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Chapter

Role of the Mechanical Interdental Plaque Control in the Management of Periodontal Health: How Many Options Do We Have?

Bahar Eren Kuru, Gizem Ince Kuka and Ogul Leman Tunar

Abstract

Untreated caries and severe periodontal disease are the most frequently encountered reasons for the tooth loss in adult population all over the world, which leads to reduced quality of life. For many years, a plethora of studies revealed the fundamental role of the microorganisms in oral biofilm in the development of caries and periodontal destruction. The primary means of oral biofilm control are through mechanical action. Although toothbrushing removes biofilm from the buccal, oral, and occlusal surfaces, it does not reach efficiently into the interdental areas. Today, several interdental cleaning devices are available over the counter for individual needs. On the other hand, this variety may be confusing for the patients to choose the right device for themselves. Therefore, dental professionals are responsible to guide their patients according to their specific needs with an evidence-based approach. Since direct evidence for the relation of interdental cleaning and periodontal disease prevention is on research, there is still a need for randomized controlled studies on interdental cleaning to increase the strength of evidence. From this standpoint, the aim of this chapter is to evaluate the cleaning efficacy of different interdental cleaning devices regarding in vitro and in vivo aspects together with patient preference and acceptance.

Keywords: mechanical interdental plaque control, dental floss, woodstick, interdental brush, rubber interdental bristle, oral irrigator

1. Introduction

Beyond dispute, dental plaque accumulation is the primary etiological factor of the diseases that are shown in the oral cavity, as caries, gingivitis, and periodontitis [1]. Dental plaque is a biofilm structure and consists of complex microbial communities. This structure resides on both hard tissues and soft tissues of the oral cavity and not easily or sufficiently removed from the surfaces by natural cleaning process (natural physiologic forces, tongue, or saliva). There are two main strategies to control or damage the biofilm structure. The first one is removing the matrix-enclosed microbial microcolonies by using shear forces that cope with the adhesion forces without damaging the cleaning material surface, meaning the mechanical biofilm removal from the surface. The second is using chemicals to kill the bacteria

and thus, later needs to clean residuals by mechanical forces. The most effective way to control the growth of biofilm is the mechanical removal of the biofilm [2].

Bacterial products of dental plaque biofilm are known to initiate host defense mechanisms, resulting hard and soft tissue destruction. Mechanical control of the dental plaque biofilm is prerequisite for the prevention and control of dental caries and periodontal diseases [3]. Regularly performed optimal oral hygiene measures alter the composition of the pocket microbiota by lowering the amount of periodontopathogens. Therefore, to obtain oral health or to control disease progression, mechanical plaque control measures must be undertaken not only in adult population or patients with periodontal disease but also in younger generation which should be educated about the prevention strategies profoundly. Long-term success of the periodontal therapy is closely related with the plaque removal efficacy of the patients [4]. Longitudinal studies reveal that sites with inadequate plaque removal present deeper probing depths and attachment loss after periodontal therapy [4, 5].

The historical background of mechanical plaque control stands the dates of ancient Egyptians who made brushes by thin wooden sticks called miswak. Today still the most widely known self-performed mechanical plaque biofilm removal/control method at home is toothbrushing. The buccal, palatinal or lingual, and occlusal surfaces of the teeth are easy to clean well with toothbrushes but do not reach the interdental region of teeth efficiently [6]. Toothbrushing when applied with a proper technique can clean only 65% of the total tooth surface. Due to limitations of the toothbrushes in the penetration of the proximal areas, interdental cleaning gains attention as a separate title. Interdental plaque biofilm control measures should be used as adjunctive to toothbrushing to complement the mechanical cleaning [7–9]. For the maintenance of the periodontal health and caries prevention, toothbrushing should be combined with interdental cleaning once every 24 hours [10, 11].

