival and/or periodontal related scores *(Outcome)*?
2. For an adult client with plaque and/or gingivitis *(Population)*, will manual tooth brushing using a specific technique, duration, force and/or frequency *(Intervention)* as compared to normal manual tooth brushing *(Comparison)* better reduce plaque, and/or reduce bleeding and/or gingival and/or periodontal related scores *(Outcome)*?
3. For an adult client with plaque and/or gingivitis *(Population)*, will tooth brushing with unworn toothbrush bristles *(Intervention)* as compared to tooth brushing with worn toothbrush bristles *(Comparison)* better reduce plaque, and/or reduce bleeding and/or gingival and/or periodontal related scores *(Outcome)*?
4. For an adult client with plaque and/or gingivitis *(Population)*, will specified toothbrush storage and/or cleaning procedures *(Intervention)* as compared to normal toothbrush storage and/or no cleaning procedures *(Comparison)* better reduce microbial contamination, cross-contamination and/or re-infection *(Outcome)*?

A state-of-the-science workshop was held in 1985 to examine the status of dental plaque control measures and oral hygiene procedures.[5] A year later, the proceedings, which included both state-of-the-science and reaction papers plus reports of the working groups and workshop participant discussions, were published and included a chapter by Frandsen on mechanical oral hygiene practices.[5] Frandsen reported that the investigation was based on available research and several previous workshops: Ann Arbor (1966), Malmö (1971), Chicago (1977), and Santa Monica (1980).[5] Brothwell et al. later conducted a review, which involved a search from 1984 to 1995, thus proceeding from the 1986 workshop.[3] This subsequent review focused only on studies that examined disease outcomes, recognizing that a certain amount of plaque is compatible with a healthy periodontium.[3] In 2003, the Cochrane Collaboration conducted a systematic review and meta-analysis on manual tooth brushing versus powered tooth brushing, and that review was subsequently updated in 2005.[1,16] This present position paper uses these previous reviews as a departure point for its literature search and findings.

The literature search for the present investigation was conducted in stages beginning in April 2006 through to May 25, 2006. The search included the following databases: MedLine, CINAHL (Cumulative Index of Nursing and Allied Health Literature), and the Cochrane Controlled Trials Register. The search focused on those papers reporting on both *in vitro* and *in vivo* randomized controlled trials (RCT) but also included other relevant papers such as systematic or unsystematic reviews and various other sources including websites.

The first stage of the review was of the three databases and included combinations of the following keywords: tooth brush(ing), power, electric, manual, soft, medium, hard, bristles, filaments, method, Bass, Stillman's, Fone's, Charter's, Roll, frequency, storage, replacement, contamination and the outcome measures, plaque, gingivitis, gingival bleeding. The search was limited to the English language from 1996 to 2006 for all search terms (or combinations) with the exception of tooth brushing, power tooth brushing and manual tooth brushing. In these cases, the search was limited to the period 2000 to 2006. This initial search of the three databases, using titles, abstracts and full text, resulted in 872 articles. Papers were retrieved if they examined any of the tooth-brushing variables in relation to an outcome measure. Other relevant literature was similarly retrieved at this point if deemed to provide background information. A total of 209 papers were identified and subsequently retrieved in full text.

The second stage of the search used all papers through the initial search and involved manually checking bibliographies and references for additional salient materials. This stage resulted in an additional 29 papers being retrieved in full text. Websites were also subsequently examined including those of the Canadian Dental Association (CDA) and the American Dental Hygienists Association (ADHA).

A unique element of a position paper is the solicited input from recognized experts and researchers. For this paper, input was sought from experts within preventive oral health care, periodontology, and community oral health and epidemiology. The rationale for this combination was to provide expertise in this rather broad scientific theme of inquiry.

RESULTS

Part I: The Instrument

At the time of the Frandsen review (1986), it was reported that no evidence was yet available to show the superiority of any one specific toothbrush type or design in removing plaque, and research into the field was scanty.[5] It was reported that, in general, the available toothbrushes were satisfactory in aiding in plaque removal, providing that the individuals using them were sufficiently motivated and educated in their use.[5] At the time, it was also concluded, consistent with the Ann Arbor and Chicago workshops, that neither power nor manual toothbrushes had been shown to be superior to the other.[5] It was believed at the time of Frandsen's report that if plaque removal fails, improvements were more likely by altering the conditions

determining toothbrush use, such as tooth-brushing technique, frequency and duration, rather than the toothbrush itself.[5]

Due to technological advances, the findings from the Brothwell et al. review contrasted with the Frandsen report in that oscillating/rotating action power brushes were found to be more effective in reducing gingivitis than manual toothbrushes and less likely to cause gingival damage.[3] Furthermore, it was concluded that other designs of power toothbrushes had no advantage over manual toothbrushes.[3] While the Brothwell paper was published several years prior to the Cochrane review, these findings were in agreement with each other.

