Current Evidence on Prevention of Gingivitis: Oral Hygiene Devices and Dentifrices

Sonja Sälzer, PhD[1]
Fridus A. van der Weijden, PhD[2,3]
Christof E. Dörfer[1]
Dagmar Else Slot, PhD[3]

[1]Professor, Clinic for Conservative Dentistry and Periodontology, School for Dental Medicine, Universitätsklinikum Schleswig Holstein (UKSH), Christian-Albrechts-Universität, Kiel, Germany.

[2]Professor, Research Department of Periodontology, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; Clinic for Periodontology, Utrecht, The Netherlands.

[3]Researcher, Research Department of Periodontology, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

Correspondence to:
Dr Sonja Sälzer
Department of Periodontology
Clinic for Conservative Dentistry and Periodontology
School for Dental Medicine
Christian-Albrechts-University Kiel
Arnold-Heller-Straße 3, Haus 26
Kiel 24105, Germany
Email: saelzer@konspar.uni-kiel.de

Numerous oral hygiene products are currently available on the market, and dental care providers have to select suitable products for the individual patient. Successful oral hygiene should rely on the current best available evidence; hence, oral care providers should be up to date with the advantages and disadvantages of the available oral hygiene products in order to provide their patients with proper information during oral hygiene instruction sessions. *Int J Evid Based Pract Dent Hygienist 2017;3:118–127. doi: 10.11607/ebh.130*

Keywords: dentifrices, gingivitis, oral hygiene, tooth brushing

It is well established that dental plaque leads to gingivitis,[1] which will likely progress to periodontitis (although this is not true for all patients).[2] Periodontitis affects over 50% of the world's adult population[3] and is the sixth most prevalent human disease, with a standardized prevalence of 11%.[4] It is a major cause of tooth loss,[5] has a negative impact on oral health–related quality of life (ORHQoL), speech, nutrition, confidence, and overall well-being, and is a major factor in the increase in cost of oral health care.[6] Therefore, periodontitis represents a significant public health concern.[7]

Gingivitis at its early stage is characterized by increased gingival fluid.[8] Next, there is reddening of the gingival margin as well as aggregation and enlargement of the blood vessels in the subepithelial connective tissue. Subsequent loss of fibrous connective tissue presents clinically as swelling and loss of texture of the free gingiva. As the clinical symptoms of chronic gingivitis appear rather vague and are usually painless, most patients are unaware of the disease, and dental care practitioners often underestimate them.[8] Chronic gingivitis rarely shows spontaneous bleeding. Bleeding of the gingival tissues can be provoked by touching with a blunt device during tooth brushing or professional screening for periodontal disease. Sites with regular bleeding demonstrate a higher risk of tooth loss than the ones bleeding occasionally.[9]

Effective removal of dental plaque can prevent gingivitis.[10] For regular personal oral hygiene, tooth brushing is the most widespread means of prevention. There is substantial evidence that tooth brushing and other mechanical cleaning procedures can reliably control plaque, provided that cleaning is sufficiently thorough and performed at appropriate intervals.[11] It has been shown that individuals benefit from good oral hygiene[12–18]; however, the effect of daily oral care on the prevention of periodontitis has not yet been

sufficiently proven. It is still unclear whether a health benefit results from professional mechanical plaque removal, oral hygiene instructions, or a combination thereof.[12–15,19] Repeated oral hygiene instructions seem to result in a benefit similar to that of repeated professional mechanical plaque removal.[19,20]

Oral hygiene and prevention of gingivitis

Natural physiologic forces and masticatory patterns can influence plaque growth in the human dentition. This effect, however, is limited to regions at low risk for periodontal diseases, such as incisal and occlusal areas. Due to its rough dorsum, tongue movement appears to support the removal of plaque on the lingual surfaces and to a lesser extent on the buccal aspects of the posterior teeth, and the cheeks might also help to limit plaque growth on the buccal surfaces of the posterior teeth. Saliva might have a limited effect on cleaning debris from interproximal spaces and occlusal pits, but is less effective in removing and/or washing out plaque. As these natural cleaning mechanisms are insufficient with respect to the prevention of inflammation, the periodontium seems to be primarily influenced by the quality and precision of mechanical plaque control.[6,21] How often teeth must be brushed and how much plaque should be eliminated to prevent periodontal disease is unknown.[10] In daily practice, it is generally recommended to brush twice daily with a fluoride-containing toothpaste for 2 minutes[22] to eliminate plaque, prevent caries, and give a feeling of oral freshness.[21] However, patients with periodontitis are likely to need more than 2 minutes.[6]

According to long-term cohort studies, improved oral hygiene in populations seems to correlate with a decreased prevalence of periodontitis.[23–25] Two long-term studies in Sweden and Norway demonstrated over the last 30 years a reduction of plaque and gingivitis parameters and the concomitant decrease of the prevalence of periodontitis and the amount of alveolar bone loss. Furthermore, the number of retained molars increased in all age groups between 20 and 80 years during this period of observation, according to the so-called Jönköping study.[23,25] A similar study carried out in Norway over the same period demonstrated corresponding results for individuals aged 35 years.[24] Although these long-term studies suppose a correlation between good oral hygiene and stable oral conditions, a control group without any preventive measurements is missing to assess the significance of daily and professional oral care. It seems most likely that improved oral hygiene helps to prevent gingivitis, and thereby the transition from gingivitis to periodontitis.[26]

Long-term clinical studies to assess the effect of plaque removal on prevention of periodontal disease with a negative control group that does not perform oral hygiene are unethical. While epidemiologic studies indicate that the level of oral hygiene in the general population has increased over recent decades, there still appears to be a need for further improvement of patient self-care. Although most people claim to brush their teeth twice daily, the effectiveness does in general not seem to be sufficient to prevent gingivitis and consequently periodontitis.