2. Interdental cleaning products

Numerous devices and methods have been introduced over the counter for interdental cleaning with different levels of efficacy. Interdental cleaning device selection should be primarily based on the contour of the papilla, size of the embrasures, tooth alignment, and patients' attitude toward oral health. When evaluating the existing products, ease of use, plaque removal efficacy, and possible tissue trauma should be considered before prescription. Since patients have different types of dentitions and interdental spaces, dental professionals should recommend the suitable devices to each individual patient and guide them according to their needs [9].

The remaining of this chapter will focus on the interdental cleaning products currently available over the counter.

2.1 Dental floss

At the beginning of the nineteenth century, Levi Spear Parmly, a dentist from New Orleans, first introduced the idea of tooth flossing with a piece of silk thread. Within years, commercial production of unwaxed silk floss enabled the home use, and in 1898, dental floss was patented by the Johnson & Johnson Company of Brunswick, New Jersey. During the 1940s, nylon replaced silk as the material for dental floss due to its consistent texture and resistance to shredding. Nylon usage also yielded the development of dental tape, broader type of dental floss, in the 1950s [12].

Today several types of flosses are available. While waxed floss is generally recommended to individuals with tight interproximal contacts, unwaxed floss is suitable for the normal tooth contacts since it slides through the contact area easily. Different materials and floss designs also make it possible to clean around braces and fixed partial dentures. The American Dental Association (ADA) reported that up to 80% of plaque can be removed by flossing [13]. However, most of the people find flossing difficult and time-consuming. To make flossing easier, disposable floss holders or powered flossing devices have been introduced. Comparing the use of powered devices with manual flossing, no significant differences were detected in terms of plaque and gingivitis reduction [14].

In individuals with intact papilla which only allows the penetration of dental floss, flossing is the best option for interdental cleaning [9]. However, dental professional should spend time to motivate and properly instruct the patient about the flossing since the effectiveness is technique sensitive. Studies mainly attributed the lack of efficacy of flossing to manual complexity of the technique and/or to the lack of patients' compliance [15]. On the other hand, in a recent study which conducted in young subjects without interdental attachment loss, toothbrushing in combination with flossing was reported to be capable of both plaque and gingival inflammation reduction [16].

Berchier et al. [17] conducted a meta-analysis including 11 randomized clinical trials (RCTs) comparing toothbrushing and flossing (test) to toothbrushing alone (control). Results of this meta-analysis revealed no significant differences between test and control groups in terms of plaque and gingival indices. In 2011, Sambunjak et al. [18] investigated the added benefit of flossing to toothbrushing with a systematic review. This review included 12 RCTs with a total of 582 participants. As a result, authors concluded that toothbrushing combined with flossing reduced gingivitis compared to toothbrushing alone. Regarding to plaque reduction, weak and inconsistent statements were associated with toothbrushing and flossing combination at 1- and 3-month periods. No information was available in terms of dental caries prevention because of the short trial periods and difficulties of the early-stage caries detection.

Current literature unfortunately does not support dental floss usage on a routine basis. However, absence of an evidence does not mean absence of an effect [19]. The presence of a weak evidence regarding to the use of dental floss in combination with toothbrushing is mainly related to study designs and small sample size of the studies. Long-term RCTs with higher sample size populations and retrospective studies are needed to increase the strength of data [20].

2.2 Woodsticks

The use of dental woodsticks is usually advised by dental professionals to massage the inflamed gingiva, to reduce the inflammation of interdental area, and to increase the keratinization. Woodsticks, made of soft wood, have a wedge-like triangular design suitable for the interdental anatomy. When inserted, the base of the triangle should rest on the gingival side, whereas the tip should point occlusally or incisally [21, 22]. Triangular-shaped woodsticks with low surface hardness and high strength values were shown to be more suitable for interdental cleaning than rounded toothpicks [23]. Previous in vitro studies revealed that triangular-shaped woodsticks which are inserted interdentally could maintain 2–3 mm subgingival plaque-free zone. The resilience of the gingival papilla allows cleaning of the subgingival margins of the restorations which also reduces the risk of the recurrent caries development [21, 23].