Commonly agreed-upon features for manual toothbrushes included a large, comfortable handle with a good grip and a small-to-moderate-sized contoured brush head set on an angle.[5,6,17]

Manual versus manual toothbrushes

The abundant research and development surrounding manual toothbrush designs have not reinforced Frandsen's assertion that improvements in plaque control will result from users' technique rather than from the instrument itself. However, despite continuous toothbrush modifications, compelling evidence is yet to emerge that demonstrates one toothbrush design to be consistently superior in plaque removal and to improve gingival outcomes.

Recent short-term trials evaluating manual toothbrush designs have shown some designs to be significantly superior in plaque removal.[7,18,19] For example, toothbrush prototypes with multi-level bristle trim patterns or those with tightly packed and tapered bristles have demonstrated significant reductions in plaque scores over a conventional toothbrush design.[7,18] However, other studies with variously designed manual toothbrushes have shown no significant differences in plaque removal.[10,20-22]

A relatively newly designed manual toothbrush (Oral-B CrossAction) has undergone considerable study. This toothbrush has angled filaments in opposing directions (criss-cross) along the horizontal axis of the brush and features elliptical-shaped tufts of bristles and a large monotuft at the tip containing more than 700 filaments. This manual brush has shown significant improvements in plaque removal in laboratory studies[23] and in several *in vivo* studies,[24-28] which have also shown gingivitis reductions.[26] However, conflicting results have also emerged: other studies show other manual designs to significantly reduce plaque[19,29] and gingivitis[29] scores more effectively, while yet other studies have demonstrated no difference.[22] The successor to this manual toothbrush (Oral-B CrossAction Vitalizer) has been modified with two lateral rows of non-latex rubber nubs; it has been shown to be more effective than its predecessor and another conventional manual toothbrush.[30] Some authors are still in agreement with the Frandsen and Brothwell reviews, concluding that the technique employed may be a more important variable than the toothbrush design where manual brushes are concerned.[20]

Powered versus manual toothbrushes

A Cochrane systematic review and meta-analysis published in 2003 compared tooth brushing with powered toothbrushes to various manual toothbrushes.[16] Systematic reviews of randomized controlled trials (RCTs) are considered the gold standard for assessing health care intervention effectiveness. By using explicit and stringent scientific methods, they provide objective and comprehensive reviews of the available literature.[31] The literature search for the Cochrane systematic review was conducted from 1966 to 2002 with 354 articles being identified. Using stringent exclusion criteria (RCT, ≥ 28 days, clinical etc.), 29 trials were included in the final analysis. The primary reason for excluding a study from the meta-analysis was that the study was too short in duration.[31] Approximately 25 powered toothbrushes were clustered into six modes of action: side-to-side (moves laterally), counter oscillation (adjacent tufts independently rotate in one direction, then the other, and in opposite direction to adjacent tufts), rotation oscillation (brush head rotates in one direction and then the other), circular (brush head rotates in one direction), ultrasonic (bristles vibrate at ultrasonic frequencies [> 20 kHz]), and unknown.[16]

Compelling evidence is yet to emerge that demonstrates one [manual] toothbrush design to be consistently superior in plaque removal and to improve gingival outcomes.

The primary outcome measures used in the studies that were included in the meta-analysis and its subsequent update were quantified levels of plaque and/or gingivitis.[1,16,31] When possible, gingivitis values were recorded at the time of arrival for assessment. But, where necessary, values were taken after tooth brushing was conducted at the assessment visit as it was assumed that a single tooth brushing would not influence the gingival outcome scores.[1,16] However, only those plaque values taken before brushing at the assessment visit were included in the reviews because these scores were believed to be more reflective of actual home use.[1,16]

The only cluster that removed more plaque (7%) and reduced gingivitis more effectively (17%) than manual tooth brushing in both the short (≥ 28 days and long term (≥ 3 months) was the rotational oscillation powered toothbrush cluster. The authors concluded that both manual and powered toothbrushes were effective in reducing gingivitis, possibly preventing periodontitis, and preventing tooth decay if using fluoridated toothpaste.[16]

The Cochrane review is significant to this body of literature because it is the most comprehensive independent review of power tooth brushing ever conducted.[11] The review was updated in 2005 with the search extending into 2004 but it still confined studies to those comparing various manual toothbrushes with powered brushes.[1] However, the clustering was somewhat different in that

there were seven groups, with the ionic group being added: side-to-side laterally, counter oscillation, rotation oscillation, circular, ultrasonic, ionic (brush aims to impart an electrical charge to tooth surface) and, finally, unknown motion.[1]

In the update, results and conclusions were similar to the previous Cochrane review. The rotation oscillation brushes removed more plaque and reduced gingivitis more effectively than manual brushes in the short term (11% plaque reductions and 6% gingival indices reductions) and reduced gingivitis over three months (17% Bleeding on Probing reductions).[1] It was concluded that individuals who prefer to use a power toothbrush can be assured that powered tooth brushing is at least as effective as manual tooth brushing, and there is no evidence that powered tooth brushing will cause any more injuries to the gums than with manual.[1] Thus, Frandsen's and Brothwell's conclusions that use of a manual toothbrush is worthwhile were reaffirmed.