Tooth brushing

Without doubt, utilization of a toothbrush is essential to efficiently remove plaque. Manual toothbrushes are available in different designs, varying in shape of the handle, brush head, arrangement of bristles, and filament shapes. Handles might be ergonomically designed, and shape might be tailored to suit a particular brushing technique. The brush head is continuously under development to improve its effectiveness. A majority of the population (eg, 80% to 90% of the German population) claim to brush their teeth twice daily for 2 minutes.[27] The effectiveness of tooth brushing, however, appears not to be as high as might conclusively be suspected. Success of tooth brushing still seems to be determined primarily by the user's dexterity and accuracy.[11]

A systematic evaluation of the existing literature found the effect of a single brushing exercise with a manual toothbrush to be an approximately 42% reduction in plaque score[28]; corresponding data related to power toothbrushes indicated an overall 46% reduction.[29] Considering that these data emerged from controlled clinical trials, the efficiency of tooth brushing in daily life may be even less when no Hawthorne effect contributes to patient performance. For manual tooth brushing, no superiority of a certain brushing technique has been demonstrated. An intense computer-based instruction and additional oral and written information either explaining the Bass or the Fones technique compared to no specific brushing technique does not result in a

difference in plaque removal after 6 and 12 weeks.[30] A patient who is motivated and compliant with professional advice and instructions is likely to achieve and sustain ideal levels of plaque control.[31] The effect of preventive measurements is larger in areas of high risk (eg, in areas with high levels of plaque), and so instructions should be given based on individual needs. Many patients spend too little time brushing or brush haphazardly, especially at the end of the tooth brushing session when lacking concentration.

Instruction methods

Millions of oral hygiene instructions are given each day by dental care professionals. However, these recommendations vary largely depending on the individual dental professional, dental association, dentifrice and toothbrush company, and dental textbook.[32] Good oral hygiene requires a highly motivated patient who is individually instructed to change behavior sustainably and who has good knowledge of the most effective methods of plaque removal from the marginal, submarginal, and interproximal areas of teeth.[33] Above all, the advice must be implemented into the patient's daily routine. Therefore, the instructor should take the patient's current individual habits and personal skills into account.

A variety of methods can be used to deliver advice and instructions. For example, instructions can be given during one visit only or step by step over several visits. They can be provided through the use of pamphlets or video or through personal instruction given by a dental professional. Instructions by video seem to improve the efficacy of plaque removal more than written instructions.[34] Currently, attempts are being made to stimulate daily oral care by giving feedback with respect to self-performance.[35] In a clinical pilot study by Graetz et al,[21,35] participants were randomly assigned to either a digital monitoring and training system group or to a regular manual toothbrush control group. Both groups were instructed to brush their teeth twice daily for 6 weeks. The test group used a manual toothbrush with a monitoring system that provided sensory information concerning the orientation and linear displacement of the toothbrush. Subsequently, both groups were requested to brush for another 8 weeks with a toothbrush of their own liking without any additional interference. According to the results of this study, the monitoring system led to a prolonged learning effect, resulting in improved oral hygiene. Similar feedback systems are now available for the consumer. For instance, Oral-B (Procter & Gamble) has recently launched a monitoring system that can be installed on a smartphone.[36] It tracks the areas being brushed and the pressure applied by a video recognition and motion sensor. With such a device, the patient receives feedback twice daily on their brushing performance. Repeated oral hygiene instructions over a series of visits with regular feedback and reinforcement of home-care activities has already been proposed by Rylander and Lindhe.[37]

Efficacy

Developments in the design and function of toothbrushes have been demonstrated to influence brushing efficiency.[28] Due to cleaning performance and user-friendly practicability, power toothbrushes are becoming more and more popular. In Germany, for example, 36% of children, 39% of adults, and 18% of seniors use a power toothbrush. Today, power toothbrushes, in particular rotating and oscillating toothbrushes, seem to be superior to manual toothbrushes.[11,38] A recent meta-analysis by the Cochrane Collaboration demonstrated a superior reduction in Plaque Index score in the short term (study duration 1–3 months) of 11% and in the long term (> 3 months) of 21% of oscillating-rotating toothbrushes.[38] Similar results were demonstrated for parameters of gingivitis, which improved by 6% short term and by 11% long term. However, clinical consequences to the patient, such as prevention of caries or periodontitis, remain unclear.

Safety

The risks of power toothbrushes are widely discussed. A common concern related to tooth brushing is the development of gingival recessions as a negative side effect. Although gingival recessions are associated with different etiologic risk factors such as gingival biotype, orthodontic treatment, and occlusal trauma, inadequate use of toothbrush is likely to be the most significant cause.[39] Only limited long-term evidence exists concerning this matter.[11] In general, the data to support or refute the association between tooth brushing and traumatizing hard and soft tissues is largely inconclusive.[40] A large body of published research in the preceding two decades has consistently shown oscillating-rotating toothbrushes to be as safe as manual toothbrushes, demonstrating that these power toothbrushes do not pose a clinically relevant concern to hard or soft tissues.[41] Meta-analysis showed that the mean change in gingival recession was not

significantly different in participants brushing with an oscillating-rotating power brush compared to participants brushing with a manual toothbrush. A recent study with a 3-year observation period found no differences in the change of recessions between participants with pre-existing gingival recessions using an oscillating-rotating power toothbrush or a manual toothbrush. In both groups, a clinically minor but statistically significant reduction in gingival recessions was seen,[42] which might be due to improved tooth brushing. In a 5-year prospective cohort study, Schoo et al confirmed that elimination of traumatic oral hygiene habits will in general be sufficient to prevent further clinically significant increases in gingival recessions.[43]

Furthermore, a newly developed multidirectional power toothbrush was evaluated in this respect.[44] The effect of brushing with this power toothbrush was compared to brushing with a manual toothbrush (American Dental Association reference brush) in participants with pre-existing midbuccal gingival recessions of ≥ 2 mm. This study population was considered to be at high risk to further develop gingival recessions. In total, 107 participants were randomly assigned to brush with either a power or a manual toothbrush. They were instructed to brush twice daily and were followed up for 12 months. The results showed that the pre-existing gingival recessions at midbuccal sites significantly decreased in both groups from 2.2 to 2.1 mm ($P < .05$). To verify the clinically obtained data, measurements were performed on stone cast impressions. These data correlated well with the clinical outcomes. Conclusively, this newly developed power toothbrush appeared to be as safe as the manual toothbrush during 12 months of use.

