Toothbrushing efficacy

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General discussion

The main focus of this thesis has been the efficacy of toothbrushing. Although toothbrushing is an everyday activity for almost every individual, the results of the studies highlighted in this thesis may not be of primary interest to the average layman. The individuals’ choice which toothbrush to buy may not be directed by scientific results indicating that a specific brush type is superior to another. Personal attitudes, beliefs, and preferences are the underlying component in decision making of individuals when buying consumer goods (1). If a person does not like a certain type of toothbrush he may opt for a different one which does fulfil the personal requirements. Better results may more likely to achieve when someone uses a toothbrush that is fully embraced by this individual (2). The dental hygienist is obviously the one who supports the patient with advice and instructions on oral care products in order to reach or maintain oral health. However, the dental professional instructing a patient with a clinically proven superior product which the patient does not like, is unlikely to end up with a satisfactory result. Therefore one should take into account that oral hygiene products are not the only things that matter.

A question which may arise when focussing on toothbrushes is: “Why do we use a toothbrush?” The answer is probably: Because there is no better tool to clean teeth than a toothbrush. In chapter 2 the existential right of the toothbrush was confirmed. The finger-brush under investigation could have been another step in the evolution of toothbrushes developing from wooden sticks via natural hairs to nylon haired brushes. However, the manual toothbrush was not outperformed by the finger-brush with sophisticated stitched-on microfibers. The finger brush did indeed remove plaque, though especially the approximal areas showed large differences as compared to the manual brush. Although significantly less effective, the percentage plaque score reduction of the finger-brush reached an average of 62%. This seems a poor results as compared to the 79% of the manual toothbrush. However, when this 62% is compared to the average weighted mean (WM) plaque score reduction of the study in chapter 9, being 46% using powered toothbrushes, these may seem conflicting results. The most plausible explanation is that the used plaque index plays an important role in these observations. As concluded in chapter 9 the index scale to score plaque is highly influencing the outcome percentage plaque score reduction. The finger-brush study was performed using the Silness & Løe (S&L) plaque index and the above mentioned 46% WM reduction is calculated based on two other plaque indices being the Quigley & Hein index (Q&H) and the Navy index (3-5). The S&L plaque index is not as commonly used in plaque removal studies as compared to the other two more popular indices. Therefore no weighted mean could be calculated for the S&L plaque index in the review reported in chapter 9. However, when searching for S&L single use studies, percentage plaque score reductions generally range from 62% to 88% (6-8). These higher percentage plaque score reductions may be influenced by the fact that a 1-unit decrease on the 4-point S&L scale represents 25% whereas a 1-unit decrease on the 6-point Q&H scale represents 17%. Thus it can be concluded that when using the S&L index to score plaque the outcome is likely to end up with higher percentage plaque score reductions as compared to what can be expected from Navy and Q&H. Therefore
caution should be taken into account when comparing efficacy studies on plaque removal when different methods to score plaque are used.

The question previously mentioned can be asked a second time when differently stressed. "Why do we use a toothbrush?" The answer to this question may be more complicated regarding the different points of view which need to be considered. The dental professional may put more emphasis on clinical goals such as the level of plaque removal to a sufficient extend to prevent caries and gum disease, whereas the patient may give more value to the fresh feeling after brushing. Considering the fact that most people cannot live without the toothbrush but at the same time use the toothbrush for close to a minute on average per day, one may classify toothbrushing for many people as a ‘must do’ (9-12). A single brushing episode of less than a minute may not always result in sufficient plaque removal to prevent or resolve gingival disease but could fulfil the wish to obtain a fresh feeling.

From the dental professionals’ point of view two aspects are key in toothbrushing: efficacy and safety. The efficacy of a toothbrush is based on laws of physics. The forces of compression and deflection of the filaments provide the energy needed for plaque removal as a result of resistance. These forces alter when the length of a filament changes or when the thickness of a filament varies or when a filament is bended without pressure. The study reported in Chapter 4 (Old vs New) assessed the proposed loss in efficacy of toothbrushes which were likely to show wear. In this study brushes were used for 3 months and then compared to a new brush in terms of plaque removal. It was concluded that the brush loses efficacy when the filaments become splayed. This splaying is the loss of texture of the individual tufts and considered as wear. It was also concluded that there is high variation in the ability of study participants to wear out their brushes even though all received a similar instruction in use. Therefore it is a good reason to use new brushes in toothbrush research and to provide fresh brushes at intervals during long-term studies.