Individuals who prefer to use a power toothbrush can be assured that powered tooth brushing is at least as effective as manual tooth brushing, and there is no evidence that powered tooth brushing will cause any more injuries to the gums than with manual.

The investigators of both the Cochrane review and the update identified several possible weaknesses of the study and its update, including the grouping of the brushes by their modes of action.[1,16] While these groupings allowed for a more powerful meta-analysis, subtle differences between brushes could not be assessed.[1,16] For example, isolated, individual toothbrush design features such as toothbrush head size and design and filament size and arrangement could not be analyzed.[1,16] This limitation may in turn imply that while some oscillating, rotational toothbrushes are more effective than manual toothbrushes, some indeed may not be. Furthermore, the effectiveness of some individual designs may have been masked due to clustering with less effective designs. For example, some much earlier designs were grouped together with later versions with similar modes of action. Furthermore, because of the length of the trials included in the review (typically less than three months), only the clinical significance of plaque and gingivitis reductions could be assessed and not the impact on reductions of periodontal destruction.[16]

While studies of fewer than 28 days were excluded from the Cochrane review, several recent single-use and shorter-term studies have been conducted comparing power toothbrushes with various manual toothbrushes, and since the Cochrane update, 28-day or longer studies have been published. Results from these studies have demonstrated that various powered designs—including hybrid power designs (meaning a combination of design features, for example a power rotational head and a manual component), battery-operated and rechargeable rotational oscillating designs and sonic re-chargeable designs—have been shown to be significantly more effective in reducing plaque than conventional manual toothbrushes.[2,13,21,32-37] Similarly, findings were reported, demonstrating hybrid power designs (Crest SpinBrush Pro) to be superior in plaque reduction to non-conventional manual toothbrushes (Oral-B CrossAction).[27]

However, other studies produced conflicting results and have revealed manual toothbrushes to be more effective than powered toothbrushes,[31,33,38,39] or of equal effectiveness.[40] A more recent manual toothbrush design (discussed previously), distinct in that it has a brush head with tufts of bristles angled from the vertical (Oral-B CrossAction), has been shown to be more effective in plaque removal than two different battery-powered designs: one a oscillating rotating design (Colgate Actibrush) and the other a hybrid design that combines an oscillating rotational head with an un-powered component (Dr. Johns Spin Brush Classic).[38,39] These plaque reductions were confirmed in longer-term studies, but no significant differences were shown in gingivitis scores.[39] In a single-use study, a recent modification of this particular manual toothbrush design (Oral-B CrossAction Vitalizer) has also been shown to be superior in plaque removal than a battery-operated hybrid design.[30]

Powered versus powered toothbrushes

Several studies have been conducted that compare oscillating rotating, and now pulsating, power toothbrushes with high-frequency/sonic tooth brushes.[37,41,42] Some of these studies have been consistent with the Cochrane findings in that the oscillating rotational brushes had significantly greater reductions in plaque on all surfaces,[9,41-44] and in other studies, on some surfaces.[37] Some of these same trials were also able to show reductions in gingival parameters, including gingival bleeding.[9,37] In addition, some of these same studies conducted surveys of study participants and showed significantly greater preference for the oscillating, rotational design.[9,42]

Interestingly, results of other studies conflict with the preceding findings. While the oscillating, rotating, pulsating power toothbrush has demonstrated greater reductions in plaque and bleeding indices over the sonic brush, these differences were not found to be statistically significant.[45] The efficacy of sonic brushes is claimed to be the result of "micro-streaming" of the saliva-toothpaste slurry caused by the high-frequency bristle movement, resulting in a "beyond the bristle" efficacy.[37,42] This effect is described as generating localized hydrodynamic shear forces in the fluids that surround the brush head.[46] In an uncontrolled study comparing two sonic toothbrushes with oval heads in reversing experimental gingivitis, no difference between the two brushes could be detected.[47] In an *in vitro* study comparing a sonic brush with an oscillating, rotating, pulsating power toothbrush, it was shown

that the sonic brush was capable of removing significantly more plaque bacteria beyond its bristles than the other.[46] The authors concluded that this would result in more effective plaque control *in vivo,*[46] although this was not demonstrated.