Interdental oral hygiene

Interdental surfaces of molars and premolars are the primary predisposing sites for plaque adhesion. As these surfaces cannot be efficiently reached by the toothbrush and are not easily visible, caries and periodontitis develop here more often than on facial sites.[45,46] Thorough and intense interdental cleaning should therefore be a principal goal of daily oral care, as it helps to reduce the extension and severity of periodontal disease.[47] Numerous devices for self-care interdental cleaning such as dental floss, interdental brushes, and woodsticks are available on the market, but the great variety of products makes it difficult for the patient to choose the most appropriate device; even for the dental care professional, the most appropriate one to recommend is not so obvious. The choice of the interdental cleaning product is usually made individually, depending on patient preferences and the expected likelihood of using it, as well as on the size and shade of the interdental space, contour of the gingiva, tooth alignment, and dexterity and motivation of the patient. Good interdental oral hygiene will require a device that can penetrate between adjacent teeth and is well accepted by the patient.[11] Furthermore, the choice should depend on the latest evidence.

The use of interdental cleaning devices is still low. In Germany, for example, 1.4 interdental brushes are used per head in a year, and 20.1 strings of floss are used.[48] Only 17% of children, 44% of adults, and 15% of seniors state they use dental floss, while 8%, 6% and 7% use interdental brushes, respectively.[27] An ideal interdental cleaning device should be user friendly, remove plaque effectively, and have no deleterious effects on the soft or hard tissues.[31] The effectiveness of interdental cleaning devices with regard to interdental mechanical plaque control in managing gingivitis was investigated in a recent meta-review.[49] The search of three internet sources resulted in 395 articles, and 6 systematic reviews were included after screening.

Dental floss

Levi Spear Parmly, a dentist based in New Orleans, is credited with being the inventor of modern dental floss.[31] As early as 1815, Parmly recommended tooth flossing with a piece of silk thread. In 1882, the Codman and Shurtleft Company of Randolph, Massachusetts started to mass produce unwaxed silk floss for commercial home use. In 1898, the Johnson & Johnson Company of New Brunswick, New Jersey was the first to patent dental floss. Dr Charles C. Bass developed nylon floss as a replacement for silk floss during World War II and was partly responsible for making flossing an important part of dental hygiene, which is still commonly recommended.[50]

The application of dental floss is rather demanding, as the insertion and the actual cleaning require a high level of tactile and fine motor skills as well as good knowledge of anatomical conditions.[51] Dental floss might be either monofil (made up of expanded polytetrafluoroethylene [ePTFE]), polyfil (made up of twisted single filaments of varying

number, diameter, degree, and orientation of the filaments, depending on the product), or pseudo-polyfil (when the single filaments are embedded in a matrix). Waxed dental floss is also available, with added flavors and preventive agents such as fluoride. Two systematic reviews evaluating dental floss were found to be eligible for the meta-review.[49] According to the synopsis, the evidence for the use of dental floss in addition to tooth brushing for prevention of gingivitis is weak, and the magnitude of the effect is small. Most of the studies could not demonstrate that flossing is generally effective in plaque removal. However, the use of dental floss should not be precluded, as it is still suitable in case other more effective interdental cleaning devices will not pass through the interproximal area without trauma.[6] So far, no differences between different types of dental floss have been established.[16,52,53]

Dental woodsticks

The toothpick might date back to the days of cave people, who probably used sticks to pick food from between their teeth. Recently, a 1.2-million-year-old hominin jawbone was discovered at an excavation in northern Spain that had an interproximal groove in which fragments of nonedible wood were found, suggesting interdental oral hygiene activities.[54] The ancient Romans made use of toothpicks fabricated from bone and metal. Saxon women carried ivory toothpicks. The evolution of the primitive toothpick took a second pathway in more acquisitive societies, becoming part of personal care kits along with depilatory tweezers and earwax scoops. In 1872, Silas Noble and J. P. Cooley patented the first toothpick-manufacturing machine.[31] In contrast to toothpicks, dental woodsticks have a triangular midsection and taper at the edges. They are made up of long-fiber shatterproof wood and are available in different sizes. Their application is similar to that of interdental brushes. However, they cannot reach root concavities and cannot be inserted at a correct angle in the most posterior interdental spaces.

One systematic review evaluated the effect of woodsticks. The evidence to use woodsticks in addition to tooth brushing is weak and of unclear magnitude with regard to gingivitis, and there is no evidence concerning the reduction of plaque. However, gingival bleeding can be reduced significantly better by woodsticks compared to tooth brushing alone.[55] Bleeding following the use of woodsticks can be used to increase patient motivation and awareness of gingival health. Several studies have illustrated the clinical effectiveness of gingival self-assessment.[56] The presence of bleeding provides immediate feedback on the level of gingival health. The dental care professional can easily demonstrate the gingival condition to the patient using an interdental bleeding index for this obvious clinical manifestation. This monitoring device could encourage patients to include woodsticks as part of their oral hygiene regimen.[31]

Interdental brushes

Interdental brushes were introduced in the 1960s as an alternative to woodsticks.[31] They are built of helically aligned filaments fixed to a twisted central wire. Their structure might differ in shape (eg, cylindrical or conical, angled or straight) and stiffness of filaments. Areas not accessible by the toothbrush, like the central part of the interdental space and the embrasure, can be reached effectively by interdental brushes.[57,58] Concavities in the approximal root areas are especially not accessible for the toothbrush, nor for dental floss or woodsticks. Interdental brushes may remove plaque as far as 2 to 2.5 mm below the gingival margin.[59]

