Toothbrush technology, dentifrices and dental biofilm removal

A Peer-Reviewed Publication
Written by Fiona M. Collins, BDS, MBA, MA

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Educational Objectives
The overall goal of this course is to provide information on the removal of plaque (dental biofilm) during home care oral hygiene with toothbrushes and dentifrices.
Upon completion of this course, the clinician will be able to do the following:
1. Provide a brief overview of dental biofilm development and bacterial growth.
2. Describe the attributes of ideal toothbrushes and dentifrices.
3. Know the considerations involved in selecting a manual, powered or sonic brush
4. Understand the considerations involved in dentifrice selection with respect to plaque removal.

Abstract
Dental plaque is a complex biofilm consisting of a polysaccharide matrix containing bacteria, voids and nonvital material of bacterial origin. Both cariogenic and periodontopathic bacteria reside in dental biofilm (plaque). While other factors must also be present for caries or periodontal disease to exist in a patient, without these bacteria neither bacterial disease will occur. The primary goal of toothbrushing is to remove the dental biofilm present on and adjacent to the teeth, thereby removing the bacteria associated with caries and periodontal disease; use of a dentifrice while brushing helps remove plaque and will also deliver agents to the tooth surface. Manual, powered and sonic brushes have all been shown to be effective and safe for the removal of plaque, when used appropriately. Selecting or recommending oral hygiene aids involves a number of considerations, including effectiveness, cleaning ability, ease of use and likely compliance.

Introduction
Since prehistoric times, man has devised a variety of methods to clean and whiten teeth. Some of the earliest devices used as “toothbrushes” were similar to some woodstick devices currently in use. It was not until the second half of the 20th century that first powered and later sonic toothbrushes were introduced. Modern toothpaste precursors were developed starting in the early 1800s. The development of toothbrushes and dentifrices accelerated in the latter half of the 20th century, in the search for products ideally suited to their purpose.

Early efforts at tooth cleaning were focused on making teeth look cleaner and whiter and freshening breath. There was, however, no understanding of dental biofilm (plaque). One of the first people to try to understand the oral ecology was Willoughby Miller, who believed that periodontal disease was caused by microbes, and who also published an article identifying several acidogenic bacteria. Seminal research in the 1960s and 1970s by Loe and others definitively demonstrated the role of plaque as a bacterial ecology involved in the development of periodontal disease. Bacteria were also known to be associated with caries.

By the 1980s, it was known that dental plaque consisted of a complex environment containing both periodontopathic and cariogenic bacteria. The main cariogenic bacteria contained in dental biofilm are Streptococcus mutans, with lactobacilli and minor bacteria also playing a role. The associations among, and proportions of, bacteria change over time as strains that are more virulent are introduced. Supragingival plaque contains more aerobic bacteria (e.g., Streptococcus mutans) and acts as a bacterial reservoir for subgingival plaque. Subgingival plaque contains a high proportion of anaerobic bacteria (periodontopathogens). Gram-negative anaerobic bacteria gradually increase in number and alter the nature of the biofilm. Socransky and Haffajee discovered that dental biofilm is made up of specific groupings of bacteria consisting of five complexes of varying pathogenicity and virulence. Three periodontopathogens in the red complex of bacteria — T. forsythensis, P. gingivalis and T. denticola — are considered to be the most common bacteria associated with periodontal disease. In mature biofilm, the bacteria are enveloped by the biofilm structure, which consists mainly of a polysaccharide matrix containing voids as well as nonvital material of bacterial origin. It is important to note that periodontal disease will not result from the presence of a bacterial infection on its own, but involves local and systemic contributing factors and the host response.

Reducing, removing or changing the biofilm is carried out to try to reduce the bacteria associated with caries and periodontal disease, to freshen the breath and for social acceptance. A plethora of products is available for these indications, including toothbrushes, dentifrices, rinses, creams, and professional and prescription products. Agents that have antibacterial properties include triclosan/copolymer, essential oils, chlorhexidine, xylitol and cetylpyridinium chloride. The scope of this article is to address plaque removal.

Ideal Toothbrush and Dentifrice Properties
Toothbrushes are designed for dental plaque removal in as efficacious a manner as possible, without damaging the hard or soft tissues, and dentifrice slurry provides some cleaning ability with a toothbrush.