An interesting question which presumably everyone who owns a toothbrush has asked himself at least once is: “When should I replace my toothbrush?” In general ‘time’ will be used as a parameter to decide when to replace a toothbrush. The recommendations that dental professionals give their patients may vary from country to country, but time spans usually range from two to four months (13-15). Some research has been performed on the aging process of toothbrushes however a strict advice of a specific interval to renew a toothbrush is not available and therefore not evidence based but rather anecdotal. Perhaps the lack of such a guideline is the result of the many factors that interfere with the ageing process of toothbrushes and consequently the assumed decrease in efficacy of plaque removal.

A different point of view to address toothbrush renewal is to focus on brush wear instead of brush age. In chapter 4 it was described that toothbrushes gradually become less effective when the degree of wear increases. The higher the wear score the less plaque reduction can be expected. The shear forces applied with the tips of the filaments needed to disrupt plaque adhered to the tooth surface may become less strong when the filaments are losing their straight appearance and become bended. The
more bended a filament is, the less contact the tip of the filament will make with the tooth surface and consequently become less effective. Therefore the degree of wear was suggested be a better parameter to take into account than the age of a toothbrush or the time that it has been in use to decide when a toothbrush should be replaced.

Toothbrushes should not only be efficacious but also safe. However toothbrushes have been reported to be able to cause severe injuries and in a few cases lead to death (16). This however should not be interpreted in such a way that toothbrushing is not safe. People must not be discouraged to brush their teeth as the incidence of fatal or severe injury is really low and often related to incorrect use as a result of ingestion or impaction of brushes. Moreover, the benefits of toothbrushing outweigh by far the hazards when used in a correct manner even though little (reversible) damage to oral tissues is quite common.

Safety with regard to toothbrushing was focused on in chapters 5 & 6 and was addressed to soft oral tissues. It is clear that brush handles are supposed to be smooth and do not contain sharp edges or points which may cause damage and the same holds true for the nylon filaments. It is believed however that vigorous brushing can cause gingival recession although scientific evidence for a direct correlation is lacking (chapter 6). This lack of proof is possibly due to the fact that gingival recession has a multi-factorial cause, and that the development of gingival recession usually proceeds really slow (17-20). The use of a surrogate variable for safety such as gingival abrasion (GA) has been suggested to simplify the assessment of safety to soft oral tissues (21). It is suggested that the less abrasion a toothbrush induces, the gentler or safer to gingival tissue the brush is. This however, does not imply that a toothbrush which causes high GA scores is not safe. A direct relation to irreversible damage to the gingivae such as gingival recession as a result of gingival abrasion has never been established (chapter 5). Therefore a safety threshold of a certain amount of gingival abrasion scores up to which a brush can be considered as ‘safe’, is difficult to define.

The studies from this thesis described in chapters 3, 4, 5, 6 and 7 all used gingival abrasion as safety parameter. In the studies reported in chapter 5 and chapter 6 the GA scores were the primary response parameter which consisted of a pre-brushing and post-brushing assessment and allowed for an instant effect measurement. The studies in the other chapters GA scores were used as secondary response parameter. The two studies which focussed on GA scores showed similar values even though different brushes were under investigation. It has to be taken into account that in chapter 6 the GA scores were assessed full mouth and represent one manual brush, whereas in chapter 5 a split mouth model was adopted for two different manual brushes and half mouth scores were obtained. However, when these two half mouth scores are added they represent a full mouth value. The summed half mouth scores are approximately 9.9 for pre-brushing and show a 27.3 for post-brushing resulting in a 17.3 increment (22). When compared to the full mouth data from chapter 6 the pre-brushing GA scores are 11.5 and the post-brushing GA scores 26.6 which results in a 15.1 incremental change (23). Although both studies had different examiners for GA, the abrasion scores are of similar magnitudes.
Chapters 7 and 8 are long-term studies which are more suitable when focusing on gingival inflammation although plaque scores and other parameters were also assessed. The study in chapter 7 (prevention study) was designed to investigate whether a population of young adults, showing moderate signs of gingival inflammation, can be guarded for relapse after having intentionally and artificially introduced a healthy gingival condition supported by professional instructions and the use of a combination of two mouthrinses. It was shown that the study population was able to maintain a healthier gingival condition for the total study duration of 9 months. The study in chapter 8 (healing study) was designed differently. In this study the objective was to heal an intentionally and artificially introduced experimental gingival inflammation. Results showed that after four weeks of brushing twice daily, the population did not manage to reach the level of gingival health they started with.