Woodsticks have an advantage of the ease of use; therefore, they can be recommended in the cases of poor manual dexterity. If interdental spaces are sufficient, woodsticks may be an appropriate substitute to dental floss, especially for the secondary prevention of periodontal diseases. Although woodsticks have a good cleaning capacity on the buccal part of the interproximal area, their efficacy is reduced on the lingual side and the posterior area. The main disadvantage of the woodsticks is, when used in the healthy dentition, they depress the gingival margin and may cause the permanent loss of papilla [3].

Hoenderdos et al. [21] performed a systematic review to evaluate the efficacy of the adjunctive usage of woodsticks to toothbrushing compared to daily toothbrushing alone or other adjunctively used interdental cleaning devices on periodontal clinical parameters. Results of this systematic review failed to reveal any additional effect of woodsticks on plaque index. On the other hand, their additional use provided a significant improvement in interdental gingival inflammation by the reduction of the bleeding tendency. These results were explained by the physical action of the woodsticks that can mostly remove the subgingival plaque in the interdental area by depressing the papilla, which is not visible and evaluated by the plaque indices. Therefore, subgingival elimination of the plaque might induce a beneficial effect on interdental gingival inflammation without inducing a chance in plaque index values.

The evidence for the efficacy of woodsticks as adjunct to toothbrushing is weak. Within the limitations of the available data, woodsticks have the benefit on bleeding scores without significant impact on plaque reduction [9, 24].

2.3 Interdental brushes

For the last 50 years, since its development, the interdental brush (IDB) has taken its place in the market of oral hygiene products. Simply the architecture of the IDB is seen that a thin brush is composed of soft nylon filaments wrapped around by a fine stainless steel wire. The thickness of this metal wire and the length of the nylon filaments differ from brand to brand and vary according to the size of the desired brush. The handle of the IDB may be made of a metal or plastic material. Considering the comfort and ease of use of the patient, the handle of the brushes is designed in different lengths. The shape of the IDB depends on the forms of the nylon filament arrangement. The most common forms of the nylon filament IDB are cylindrical or tapered shapes [3, 25]. The IDB can be inserted through the interdental space, and cleaning is performed with back and forth motion with several times.

A systematic review concluded that interdental plaque removal with IDB is the most efficient method for interproximal cleaning [17]. The choosing of the IDB size is the key point of the interdental clinical efficacy. The 11th European Workshop in Periodontology on the primary prevention of periodontal diseases published a report and recommended that if gingival inflammation exists, professionals should teach their patients the use of IDBs [26]. When the interdental space is stuffed with the papilla, especially in young individuals, dental floss is the best choice that can reach into this area [27]. IDBs should be the first choice for larger interdental spaces where the gingival recession, attachment loss, and root exposure exist [26, 27]. IDBs have superiority of reaching interdental grooves or fissures than other interdental cleaning devices [9, 28]. Regarding the determination of the suitable size, IDB needs to fit the interdental area and moves without inducing any hard tissue abrasion or soft tissue trauma. Improper use or inappropriate size selection may result dentin hypersensitivity as well as the soft tissue damage.

Christou et al. [29] designed a split-mouth RCT that aimed to compare the clinical efficacy of dental floss and IDB, adjunct to toothbrushing. After 6 week period, in combination with a manual toothbrush, the use of IDB was found more effective in plaque removal and probing depth (PD) reduction compared to dental floss. Since no difference was detected between IDB and dental floss in terms of bleeding scores, higher PD reduction was speculated to be due to marginal gingival recession induced by IDB. Tu et al. [30] reanalyzed the data of this RCT by structural equation modeling to test whether the greater PD reduction of IDBs compared to dental floss was due to plaque removal or to mechanical depression of the interdental papilla. Results of the structural equation modeling revealed that the greater reduction in PD with IDB than that of dental floss was mainly due to the greater efficiency in plaque removal rather than to the compression of the papilla. In another split-mouth trial, IDB and dental floss showed similar effects on subgingival plaque and gingival inflammation. However, patients preferred IDB to dental floss due to ease of use [25].