Of the increasing number of powered toothbrushes becoming available, many are low-cost battery-operated designs, but there is a lack of published clinical data to support their use.[38] A laboratory study comparing battery-operated oscillating, rotating power toothbrushes with each other has shown significant differences between brushes in removing artificial plaque.[48] In single-use studies comparing a battery-operated oscillating, rotating power toothbrush (Colgate Actibrush) with a hybrid design (Crest SpinBrush), the latter significantly outperformed the former in plaque reduction.[49,50] A three-month *in vivo* study comparing two battery-operated oscillating, rotating power toothbrushes (Braun Oral-B [D4], Colgate Actibrush) showed that one (D4) was superior to the other.[51] A single-use cross-over study compared a re-chargeable oscillating, rotating, pulsating power toothbrush (Braun Oral-B 3D Excel [D17]) with a battery-operated oscillating, rotating brush (Colgate Actibrush). Results showed the re-chargeable design to affect significantly greater plaque removal.[52]

Other single-use studies have compared different powered hybrid designs with subtle design modifications to each other (Crest SpinBrush flat bristle profile, Crest SpinBrush rippled bristle profile). In some cases, the studies found significant improvements in plaque removal scores;[53] in other cases, no significant differences were evident (Crest SpinBrush Pro, re-designed Crest SpinBrush Pro).[54]

Bristle design

For most of the previous century, manual toothbrush designs have had flat bristle trim patterns and rectangular heads.[35] More recently, brush heads have been modified into more tapered, oval and diamond shapes with bristle trim patterns evolving into bi-leveled, multi-leveled and rippled trims, and some designs having criss-cross angulated bristle tufts.[35]

Based on available evidence at the time, Frandsen recommended that a manual toothbrush have soft nylon end-rounded bristles with a diameter of approximately 0.2 mm and a length of 10 mm with a multi-tufted straight trimmed brush head design.[5] According to the Brothwell review, more recent studies suggested serrated tufts, raised toe bristles, and an angled head may present advantages.[3] It was concluded in that latter review that most commercially available manual brushes could be used effectively with the exception of foam brushes, which had been shown to be less effective.[3]

Toothbrush design is believed to have an impact on tooth-brushing efficacy, particularly in areas that have traditionally been more difficult to clean, such as the lingual, interproximal, and posterior surfaces.[18] Design modifications can include improvements to the handle, brush head, and bristles. However, some reports are more in alignment with Frandsen's assertion in that they claim the design features of a toothbrush have little to do with plaque removal efficacy,[20] and poor technique combined with insufficient brushing duration lead to inadequate plaque removal.[26]

Of toothbrush components, perhaps the most studied is the bristle design. It is believed that the bristle design contributes to the plaque removal efficacy of the toothbrush, and more tapered bristles have been shown *in vitro* to have improved access to the sub-gingival region.[55] Other *in vitro* studies have shown modified filaments to be superior in plaque removal to end-rounded designs. For example, feathered filaments, when compared with end-rounded filaments, removed significantly more artificial plaque below the gingival margin than the control.[56] In a recent RCT, conical shaped filaments with "microfine tips" that immediately bend when pressure is applied were evaluated against an American Dental Association (ADA) reference toothbrush, using several outcome measures.[8] However, no significant difference was detected between the two designs.[8]

Toothbrush design is believed to have an impact on tooth-brushing efficacy.

It is believed that filament stiffness can contribute to the traumatic potential of a toothbrush, but the influence of this factor is not clear.[6,17] The majority of commercially available toothbrushes today are marketed as being "soft," meaning that they have thinner diameter bristles and some degree of polishing applied to the cut ends.[12] However, hard-bristled brushes have been shown to be more effective in plaque removal than medium bristles in one study that employed several tooth-brushing techniques.[57] While conventional brushes typically incorporate cylindrical filaments with end-rounded tips,[8] filaments can be of different materials, lengths, thicknesses, and tip geometries and be situated within the brush head with varying compactness and angulations to the head.[58]

Bristle tips have received much attention from researchers. Contemporary understanding favours end-rounded filament tips as they are believed to be less abrasive to soft tissue; however, their clinical value is less defined.[12,17,59] Despite many toothbrush designs claiming to have end-rounded bristles, studies have shown that commercially available toothbrushes demonstrate non-uniform filament morphology and that many brushes do not present with an acceptable level of quality.[12,17,60] While the proportion of acceptable tips may be increasing,[17] regardless of the original geometry of bristle tip, rounding of sharp-edged filaments occurs when the brush is being used by the client.[12,17] It has been shown that, when less than 10% of the expected toothbrush life has elapsed, bristle tips of various geometries will display a flattened shape.[12] This change in bristle tip geometry has not been shown to significantly affect the abrasiveness of the brush.[12] Despite this, it is asserted that filaments should begin with an acceptable level of quality.[60]

Individuals typically brush for about one minute or less but … most people significantly overestimate tooth-brushing duration.