When comparing the bleeding scores of both populations reported in chapter 7 and 8 the scores are more or less equal when they entered the respective protocols at Day 0. At day 21 the population in chapter 7 showed a significant (expected) decrease as result of very good oral hygiene whereas the population in chapter 8 showed the opposite being a significant (expected) increase in bleeding scores as result of no oral hygiene. After these 21 day intervention phases both populations were instructed to follow a regular oral hygiene regimen of 2 minutes toothbrushing twice daily. Interestingly both populations were professionally instructed in the use of the products they had to use in order to achieve maximum performance (24-25). Therefore the aspect of instruction does not seem to clarify the difference in results at the end of both studies. Another interesting item is that both populations received a professional dental scale and polish (or prophylaxis) at day 21 in order to have all participants continue the study with equally clean teeth. In the prevention study this prophylaxis was performed after a period of good oral hygiene supported by the use of chlorhexidine and hydrogen peroxide rinses, whereas the population of the healing study received the prophylaxis after a period of no oral hygiene. Perhaps the combination of a dental prophylaxis after the use of both rinses together with repeated professional oral hygiene instruction is of such value that this has great effect on the gingival condition for a significant duration of time. Another explanation for the observed higher bleeding scores at week 4 in chapter 8 as compared to day 0 may be the duration of the study. Maybe 4 weeks is a relatively short period to expect gingivitis scores to decrease to a level which is alike scores populations started with. In two other studies reporting three experiments using the same design the populations also did not manage to resolve gingivitis scores to a level they started with (26-27). This is in contrast with the observation reported in the original experimental gingivitis study by Löe et al. which showed that this in fact is possible. However it should be noted that a direct comparison is not completely fair as a different parameter was used to assess gingival health (28).

The study reported in chapter 9 is a literature study which tried to retrieve the answer to the question: “How effective are powered toothbrushes?” This study focused on the instant effect on plaque scores following a brushing exercise. As this study finally included 58 papers resulting in a large dataset it may be questioned why it was chosen to report all results by means of WM percentage difference. It is discussed that plaque index scores may reflect the actual amount of plaque in a more accurate way
than percentages do. In this respect a meta-analyses may have been more appropriate. In the present study it was deliberately chosen not to perform a meta-analysis because that would have introduced a huge selection bias by the authors based on the data needed for such a calculation. Nearly two-thirds of the experiments included in the present analyses would have been excluded as many studies did not fully report all the required data. Such a dataset does not allow for all the sub-analyses which were carried out. Especially these sub-analyses based on a minimum of 10 experiments gave insight in all the different factors which contribute to the variation in the observed efficacy of powered toothbrushes.

In this thesis the dental literature on toothbrushing efficacy has been scrutinized. Scientific research papers which test and discuss toothbrushes are published in high numbers. Toothbrushes have been tested versus competitors and or predecessors usually with the aim to assess improved efficacy or to claim superiority. However, worldwide presumably countless different types of toothbrushes are available and therefore one should take into account that research itself introduces a bias. Not all toothbrushes produced by manufacturers are subject to (clinical) research and thus will not be presented in scientific journals. Moreover, not all research which is performed will be published. Scientists may extensively search medical databases for the best evidence but, as clinical research is expensive, not all manufacturers will test their products and/or report results in the dental literature. Nevertheless, evidence based practice is the current standard and therefore in a certain way limited to selected and tested toothbrushes only.
References