Two of the systematic reviews included in the meta-review investigated interdental brushes. The evidence for interdental brushes with respect to reduction of plaque and gingivitis is moderate, and the effect large. Interdental brushes seem to be the most effective method to remove interdental plaque. No systematic evaluation of the different designs emerged. However, it has been shown by randomized controlled trials (RCTs) that the design might influence the effectiveness—eg, cylindrical-shaped interdental brushes seem to remove approximal plaque more effectively than conical shaped ones,[60] and straight brushes more effectively than angled ones.[61] Few studies have investigated the effectiveness of the more recently introduced interdental cleaning devices with rubber bristles. According to this preliminary data, their effectiveness seems to be comparable to that of standard interdental cleaning devices, and they are well accepted by the patients.[62,63]

Oral irrigators

The oral irrigator was developed by a hydraulic engineer, John Mattingly, and a dentist, Gerald Moyer. It was introduced to the dental profession in 1962 and has been studied extensively for the past several

decades.[31] Oral irrigators are designed to flush away loosely adhered plaque through the mechanical action of a stream of water. As evaluated in one systematic review, the evidence to use an oral irrigator is weak and of unclear magnitude. Although it has been demonstrated to improve gingival health compared to tooth brushing only, it does not seem to further reduce visible plaque.[64] Further clinical long-term studies are needed to evaluate its effect. Applying chlorhexidine by an oral irrigator seems to be more effective than rinsing alone with regard to parameters of plaque and gingivitis.[65,66] The included systematic review did not evaluate specially designed blunt-ended cannulae (Pik Pocket subgingival irrigation tip, Water Pik), and it did not include an assessment of the recently developed Sonicare Air Floss (AF; Philips Healthcare).[67–69]

Based on the outcomes of this meta-review, the European Federation of Periodontology offered the following conclusion in a recent guideline[70]:

> *…[daily interproximal cleaning] is essential for maintaining interproximal gingival health, but there is no evidence to support the use of dental floss for interdental cleaning in periodontitis patients. Interdental brushes are the most effective method and the method of choice where spaces will accommodate their atraumatic use. However, caution is advised in their use at healthy sites where interdental spaces may be too narrow to safely accommodate them. Here, there may be a role for dental floss.*

Consequently, instructions should be given individually according to contour and consistency of the gingival tissues, the size of the interproximal embrasures, tooth position and alignment, and the ability and motivation of the patient.[31] Furthermore, to achieve maximum effectiveness, the oral hygiene advice delivered to the patient must contain enough information to enable the patient to be able to identify each site in turn, to select a device, and to clean all interdental surfaces effectively.[71] Gingival bleeding during interdental cleaning can be the result of trauma, such as lacerations and gingival erosions, or it can be an indication of inflammation.[31] Patients must be aware that bleeding per se is not a sign that interdental cleaning should be avoided, but is more likely an indicator of inflammation that needs to be treated.[72]

Dentifrices

The use of a toothbrush is usually combined with that of a dentifrice, with the intention of facilitating plaque removal by applying agents to the tooth surfaces for therapeutic or preventive reasons, to produce fresh breath, and to make the tooth brushing procedure more pleasant. Dentifrice was used as early as 500 BC in both China and India, and modern toothpastes were developed in the 1800s: In 1824 a dentist named Dr Peabody (his full name has been lost to history) was the first person to add soap to toothpaste, in the 1850s John Harris first added chalk to toothpaste, in 1873 Colgate mass produced the first toothpaste in a jar, and in 1892 Dr Washington Sheffield of Connecticut manufactured toothpaste in a collapsible tube.[31] However, brushing with a dentifrice does not provide an added effect for the mechanical removal of dental plaque,[73] although its application has been proven of value, as it gives the patient a feeling of oral freshness and allows the application of additional agents such as anti-caries and anti-inflammatory substances.[74] Dentifrices traditionally contain abrasives to help remove stained pellicles and polish the teeth.[75] Today, a silicate is most commonly incorporated. Even though the abrasiveness is often discussed, Radioactive Dentin Abrasion (RDA) values of up to 250 are generally accepted to be secure.

Active agents

The most commonly included medical active agents are fluorides. Brushing with a fluoride-containing dentifrice reduces dental caries when compared to nonfluoride dentifrices.[76] Furthermore, several formulations with specific chemical agents for the management of plaque and gingivitis are marketed. When compared to negative controls, only a few of them provide statistically significant improvements in gingival, bleeding, and plaque indices.[77] Tin combined with fluoride (stannous fluoride) has been used in dentifrice formulations since the beginning of the 1940s. Besides its caries-preventive properties, it acts as an anti-inflammatory. Triclosan, introduced in the 1980s, is another antimicrobial agent commonly used in many oral care products. Due to its antibacterial, antifungal, and antiviral properties, it is commonly found in products such as acne creams, deodorants, and hand soaps. With regard to parameters of plaque and gingivitis, the superiority of stannous fluoride and triclosan as compared to sodium fluoride has been demonstrated in systematic reviews.[78–82]

A recent systematic review compared stannous fluoride and triclosan directly.[83] A total of 11 studies with a minimum duration of 4 weeks were included in the systematic review. Both dentifrices seemed to be clinically equally effective with regard to gingivitis and plaque parameters. An often-reported adverse event of stannous fluoride is staining; accordingly, in the present systematic review, both of the studies included that evaluated staining showed a significantly higher risk for the group brushing with a dentifrice containing stannous fluoride compared to one containing triclosan. Reportedly, adding hexametaphosphate to the dentifrice can reduce this risk.[27,84,85] A recent Cochrane systematic review demonstrated that, compared to a standard dentifrice with fluoride, dentifrice containing triclosan showed reductions in plaque, gingivitis, and bleeding scores, as well as a 5% reduction of tooth decay in patients without periodontitis.[81] The evidence to show a superiority of one of the dentifrices to prevent periodontitis was insufficient. These data were elevated in only one study with an estimated low GRADE of evidence in patients 11 to 13 years of age. No harmful side effects were associated with the triclosan/copolymer toothpastes in studies up to 3 years in length.