Slot et al. [31] conducted a systematic review to evaluate the efficacy of IDBs and other interdental cleaning devices on plaque and parameters of periodontal inflammation. Regarding plaque, additional use of IDBs resulted significantly more plaque reduction compared to toothbrushing alone. Comparing IDB to dental floss, most of the studies revealed significant difference on plaque index parameter in favor of the IDB. Also, IDBs were detected to remove more plaque than woodsticks. Collective data of the studies included in this systematic review made a meta-analysis possible for the comparison of IDBs to dental floss as adjuncts to toothbrushing. End scores revealed significant difference in favor of the IDB group only according to Silness and Löe [32] plaque index. However, no statistically significant differences were observed with other indices as Quigley and Hein [33] plaque index and bleeding on probing (BoP).

To enhance the ease of use especially in the premolar and molar regions, angled IDBs have been introduced. Jordan et al. [34] reported better plaque removal efficacy of straight IDB compared to the angled one. However, no systematic reviews are available regarding the evaluation of the efficacy of an angled or straight IDBs and their filament hardness.

Results of the meta-analysis reveal moderate evidence regarding the efficacy of IDB usage as adjunct to toothbrushing. With standardizing the results retrieved from different periodontal indices, adjunctive usage of IDB yields 34 and 32% gingivitis and plaque score reductions, respectively [35].

2.4 Rubber interdental bristles

A rubber bristles interdental cleaner (RBIC) visually resembles an IDB, but does not have a metal-core or nylon filaments. Instead, it has small elastomeric fingers protruding perpendicularly from a plastic core.

Rubber interdental bristles (RIBs) are recently introduced interdental cleaners with small elastomeric finger-like extensions perpendicular to the plastic core. Unlike interdental brushes (IB), they do not have a metal-core and nylon filaments. Therefore, induction of the dentin hypersensitivity and the risk of soft tissue damage are limited [36].

Yost et al. [36] compared the performance of RIB, IDB, and flosser to dental floss for plaque removal efficacy and gingivitis reduction. As a result, authors reported that RIBs had similar efficacy in plaque and gingivitis reduction compared to conventional IDBs. Abouassi et al. [37] conducted a single-blind, prospective RCT with a crossover design to compare RIB with a standard metal-core IDB for their efficacy on gingival bleeding, plaque removal, and patient experience in 39 subjects. After 4 weeks of usage of the products, both groups showed significant

decreases in plaque accumulation and bleeding with no significant differences between them. However, RIBs were found significantly more comfortable for participants than IDBs. In a recent RCT, RIB was compared to IDB in terms of gingivitis reduction and patient perception. For this purpose, parallel, split-mouth, and examiner-blind study was performed in 42 systemically healthy individuals with experimentally induced gingivitis. After prophylaxis, participants refrained from plaque biofilm control measures for 21 day period, followed by 4 week usage of the assigned interdental cleaning device as an adjunct to toothbrushing. Results of this trial revealed that RIB usage in addition to toothbrushing was more effective in gingival inflammation reduction compared to IDBs after 4 weeks. Also, RIB was more appreciated by participants and caused less abrasion of the gingiva [38].

To evaluate the cleaning efficacy of IDBs, RIBs, and woodsticks in vitro, our research group performed a study on 72 extracted human teeth without approximal caries and restorations. Teeth were grouped as incisors, premolars, and molars and embedded to acrylic resin. Artificial contacts were designed to be separable from the interproximal parts. Interproximal surfaces of the teeth were dyed with contact spray. Three groups of approximately same sized interdental cleaning devices, RIB (Tepe Easypick™ XS/ S), IDB (TePe® 0.45) and woodsticks (TePe® Dental Stick Slim) were selected. After the application of interdental devices, the teeth were separated from the interproximal surfaces. The teeth were digitally photographed and by using AutoCAD™ software, the dye removal was calculated (**Figures 1** and **2**). Results of this study revealed that IDB's relative cleaning efficacy was better than that of RIBs and woodsticks [39].