PART II: THE USER

Tooth-brushing duration

Frandsen and later Brothwell et al. did not make conclusions regarding the optimal duration of tooth brushing. Recent reports have concluded that tooth-brushing duration is an important variable in plaque removal efficacy.[18] However, scientific investigations into the ideal brushing time have been problematic.[6] While it is believed that increased brushing time does result in more plaque removal, the brushing technique used can confound study comparisons.[6] Some have recommended three minutes as ideal for manual brushing.[6]

It has been shown that individuals typically brush for about one minute or less but that most people significantly overestimate tooth-brushing duration.[18] Studies have shown ranges of brushing times from 56.7 to 83.5 seconds, whereas estimated brushing times by these subjects range from 134.1 to 154.6 seconds.[4,10] These differences between actual and estimated brushing times have been found to be statistically significant.

Recent studies have shown that a significant relationship exists between recession and tooth-brushing duration.[61] In a study using a powered toothbrush, both brushing force and duration significantly affected the level of plaque removed, but these outcomes were not uniform.[62] The authors concluded that little advantage could be realized when brushing for more than two minutes at a force of 150 grams (g).[62] Powered toothbrush designs have incorporated this understanding by incorporating timers, typically set for two minutes, to enable the user to accurately assess their brushing time. However, the efficacy of this feature has not been evaluated.[63]

Tooth-brushing frequency

In the state-of-the-science workshop, Frandsen reported that confusion surrounded optimum brushing frequency.[5] He reiterated that the quality of brushing is likely a more important factor than the frequency.[5] Frandsen concluded that findings from the previous workshops, which had identified a brushing frequency up to two times a day, was still substantiated and that no significant gains could be achieved by increasing this frequency.[5] The Brothwell update, while concluding that studies have suggested that increased brushing frequency is indeed related to improvements in periodontal health, asserted that no optimum frequency had yet been established.[3]

Since these reviews, few studies have been published on tooth-brushing frequency, and those that have been published also found frequency data to be equivocal.[61] Recent research conducted on dogs reinforced tooth brushing once a day as being necessary to maintain gingival fibroblast activity and proliferation of the junctional epithelium.[64] However, a study conducted in 2001 assessed the relationship among several variables, including frequency of tooth brushing, on recession and found that a significant positive relationship did exist.[61]

Tooth-brushing force

Most of the literature surrounding tooth-brushing force has examined its impact on gingival abrasions and recession and hard-tissue abrasions. Fewer studies have looked at the relationship between force and plaque removal efficacy. Of those that have been conducted in the last decade, it has been demonstrated for manual and power tooth brushing that increased pressure, up to a point, is associated with an increase in plaque removal efficacy.[65,66] Interestingly, further force resulted in reduced efficacy.[65] However, other recent studies have demonstrated contradictory findings and have shown that a lower force (± 1.5 Newtons [N]) with powered tooth brushing resulted in greater plaque removal compared with higher forces (± 3.5 N).[14] The optimal force has been found to be between 300 to 400 g.[65,66] Further confusing the literature, several other authors have concluded that no correlation has been shown between force and efficacy.[65,66] Manual tooth brushing has been associated with greater levels of tooth-brushing force and perception of force with manual toothbrushes is less accurate.[14,66]

Both powered and manual toothbrush designs have incorporated mechanisms to provide feedback to the user when employing excessive force.[63] A recent study examined the impact of an audible feedback mechanism that was sufficiently sensitive to enable users to modify their brushing behaviours.[63] Results showed that tooth-brushing behaviour was modified subsequent to use with the feedback system and that an optimum range of feedback force was determined to be from 250 to 280 g.[63] Some powered toothbrushes (Braun oscillating/rotational powered toothbrush) stop entirely or partially (pulsating motion) when excessive amounts of force are employed by the user (over 2.5 N).[14]

Tooth-brushing method

Frandsen reported that, while a multitude of tooth-brushing techniques were developed, no one method had been shown to be superior.[5] Research conducted into methods was sparse, and that which had been conducted up to that point had been equivocal.[5] Furthermore, it was concluded that the conscientious and correct application of a brushing method was more critical than use of any specific method.[5] The Brothwell et al. update found no published literature recommending a specific method but did, however, recommend avoiding overly forceful brushing.[3]

Manual tooth-brushing methods including Bass, Stillman's, Fones, Charter's, horizontal, vertical, scrub, and roll have been taught for decades, with the Bass and roll methods the most commonly recommended.[5,6,67] It has been estimated that over 90% of people employ their "personal tooth-brushing method," which is generally a

"scrub" method using vigorous horizontal, vertical, and/or circular movements.[67] While this method will remove plaque from smooth outer and inner surfaces of the teeth, it has been considered detrimental because it can encourage gingival recession and areas of tooth abrasion.[67]

Prior to 2003, some studies indicated that specific tooth-brushing techniques produce superior oral hygiene than a "normal" technique (meaning scrubbing) while no one method had been shown to be superior.[67] It has been reported that study findings were largely equivocal: some studies showed the Bass method to be superior in plaque removal to other methods while in other trials, either no differences were detected or the Bass technique was found to be less effective that other methods.[67]