In patients with periodontitis, a reduced risk of further attachment loss when participants brush with a dentifrice containing triclosan compared to a dentifrice containing fluoride has been observed in randomized controlled clinical studies.[86,87] Conversely, in a randomized study comparing patients involved in a periodontal maintenance program over 3 years, no clinical or microbiologic differences were found for patients brushing with a manual toothbrush and a standard fluoride dentifrice compared to patients brushing with a power toothbrush and a triclosan-containing dentifrice.[88]

Triclosan is an antimicrobial substance that, apart from being a dentifrice ingredient, is added to many other household products such as soaps, antiperspirants, toys, and kitchen utensils.[89,90] Concerns regarding environmental and health effects are extensively discussed,[89–91] but there is no evidence that triclosan is hazardous to humans.[89,90] Overall resistance rates and cross-resistance rates in community settings are low, although in laboratory settings resistance to triclosan and cross-resistance to antimicrobials have been demonstrated.[91] There are, however, case reports on contact sensitization to triclosan-containing dentifrices leading to blistering eruption on the buccal mucosa and lips.[92] A recent review on the risks and benefits of triclosan-containing soap demonstrated conflicting effects concerning its efficacy compared to nonantimicrobial soap.[91] Consequently, the authors concluded that the risk of resistance outweighs the beneficial effects of triclosan-containing soap. Furthermore, the US Food and Drug Administration (FDA) recommends washing hands with plain soap and water, as no beneficial effects of triclosan-containing soap compared to a plain soap have been proven so far.[89] The amount of triclosan applied through dentifrice use, which commonly contains 0.03% triclosan, is comparatively small. Nevertheless, with regard to the common concerns and the similar efficacy compared to a stannous fluoride–containing dentifrice, the latter should still be the primary choice.

Detergents

In order to improve plaque removal as well as to disperse the toothpaste product in the mouth by a foaming effect, detergents (or surfactants) are frequently added to dentifrice. Early versions of dentifrice contained soap and were usually powders.[93] During the 1850s, a so-called Crème Dentifrice was developed. Since 1945, soap has been replaced by other ingredients to make the paste into a smooth paste or emulsion. Today, the most widely used detergent is sodium lauryl sulphate. However, it is unclear whether the foaming effect improves plaque reduction or patient acceptance.

Two recent studies investigated the influence of the commonly used detergent sodium lauryl sulphate on plaque and gingivitis scores.[94,95] A total of 120 participants with gingivitis were randomized to brush their teeth for 8 weeks with either a sodium lauryl sulphate–containing dentifrice (Colgate caries protection, Colgate-Palmolive) or a sodium lauryl sulphate–free dentifrice (Zendium classic, Sara Lee).[94] The two groups showed no significant differences for bleeding on marginal probing, plaque, or abrasion scores; however, the visual analog scale for taste, freshness, and foaming effect were significantly in favor of the dentifrices containing sodium lauryl sulphate. In a further study, dentifrice without sodium lauryl sulphate was compared to two commercially available dentifrices containing sodium lauryl sulphate.[95] In total, 90 volunteers showing moderate gingivitis were asked to brush with their randomly assigned product over 4 weeks. The products were either a sodium lauryl sulphate–free dentifrice containing enzymes, colostrume, and low concen-

trations of zinc (Zendium Classic, Sara Lee) or one of two dentifrices containing sodium lauryl sulphate (Sensodyne, GlaxoSmithKline; Colgate Caries protection, Colgate-Palmolive Co). As in the study mentioned above, no differences with regard to plaque and gingivitis scores could be observed between the groups. The participants appreciated the dentifrice containing sodium lauryl sulphate more with respect to taste. It has been shown previously that sodium lauryl sulphate might be irritating to the oral mucosa in susceptible patients.[96,97] Furthermore, sodium lauryl sulphate alone seems to lead to an increased permeability of the mucosa, but not if triclosan or stannous fluoride is added.[98] Although dentifrice without sodium lauryl sulphate seems to be less appreciated by the patient, it seems to be beneficial in susceptible patients, in particular patients with recurrent aphthous ulcers.[97]

Conclusions

Oral hygiene self-care should be provided individually to each patient according to the clinical situation and the patient's individual habits, personal skills, and preferences. Powered toothbrushes, brushing in combination with direct feedback systems, dentifrices that contain stannous fluoride or triclosan, and the correct application of an individually adjusted interdental cleaning device might lead to improved effectiveness. Because of the similar efficacies of triclosan- and stannous fluoride–containing dentifrices and the common concerns regarding triclosan, stannous fluoride might be the better choice of the two. Sodium lauryl sulphate does not contribute to a reduction in plaque or gingivitis. Patients appreciate the foaming effect of dentifrices containing sodium lauryl sulphate, but these dentifrices might be avoided in susceptible patients without risking any harms.

Acknowledgments

The authors declare that they have no conflicts of interest. This study was self-funded by the authors and their institutions. Ethical approval was not required. Cited papers of their own research group have already been published in scientific dental journals; therefore, some duplication of the text is inevitable.