Recently, Graziani et al. [16] conducted a RCT to evaluate the efficacy of different adjunctively used interdental cleaning devices in unsupervised participants with intact interdental papilla. Sixty subjects were randomized to four groups with different oral hygiene regimens as manual toothbrushing alone; manual toothbrushing plus dental floss; manual toothbrushing plus IDB; and manual toothbrushing plus RIB. At the end of the 28 day trial period, toothbrushing or toothbrushing and adjunctive use of interdental cleaning devices such as dental floss, IDBs, or RIBs significantly reduced both plaque and gingival inflammation. Interdental plaque scores decreased in groups using IDBs and RIBs as adjuncts compared to toothbrushing alone. Interdental inflammation was significantly reduced in RIB group compared to dental floss.

Due to the limited number of the published data regarding RIBs, a detailed systematic evaluation of these devices is yet impossible.

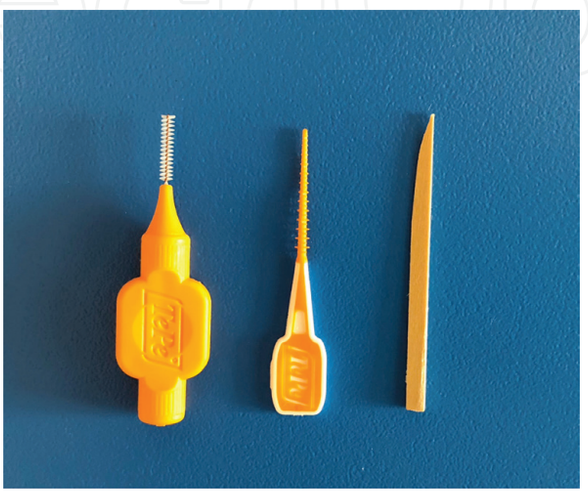

Figure 1.
Interdental cleaning devices used in the study. From left to right; Interdental brush (TePe® 0.45), Rubber Interdental Bristle (Tepe Easypick™ XS/S), C) Woodsticks (TePe® Dental Stick Slim).

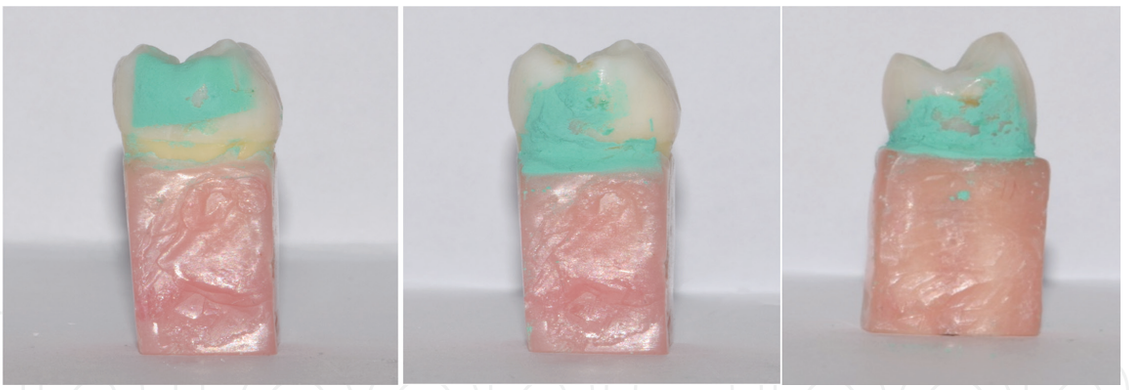

Figure 2.
After application of the interdental cleaning devices. From left to right; Interdental brush, Rubber Interdental Bristle, Woodstick.