Recent studies compared three-minute brushing with either the modified Bass or "normal" method and found that the modified Bass method removed significantly more supra-gingival plaque than did the normal technique for all sites and all times examined.[67] The modified Bass method was especially effective on the lingual sites,[67] an area commonly showing higher plaque scores.

lower plaque scores and significantly improved gingivitis scores;[70,72] other investigators have concluded that toothbrush age and wear was not related to plaque control.[69,73,74] Further contradictory results have also emerged with improved plaque scores with less-worn brushes but improved gingivitis scores with more-worn brushes.[68]

Soft-tissue lesions

Incorrect tooth-brushing techniques, particularly very vigorous methods, have traditionally been strongly linked with gingival abrasions and recession,[12,75] but research confirming this association has been less clear.[76] A 2003 review asserted that only circumstantial evidence existed linking improper toothbrush use to recession and that recession likely has a multi-factorial etiology.[15]

Tooth brushing has been described as a traumatic procedure to the gingiva[14] and that, under scanning electron microscopic examination, brushing in many cases results in moderate-to-severe injuries to the gingiva.[77] While gingival abrasion is not a common finding,[14] gingival recession is a fairly common phenomenon with 78% to 100%

Some studies indicate that using newer toothbrushes results in lower plaque scores and significantly improved gingivitis scores; other investigators have concluded that toothbrush age and wear was not related to plaque control.

PART III: OTHER VARIABLES

Bristle wear

Indicators of a worn-out toothbrush are bristles that are splaying, bending, curling, spreading, bending, tapering, or have matting of the filaments.[68,69] While neither Frandsen nor Brothwell reached conclusions about the association between bristle wear and toothbrush efficacy, it has typically been recommended that toothbrushes be replaced every three months as it is generally believed toothbrushes are less effective as they become worn.[70] The occurrence of toothbrush wear is also highly variable:[68,71] brushes used by some individuals show evidence of wear within two weeks of use; for others, there is little wear over six months.[69] It is believed that wear is affected by factors such as the method, frequency, and force of tooth brushing. Further complicating the issue, there have been varied methods of recording wear within studies.[69]

In a survey of Australian dentists, Daly (in Hegde) found that dentists recommend patients renew their brushes every two to three months.[69] While the hypothesis that worn brushes are less effective makes sense intuitively, the evidence supporting this belief is scarce and the studies that have been conducted have been equivocal.[68-71] In an earlier study, Daly found that there were no significant differences in plaque scores with subjects who had the highest toothbrush wear compared to those with the lowest.[71] It was concluded that the status of bristles was not critical in ensuring optimal plaque removal.[68,71] More recent trials continue to show conflicting results: some studies indicate that using newer toothbrushes results in

of the middle-aged U.S. population showing some level of recession.[61,78] In 30-to-90 year olds in the United States, almost one quarter had recession of 3 mm or greater.[78] While high levels of recession (64%) have been demonstrated in younger populations as well,[75] prevalence data suggest that the prevalence, extent, and severity of gingival recession increases with age.[78] Gingival recessions can cause thermal sensitivity, increased risk of root caries, and are a considerable aesthetic concern to clients.[78]

Recently, studies with power toothbrushes have shown consistent findings in that there were no significant differences in gingival abrasions with higher brushing forces compared to normal forces.[14,79] Most gingival abrasions were located in the mid-gingival aspect and were mostly defined as small, with medium and large abrasions being relatively uncommon.[14,75] These authors concluded that factors other than force were more important in the etiology of gingival brushing lesions.[14,79]

There was initially concern that power toothbrushes may promote gingival recession; however, current understanding considers powered tooth brushing to be at least as safe as manual tooth brushing.[14,80] Studies have shown that less force is used with power tooth brushing than with manual; specifically, a 1.0 N difference has been reported between power and manual brushing with no increase in gingival abrasion documented.[11,14,80,81] Even when greater amounts of force were employed with powered tooth brushing (± 3.5 N), there was no significant difference in gingival abrasions with the differing forces.[14]

Recent studies have recognized the role that technique, frequency, and duration of tooth brushing has on recession, showing significant relationships between recession and these variables.[61] In one study, the greatest recession was found to be associated with a horizontal scrubbing technique, and recession increased with increased duration and frequency of brushing.[61] Other studies have shown that tooth-brushing technique and brushing frequency were both associated with recession.[75] In a university dental program population, those who were in first year and used more "simple" brushing techniques (i.e., scrubbing) were found to have less recession, whereas those in fifth year who employed more sophisticated techniques demonstrated more recession.[75] Age was not found to be associated with increased recession. The somewhat contradictory results were explained by the very small proportion of the fifth-year students who had maintained simple brushing methods and who accounted for the increased recession.[75] Other studies have shown that the bristle hardness of the toothbrush was correlated with recession whereas brushing technique was not.[82] Furthermore, end-rounding of toothbrush bristles has been shown to affect the incidence of gingival abrasions.[79]