References

1. Löe H, Theilade E, Jensen SB. Experimental gingivitis in man. J Periodontol 1965;36:177–187.
2. Kinane DF, Attström R, European Workshop in Periodontology Group B. Advances in the pathogenesis of periodontitis. Group B consensus report of the fifth European Workshop in Periodontology. J Clin Periodontol 2005;32(suppl):s130–s131.
3. Petersen FC, Assev S, Scheie AA. Combined effects of NaF and SLS on acid- and polysaccharide-formation of biofilm and planktonic cells. Arch Oral Biol 2006;51:665–671.
4. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of severe tooth loss: A systematic review and meta-analysis. J Dent Res 2014;93(suppl):s20–s28.
5. van der Velden U, Amaliya A, Loos BG, et al. Java project on periodontal diseases: Causes of tooth loss in a cohort of untreated individuals. J Clin Periodontol 2015;42:824–831.
6. Chapple IL, Van der Weijden F, Doerfer C, et al. Primary prevention of periodontitis: Managing gingivitis. J Clin Periodontol 2015;4(suppl):s71–s76.
7. Benzian H, Hobdell M, Holmgren C, et al. Political priority of global oral health: An analysis of reasons for international neglect. Int Dent J 2011;61:124–130.
8. Lang NP, Schätzle MA, Löe H. Gingivitis as a risk factor in periodontal disease. J Clin Periodontol 2009;36(suppl):s3–s8.
9. Schätzle M, Löe H, Lang NP, Bürgin W, Anerud A, Boysen H. The clinical course of chronic periodontitis. J Clin Periodontol 2004; 31:1122–1127.
10. van der Weijden F, Slot DE. Oral hygiene in the prevention of periodontal diseases: The evidence. Periodontol 2000 2011;55:104–123.
11. van der Weijden FA, Slot DE. Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis a meta review. J Clin Periodontol 2015;42(suppl):s77–s91.
12. Needleman I, Suvan J, Moles DR, Pimlott J. A systematic review of professional mechanical plaque removal for prevention of periodontal diseases. J Clin Periodontol 2005;32(suppl):s229–s282.
13. van der Weijden GA, Hioe KP. A systematic review of the effectiveness of self-performed mechanical plaque removal in adults with gingivitis using a manual toothbrush. J Clin Periodontol 2005; 32(suppl):s214–s228.
14. Drisko CL. Periodontal self-care: Evidence-based support. Periodontol 2000 2013;62:243–255.
15. Hugoson A, Lundgren D, Asklöw B, Borgklint G. Effect of three different dental health preventive programmes on young adult individuals: A randomized, blinded, parallel group, controlled evaluation of oral hygiene behaviour on plaque and gingivitis. J Clin Periodontol 2007;34:407–415.
16. Hujoel PP, Cunha-Cruz J, Banting DW, Loesche WJ. Dental flossing and interproximal caries: A systematic review. J Dent Res 2006; 85:298–305.
17. Hujoel PP, Cunha-Cruz J, Loesche WJ, Robertson PB. Personal oral hygiene and chronic periodontitis: A systematic review. Periodontol 2000 2005;37:29–34.
18. Axelsson P, Nyström B, Lindhe J. The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. J Clin Periodontol 2004;31:749–757.
19. Needleman I, Nibali L, Di Iorio A. Professional mechanical plaque removal for prevention of periodontal diseases in adults—Systematic review update. J Clin Periodontol 2015;42(suppl):s12–s35.
20. van Leeuwen M, Rosema N, Versteeg PA, Slot DE, Hennequin-Hoenderdos NL, van der Weijden GA. Effectiveness of various interventions on maintenance of gingival health during 1 year—A randomized clinical trial. Int J Dent Hyg 2016 [epub aheaad of print].
21. Davies RM, Davies GM, Ellwood RP. Prevention. Part 4: Toothbrushing: What advice should be given to patients? Br Dent J 2003;195:135–141.