2.5 Oral irrigator

The oral irrigator, also called dental water jet or water flosser or waterpik device, was first introduced in the 1960s by a hydraulic engineer and a dentist from the USA. Oral irrigator is designed to remove plaque and soft debris by the mechanical action of a stream of water which can also be used with antimicrobial agents. Contrary to popular belief, studies have shown that this device has no negative effect on the junctional epithelium and demonstrated to be safe. Early studies showed the efficacy of oral irrigator on clinical parameters such as plaque, bleeding, and PD [40–42]. Although pulsating and hydrodynamic forces produced by irrigators can rinse away food debris from interdental and plaque-retentive areas, irrigation cannot be a monotherapy to remove the plaque biofilm but an adjunct to supplement other mechanical plaque control measures. Fluid flow may be either pulsated or continuous. It has been reported that a pulsating stream of water is better than a continuous flow [43, 44]. An ex vivo SEM study demonstrated that the hydraulic forces and pulsation of a dental water jet can remove the biofilm above or below the cemento-enamel junction [45].

Cutler et al. [43] conducted a study on 52 otherwise healthy, mild to moderate chronic periodontitis patients and randomly allocated them into 3 groups. In group A, no oral hygiene was performed for 14 days. Group B continued their daily oral hygiene routine, and group C performed routine oral hygiene (ROH) plus water irrigator for 14 days. Results of the study revealed that in 14 day period, oral irrigation plus ROH resulted significant reductions in PD, BoP, gingival, and plaque indices as well as IL-1 beta and PGE2 levels, compared to ROH or no oral hygiene. They concluded that oral irrigator improved the therapeutic benefit for periodontitis patients. In a 6 month, multicenter, single-blinded study, added benefit of daily oral irrigation to regular oral hygiene in clinical parameters was demonstrated in periodontitis patients under supportive periodontal treatment [46].

Husseini et al. [44] performed a systematic review to evaluate the effectiveness of oral irrigation in addition to toothbrushing on plaque and clinical parameters of periodontal inflammation compared to toothbrushing alone. As a result, authors concluded that the additional use of oral irrigator to toothbrushing had no significant effect on plaque reduction compared to toothbrushing alone. Regarding gingival inflammation, a positive trend in favor of the oral irrigation was observed for the improvement of gingival health over toothbrushing only. To explain the discrepancy of the obtained results, authors hypothesized that with the oral irrigation, populations of the key periodontopathogens are altered, thereby reducing gingival inflammation. There is also a possibility that the beneficial activity of an

oral irrigator is at least due to partial removal of food deposits and debris, flushing away of loosely adherent plaque, removal of bacterial cells, stimulation of immune responses, and interference with plaque maturation [47]. Other possibilities include mechanical stimulation of the gingiva or a combination of previously hypothesized factors. Oral irrigators may reduce plaque thickness, which may not be detected by two-dimensional scoring systems. This fact could also explain the absence of an effect on plaque reduction but a positive effect on gingival inflammation [3].

Regarding oral irrigators, exact mechanisms of action for abovementioned findings are unclear. Further RCTs are warranted to investigate the effectiveness of oral irrigators with different irrigation tips as adjuncts to regular oral hygiene measures for the long-term maintenance of periodontal health.

3. Conclusion

The goal of the mechanical plaque control is to prevent and arrest plaque biofilm-associated disease development. Therefore, oral hygiene instructions including toothbrushing techniques and interdental cleaning should be tailored to each patient based on their individual needs. New developments in interdental cleaning products and oral irrigation devices will be the topic of the future systematic reviews to guide the dental professionals for an evidence-based decision-making. When applying the evidence to clinical practice, dental professionals should choose the best oral hygiene methods according to patients' skill levels and preferences, since the patient acceptance is crucial for the long-term use of interdental cleaning devices. Today, scientific evidence regarding to the efficacy of the self-performed interdental cleaning products is only available for the dentitions that include natural teeth. With the aging of the population and new technological developments, dental implants become more and more popular treatment alternatives. Since the anatomic structures of the peri-implant tissues differ from periodontal tissues and there are different implant-supported prosthetic designs, clinical trials are required in terms of different aspects of oral hygiene around implants.

Conflict of interest

Authors declare no conflict of interest.

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