A review conducted in 2003 concluded that gingival recession has a multi-factorial etiology: anatomical factors (tooth malposition, path of tooth eruption, tooth shape, profile and position in the arch, alveolar bone dehiscence, muscle attachment, and frenal pull), pathological factors (periodontal disease and treatment and iatrogenic restorative and operative treatment), along with improper oral hygiene methods and self-inflicted injuries were all contributory.[76] Other reports are in agreement that factors beyond tooth-brushing force are more influential in gingival recession.[14] The premise exists that toothbrush trauma causes gingival abrasion leading to recession.[76] While there is evidence that gingival trauma and abrasion do occur in the short term, their consequences in regard to recession are still unclear.[76] While it is believed that abrasion plays a major role in the etiology of gingival recession, causal relationships have not been established.[76] Finally, the combined benefit of soft toothbrushes, low-abrasive toothpastes, and better patient education about less aggressive brushing techniques has contributed to less concern about gingival lesions.[12]

Hard-tissue lesions

While the term "abrasion" has been defined as a loss of hard tissue due to mechanical process involving foreign objects or substances, the term "abfraction" was traditionally associated with a pathologic loss of tooth structure caused by biomechanical loading forces, which resulted in tooth flexure.[83-86] Available data surrounding loss of cervical hard tissue are scant.[15,84] The process by which abfractions occur has not been supported by the data. Therefore, the term "non-carious cervical lesion" has been more recently accepted as it implies a multi-factorial etiology for these lesions.[15,83,84]

Studies have linked hard-tissue wear to incorrect and over-vigorous tooth brushing, in particular brushing with increased frequency, longer duration, and a scrubbing technique.[15] Additionally, intra-oral chemical forces have also been identified as contributory.[86] Frandsen reported that the exact causal mechanisms for abrasions had not yet been established.[5] However, tooth brushing was implicated in the process and more so with improper or overly-vigorous technique.[5] Even at the time of Frandsen's review, it was recognized that the etiology of hard-tissue abrasions was likely multi-factorial and that enamel abrasions were not a clinical problem although cervical ones may be for some clients.[5]

In vitro studies have shown that toothbrush abrasion can induce cervical lesions of a variety of defect shapes.[83] The most frequent morphology reported was v/wedged, followed by a mixed appearance; the least encountered was u/rounded.[83] Furthermore, the morphology of defects changed over time and increased recession was associated with cervical lesions that tended to be rounder and broader in contrast to sharper and angled lesions with decreased recession.[83] One *in vitro* study showed similar progression of lesions to that seen *in vivo*, and the authors surmised that the position of the gingival margin may also play a role in abrasion shape.[83] Prevalence data has also shown that tooth brushing is a contributing factor for wedge-shaped lesions.[84]

Anecdotal reports and *in vitro* studies have supported the contribution of tooth brushing with toothpaste as a consistent factor in hard-tissue non-carious lesions.[58,87] It is well recognized that toothpaste is important for delivering fluoride for preventing caries. Frandsen reported that dentifrice use has been associated with increased plaque reductions over brushing with water alone.[5] Interestingly, the toothbrush on its own is currently understood to have negligible effects on dentin and enamel.[58] It has become evident that abrasion is considered to be a result of the brush moving the paste over the tooth structure.[58,87] Most surprising are the accumulated data showing that soft-bristled brushes have the most influence on abrasion.[58] It is believed that the smaller diameter filaments of soft toothbrushes hold the toothpaste better than do the hard filaments, and the greater flexion of soft bristles increases the contact area of the filaments with the tooth surface.[58,87,88] In lab studies, it has been demonstrated that brushing with water resulted in no abrasion of hard surfaces.[58] Interestingly, *in vivo* studies have shown that the amount of toothpaste used with power brushes is directly related to the size of the head.[81]

While studies have demonstrated that different brushing motions result in significant differences in hard-tissue abrasion, especially with increasing numbers of brush strokes, the resulting abrasions were considered small.[87] Authors have concluded that brushing with toothpaste over many years would produce minimal damage to dentin, and tooth brushing with differing bristle stiffness likely has little clinical significance.[58,87] However, one caveat to this is in the case of abrasion in the presence of dental hard tissues that have already been demineralized by erosion, where a synergistic effect is suggested, and hard-tissue loss may have more clinical significance.[88] In

laboratory studies using previously chemically eroded bovine enamel samples, it was revealed that while manual, inactivated power and even some activated power toothbrushes induced no more loss of hard tooth structure than the erosion alone, some other activated power toothbrushes produced significantly greater abrasion.[88] It was concluded that power toothbrushes differ in their transportation of toothpaste and subsequent abrasion.[88] It was surmised that the frequency, movement, and filament configuration may influence the loss of hard tissue.[88]