22. American Dental Association. Toothbrushes. http://www.ada.org/en/member-center/oral-health-topics/toothbrushes. Accessed 27 March 2017.
23. Hugoson A, Sjödin B, Norderyd O. Trends over 30 years, 1973-2003, in the prevalence and severity of periodontal disease. J Clin Periodontol 2008;35:405–414.
24. Skudutyte-Rysstad R, Eriksen HM, Hansen BF. Trends in periodontal health among 35-year-olds in Oslo, 1973-2003. J Clin Periodontol 2007;34:867–872.
25. Norderyd O, Koch G, Papias A, et al. Oral health of individuals aged 3-80 years in Jönköping, Sweden during 40 years (1973-2013). II. Review of clinical and radiographic findings. Swed Dent J 2015;39:69–86.
26. Lang NP, Lindhe J, van der Velden U, European Workshop in Periodontology Group D. Advances in the prevention of periodontitis. Group D consensus report of the 5th European Workshop in Periodontology. J Clin Periodontol 2005;32(suppl):s291–s293.
27. Micheelis W, Schiffner U. Vierte Deutsche Mundgesundheitsstudie (DMS IV). Köln: Institut der Deutschen Zahnärzte, 2006.
28. Slot DE, Wiggelinkhuizen L, Rosema NA, van der Weijden GA. The efficacy of manual toothbrushes following a brushing exercise: A systematic review. Int J Dent Hyg 2012;10:187–197.
29. Rosema N, Slot DE, van Palenstein Helderman WH, Wiggelinkhuizen L, van der Weijden GA. The efficacy of powered toothbrushes following a brushing exercise: A systematic review. Int J Dent Hyg 2016;14:29–41.
30. Deinzer R, Harnacke D, Mengel R, Telzer M, Lotzmann U, Wöstmann B. Effectiveness of computer-based training on toothbrush skills of patients treated with crowns: A randomized controlled trial. J Periodontol 2016;87:1333–1342.
31. van der Weijden F, Slot DE, Echeverria JJ, Lindhe J. Mechanical supragingival plaque control. In: Lang NP, Lindhe J (eds). Clinical Periodontology and Implant Dentistry, ed 6. Chichester: Wiley-Blackwell, 2015:677–716.
32. Wainwright J, Sheiham A. An analysis of methods of toothbrushing recommended by dental associations, toothpaste and toothbrush companies and in dental texts. Br Dent J 2014;217:e5.
33. Tonetti MS, Chapple IL, Jepsen S, Sanz M. Primary and secondary prevention of periodontal and peri-implant diseases: Introduction to, and objectives of the 11th European Workshop on Periodontology Consensus Conference. J Clin Periodontol 2015;42(suppl):s1–s4.
34. Renton-Harper P, Addy M, Warren P, Newcombe RG. Comparison of video and written instructions for plaque removal by an oscillating/rotating/reciprocating electric toothbrush. J Clin Periodontol 1999;26:752–756.
35. Graetz C, Bielfeldt J, Wolff L, et al. Toothbrushing education via a smart software visualization system. J Periodontol 2013;84:186–195.
36. Oral-B. Oral-B Genius. http://oralb.com/en-us/genius. Accessed 27 March 2017.
37. Rylander H, Lindhe J. Cause-related periodontal therapy. In: Lindhe J, Karring T, Lang NP (eds). Clinical Periodontology and Implant Dentistry. Copenhagen: Munksgaard, 1997:438–447.
38. Yaacob M, Worthington HV, Deacon SA, et al. Powered versus manual toothbrushing for oral health. Cochrane Database Syst Rev 2014;(6):CD002281.
39. Björn AL, Andersson U, Olsson A. Gingival recession in 15-year old pupils. Swed Dent J 1981;5:141–146.
40. Heasman PA, Holliday R, Bryant A, Preshaw PM. Evidence for the occurrence of gingival recession and non-carious cervical lesions as a consequence of traumatic toothbrushing. J Clin Periodontol 2015;42(suppl):s237–s255.
41. van der Weijden FA, Campbell SL, Dörfer CE, González-Cabezas C, Slot DE. Safety of oscillating-rotating powered brushes compared to manual toothbrushes: A systematic review. J Periodontol 2011;82:5–24.
42. Dörfer CE, Staehle HJ, Wolff D. Three-year randomized study of manual and power toothbrush effects on pre-existing gingival recession. J Clin Periodontol 2016;43:512–519.
43. Schoo WH, van der Velden U. Marginal soft tissue recessions with and without attached gingiva. A five year longitudinal study. J Periodontal Res 1985;20:209–211.
44. Sälzer S, Graetz C, Plaumann A, et al. Effect of a multidirectional power toothbrush and a manual toothbrush in individuals susceptible to gingival recession: A 12-month randomized controlled clinical study. J Periodontol 2016;87:548–556.
45. Löe H. Mechanical and chemical control of dental plaque. J Clin Periodontol 1979;6:32–36.
46. Roussa E. Anatomic characteristics of the furcation and root surfaces of molar teeth and their significance in the clinical management of marginal periodontitis. Clin Anat 1998;11:177–186.
47. Sicilia A, Arregui I, Gallego M, Cabezas B, Cuesta S. A systematic review of powered vs manual toothbrushes in periodontal cause-related therapy. J Clin Periodontol 2002;29(suppl):s39–s54.
48. Bundeszahnärztekammer. Statistisches Jahrbuch 2014/2015. Berlin: Bundeszahnärztekammer, 2015.
49. Sälzer S, Slot DE, van der Weijden FA, Dörfer CE. Efficacy of interdental mechanical plaque control in managing gingivitis—A meta-review. J Clin Periodontol 2015;42(suppl):s92–s105.
50. American Dental Association. Floss/Interdental Cleaners. http://www.ada.org/en/member-center/oral-health-topics/floss. Accessed 27 March 2017.
51. Dörfer CE, Staehle HJ. Strategien der häuslichen Plaquekontrolle. Zahnmedizin up2date 2010;3:231–256.
52. Sambunjak D, Nickerson JW, Poklepovic T, et al. Flossing for the management of periodontal diseases and dental caries in adults. Cochrane Database Syst Rev 2011:(12):CD008829.
53. Berchier CE, Slot DE, Haps S, van der Weijden GA. The efficacy of dental floss in addition to a toothbrush on plaque and parameters of gingival inflammation: A systematic review. Int J Dent Hyg 2008;6:265–279.
54. Hardy K, Radini A, Buckley S, et al. Diet and environment 1.2 million years ago revealed through analysis of dental calculus from Europe's oldest hominin at Sima del Elefante, Spain. Naturwissenschaften 2017;104:2.
55. Hoenderdos NL, Slot DE, Paraskevas S, van der Weijden GA. The efficacy of woodsticks on plaque and gingival inflammation: A systematic review. Int J Dent Hyg 2008;6:280–289.
56. Walsh MM, Heckman BH, Moreau-Diettinger R. Use of gingival bleeding for reinforcement of oral home care behavior. Community Dent Oral Epidemiol 1985;13:133–135.
57. Poklepovic T, Worthington HV, Johnson TM, et al. Interdental brushing for the prevention and control of periodontal diseases and dental caries in adults. Cochrane Database Syst Rev 2013;(12):CD009857.
58. Slot DE, Dörfer CE, van der Weijden GA. The efficacy of interdental brushes on plaque and parameters of periodontal inflammation: A systematic review. Int J Dent Hyg 2008;6:253–264.
59. Waerhaug J. The interdental brush and its place in operative and crown and bridge dentistry. J Oral Rehabil 1976;3:107–113.
60. Larsen HC, Slot DE, Van Zoelen C, Barendregt DS, van der Weijden GA. The effectiveness of conically shaped compared with cylindrically shaped interdental brushes—A randomized controlled clinical trial. Int J Dent Hyg 2016 [epub ahead of print].
61. Jordan RA, Hong HM, Lucaciu A, Zimmer S. Efficacy of straight versus angled interdental brushes on interproximal tooth cleaning: A randomized controlled trial. Int J Dent Hyg 2014;12:152–157.
62. Yost KG, Mallatt ME, Liebman J. Interproximal gingivitis and plaque reduction by four interdental products. J Clin Dent 2006;17:79–83.
63. Abouassi T, Woelber JP, Holst K, et al. Clinical efficacy and patients' acceptance of a rubber interdental bristle. A randomized controlled trial. Clin Oral Investig 2014;18:1873–1880.
64. Husseini A, Slot DE, van der Weijden GA. The efficacy of oral irrigation in addition to a toothbrush on plaque and the clinical parameters of periodontal inflammation: A systematic review. Int J Dent Hyg 2008;6:304–314.