A recent review concluded that "it is now accepted that abrasion of hard tissues is almost entirely related to toothpaste, little, if any, damage occurring with a toothbrush alone" with other tooth-brushing variables such as method, force, time, frequency, type of brush, filament stiffness, filament end-rounding influencing abrasion overall.[15] The reviewers did assert that conclusions were formulated based primarily on *in vitro* studies and logical assumptions.[15] The authors also state that difficulties arise under conditions of over- or misuse of tooth brushing, but, even then, the clinical manifestations would be evident in dentin and not enamel.[15]

Tooth-brush contamination

The typical storage conditions of toothbrushes may act as a reservoir for the re-introduction of potential pathogens to the oral cavity and for the introduction of other potential pathogens from the bathroom environment.[89-92] These micro-organisms have the potential to colonize the oral cavity due to the micro-trauma that tooth brushing can cause.[93] However, studies investigating the implications of toothbrush storage and contamination have been intermittent with varying methodologies,[89,90] making it difficult to reach definite conclusions. Neither Frandsen nor Brothwell made comments surrounding this matter.

Studies that have been conducted are in agreement that toothbrushes do support a wide variety of micro-organisms.[89-92] *In vitro* research has shown the viability of micro-organisms varies depending on the aerobicity of the micro-organism (the susceptibility of the microbe to oxygen) and the design of the brush, specifically whether it had a hollow area that was accessible to the bacteria.[91] Aerobes survived best as did anaerobes on hollow designs.[91] These authors recommended solid toothbrush designs and thorough rinsing and shaking of brushes after use.[91]

Studies examining the association of filament-anchoring methods and microbial contamination showed that bristles having what is described as individual in-mold placement (where each filament, rather than the entire tuft, is placed individually into the toothbrush head), in contrast to in-mold tufting and staple set tufting, made retention of micro-organisms significantly more difficult.[93] Individual in-mold placement eliminates the bundling of filaments and associated gaps and spaces within the anchor but provides greater space between filaments and allows for more effective rinsing.[93]

Other studies have recommended antimicrobial (i.e., chlorhexidine) post-brushing sprays as a method of disinfection for preventing cross-infection or re-infection, finding that rinsing with water was ineffective in reducing contamination.[94] Interestingly, the routine use of a pre-brushing mouth rinse has been shown to be associated with the least amount of toothbrush contamination.[89,90] Toothpastes with a strong surfactant or with amine and stannous fluoride have also been shown to significantly reduce the amount of contamination of toothbrushes.[92] Antiseptic coatings placed during the manufacturing process exert contact antibacterial activity over 45 days, but investigations into the efficacy of reducing contamination have not shown positive results.[92]

In a study examining the viability of micro-organisms, specifically *Streptococcus mutans,* on toothbrushes made of opaque versus transparent brush head materials, it was demonstrated that transparent materials more effectively inhibited the retention of micro-organisms. This was due to the ability of light to penetrate more transparent materials, thus impeding the proliferation of micro-organisms.[95] However, the differences were not shown to be statistically significant and micro-organisms decreased with time, regardless of brush head materials.[95]

Other researchers have concluded that intra-individual spread does not occur readily.[96] The implications of toothbrush contamination may be more of an issue for at-risk clients, such as medically compromised individuals.[91]

CONCLUSIONS

Since the publication of the state-of-the-science workshop in 1986 and the 1998 update conducted by Brothwell et al., considerable research into tooth brushing has been conducted. This body of literature has helped to clarify some critical issues surrounding this commonly recommended and performed oral health care intervention, which has subsequently permitted researchers—and in turn, oral health care providers—to make definitive statements about these practices. However, several issues surrounding toothbrush use remain unclear and definitive conclusions still cannot be made, thus limiting the dental hygienists' capacity to make evidence-based recommendations to their clients. In these cases, dental hygienists will need to rely on their clinical experience along with the specific conditions of their clients.

RECOMMENDATIONS

The following seven recommendations represent the current understanding surrounding toothbrush use and are based on the best available evidence:

1. Manual toothbrushes are a viable option for plaque control.
2. The only power toothbrush designs that have been shown to be clinically superior to manual toothbrush designs in removing more plaque and reducing gingivitis are those that incorporate oscillating, rotating (with or without pulsating) action in a re-chargeable design; other designs of power toothbrushes have been shown to be as effective as manual toothbrushes.
3. Use of a power toothbrush is no more damaging than a manual toothbrush to oral tissues and may be less damaging.
4. Regarding the efficacy of tooth-brushing technique, no method has been shown to be clearly superior.
5. There is inconclusive evidence that worn toothbrush bristles are less effective than unworn bristles. Therefore, an ideal re-placement interval has yet to be identified.
6. Clients demonstrating gingival recession and/or non-carious hard-tissue cervical lesions should be advised on an individual basis regarding interventions, and recommendations should incorporate the multi-factorial etiology of these manifestations.
7. While research shows toothbrushes support a variety of micro-organisms, this has not been shown to translate into oral/systemic clinical manifestations.

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