65. Flemmig TF, Newman MG, Doherty FM, Grossman E, Meckel AH, Bakdash MB. Supragingival irrigation with 0.06% chlorhexidine in naturally occurring gingivitis. I. 6 month clinical observations. J Periodontol 1990;61:112–117.
66. Lang NP, Räber K. Use of oral irrigators as vehicle for the application of antimicrobial agents in chemical plaque control. J Clin Periodontol 1981;8:177–188.
67. Sharma NC, Lyle DM, Qaqish JG, Schuller R. Comparison of two power interdental cleaning devices on the reduction of gingivitis. J Clin Dent 2012;23:22–26.
68. Sharma NC, Lyle DM, Qaqish JG, Schuller R. Comparison of two power interdental cleaning devices on plaque removal. J Clin Dent 2012;23:17–21.
69. Goyal CR, Lyle DM, Qaqish JG, Schuller R. Efficacy of two interdental cleaning devices on clinical signs of inflammation: A four-week randomized controlled trial. J Clin Dent 2015;26:55–60.
70. European Federation of Periodontology. Guidelines for Effective Prevention of Periodontal Diseases. Guidance for Dental Hygienist. https://www.efp.org/perioworkshop/workshop-2014/guidelines.html. Accessed 11 May 2017.
71. Claydon NC. Current concepts in toothbrushing and interdental cleaning. Periodontol 2000 2008;48:10–22.
72. Gillette WB, Van House RL. Ill effects of improper oral hygiene procedure. J Am Dent Assoc 1980;101:476–480.
73. Valkenburg C, Slot DE, Bakker EW, van der Weijden FA. Does dentifrice use help to remove plaque? A systematic review. J Clin Periodontol 2016;43:1050–1058.
74. van Loveren C (ed). Toothpastes. Basel, Switzerland: Karger, 2014.
75. Forward GC, James AH, Barnett P, Jackson RJ. Gum health product formulations: What is in them and why? Periodontol 2000 1997; 15:32–39.
76. Marinho VC, Higgins JP, Sheiham A, Logan S. Fluoride toothpastes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev 2003;(1):CD002278.
77. Serrano J, Escribano M, Roldán S, Martín C, Herrera D. Efficacy of adjunctive anti-plaque chemical agents in managing gingivitis: A systematic review and meta-analysis. J Clin Periodontol 2015;42(suppl):s106–s138.
78. Hioe KP, van der Weijden GA. The effectiveness of self-performed mechanical plaque control with triclosan containing dentifrices. Int J Dent Hyg 2005;3:192–204.
79. Davies RM, Ellwood RP, Davies GM. The effectiveness of a toothpaste containing triclosan and polyvinyl-methyl ether maleic acid copolymer in improving plaque control and gingival health: A systematic review. J Clin Periodontol 2004;31:1029–1033.
80. Trombelli L, Farina R. Efficacy of triclosan-based toothpastes in the prevention and treatment of plaque-induced periodontal and periimplant diseases. Minerva Stomatol 2013;62:71–88.
81. Riley P, Lamont T. Triclosan/copolymer containing toothpastes for oral health. Cochrane Database Syst Rev 2013;(12):CD010514.
82. Paraskevas S, van der Weijden GA. A review of the effects of stannous fluoride on gingivitis. J Clin Periodontitis 2006;33:1–13.
83. Sälzer S, Slot DE, Dörfer CE, van der Weijden GA. Comparison of triclosan and stannous fluoride dentifrices on parameters of gingival inflammation and plaque scores: A systematic review and meta-analysis. Int J Dent Hyg 2015;13:1–17.
84. He T, Dunavent JM, Fiedler SK, Baker RA. A randomized clinical study to assess the extrinsic staining profiles of stannous- and triclosan-containing dentifrices. Am J Dent 2010;23(Spec No. B): 22B–26B.
85. Schiff T, Saletta L, Baker RA, He T, Winston JL. Anticalculus efficacy and safety of a stabilized stannous fluoride/sodium hexametaphosphate dentifrice. Compend Contin Educ Dent 2005; 26(suppl):s29–s34.
86. Rosling B, Wannfors B, Volpe AR, Furuichi Y, Ramberg P, Lindhe J. The use of a triclosan/copolymer dentifrice may retard the progression of periodontitis. J Clin Periodontol 1997;24:873–880.
87. Cullinan MP, Westerman B, Hamlet SM, Palmer JE, Faddy MJ, Seymour GJ. The effect of a triclosan-containing dentifrice on the progression of periodontal disease in an adult population. J Clin Periodontol 2003;30:414–419.
88. Bogren A, Teles RP, Torresyap G, et al. Long-term effect of the combined use of powered toothbrush and triclosan dentifrice in periodontal maintenance patients. J Clin Periodontol 2008;35: 157–164.
89. U.S. Food & Drug Administration. 5 Things to Know About Triclosan. http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm205999.htm. Accessed 27 March 2017.
90. Scientific Committee on Consumer Safety. Opinion on Triclosan - COLIPA P32. https://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_054.pdf. Accessed 27 March 2017.
91. Giuliano CA, Rybak MJ. Efficacy of triclosan as an antimicrobial hand soap and its potential impact on antimicrobial resistance: A focused review. Pharmacotherapy 2015;35:328–336.
92. Robertshaw H, Leppard B. Contact dermatitis to triclosan in toothpaste. Contact Dermatitis 2007;57:383–384.
93. Colgate-PalmoliveCompany.Historyoftoothbrushesandtoothpastes. http://www.colgate.com/en/us/oc/oral-health/basics/brushing-and-flossing/article/history-of-toothbrushes-and-toothpastes. Accessed 27 March 2017.
94. Sälzer S, Rosema NA, Martin EC, et al. The effectiveness of dentifrices without and with sodium lauryl sulfate on plaque, gingivitis and gingival abrasion—A randomized clinical trial. Clin Oral Investig 2016;20:443–450.
95. Sälzer S, Rosema N, Hennequin-Hoenderdos NL, et al. The effectiveness of a dentifrice without sodium lauryl sulphate on dental plaque and gingivitis—A randomized controlled clinical trial [epub ahead of print 8 Feb 2016]. Int J Dent Hyg; doi: 10.1111/idh.12201.
96. Skaare A, Kjaerheim V, Barkvoll P, Rølla G. Skin reactions and irritation potential of four commercial toothpastes. Acta Odontol Scand 1997;55:133–136.
97. Herlofson BB, Barkvoll P. Oral mucosal desquamation caused by two toothpaste detergents in an experimental model. Eur J Oral Sci 1996;104:21–26.
98. Healy CM, Cruchley AT, Thornhill MH, Williams DM. The effect of sodium lauryl sulphate, triclosan and zinc on the permeability of normal oral mucosa. Oral Dis 2000;6:118–123.