An ideal toothbrush should effectively and safely remove plaque and deliver agents in the dentifrice to the tooth surface. It should be easy to use, ergonomic and patient-friendly and be able to remove plaque from all surfaces of the tooth, including interstitially. For children, the toothbrush can incorporate design features that help motivate them to brush. An ideal dentifrice should help prevent plaque formation, disrupt plaque and optimize plaque removal. It should also contain agents that help protect the dentition and periodontal tissues; these include agents that prevent demineralization and aid remineralization; prevent and reduce periodontal inflammation and disease; help prevent oral ulcerations, irritations and other oral conditions; and prevent or reduce halitosis. In addition, the toothbrush and dentifrice should be effective.
without damaging the tooth surface or gingivae. Finally, in our esthetically conscious society, a toothpaste that improves esthetics by whitening the teeth through stain removal, or that gives the appearance of whiter teeth, is desirable.

Table 1. Ideal Properties

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<tr>
<td>Disrupt and remove plaque effectively</td>
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<tr>
<td>Reduce plaque</td>
</tr>
<tr>
<td>Prevent and remove stain</td>
</tr>
<tr>
<td>Deliver agents to the tooth surface</td>
</tr>
<tr>
<td>Prevent demineralization</td>
</tr>
<tr>
<td>Aid remineralization</td>
</tr>
<tr>
<td>Prevent and reduce periodontal inflammation</td>
</tr>
<tr>
<td>Prevent oral irritations and ulcerations</td>
</tr>
<tr>
<td>Prevent and reduce halitosis</td>
</tr>
<tr>
<td>Patient-friendly and ergonomic</td>
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**Toothbrushes**

The primary objective of toothbrushing is to safely and effectively remove dental biofilm from all surfaces of the dentition. While patients tend to focus on the buccal and labial aspects of the teeth, particularly the upper anterior teeth, since these are the areas that are visible and easy-to-reach, plaque removal from the lingual and interdental plaque is key; failure to regularly remove dental plaque will result in the development of a mature biofilm. Typically, brushing and interdental cleaning with the adjunctive use of floss or other interdental devices to remove plaque interdentally (where a toothbrush cannot reach or only partially reaches) are recommended for oral hygiene.

Brushing can be achieved using a manual, powered or sonic brush. Manual, powered and sonic brushes are all effective at removing dental biofilm provided they are used appropriately and are well-designed.10,11,12 Robinson et al. conducted a meta-analysis of manual and powered toothbrushes categorized by mode of action, finding that the rotation-oscillation brushes reduced plaque and gingivitis more than the manual brushes, with a 7% reduction in plaque (Quigley-Hein index) and a 17% reduction in bleeding-upon-probing (Ainamo Bay index) after more than three months. It should be noted that one of the criteria was for studies to be 28 days or longer; all studies shorter than this or not meeting other criteria were excluded.13 A small cross-over study submitted in 2006 involved 30 days use of each brush (manual, powered or ultrasonic) in orthodontic patients and a 15-day washout period between use of the different test brushes. Plaque scores were lower on the buccal surfaces with brackets when using the ultrasonic brush. Strep. Mutans levels were lower using the powered or ultrasonic brushing.14 Compliance with oral hygiene and appropriate use of toothbrushes varies15, and other factors may impact the amount of plaque removed with a given effort.

**When used appropriately, manual, powered and sonic brushes can all be effective for dental biofilm removal.**

Historically, for manual brushing patients have been taught the Bass technique and to angle the brush so that the bristles will be at 45 degrees to the sulcus. The Bass technique requires dexterity, patience and knowledge in order to perform satisfactorily. More recent manual brushes have been designed with the bristles configured at varying angles and lengths to overcome the requirement to perform the Bass technique, or with handles and grips that result in the bristles being in a tilted 45 degree angle and help patients brush.

**Figure 1. Manual brushes**

Powered brushes also require patients to master an appropriate technique; however, one advantage of powered brushes in general is their ability to remove a greater amount of plaque in a given period of time than manual brushes. One study found that 75% of dental biofilm was removed in 15 seconds with a rotation-oscillation powered brush; the same amount of plaque removal required twice as long with a manual brush.16 Sonic and powered rotation and rotation-oscillation brushes have been found in other studies to also offer superior plaque removal compared to manual brushes.

**Figure 2. Powered and sonic brushes**
One advantage of powered brushes in general is their potential to remove a greater amount of plaque in a given time.

Zimmer et al. compared two sonic brushes (Sonicare and WaterPik Sonic Speed) with a manual toothbrush in a single-blinded crossover study on 36 teenagers and adults. Each participant sequentially used each type of toothbrush for two weeks, with a two-week washout period between brush types. Both sonic brushes were found to result in superior plaque removal and prevention of gingivitis compared to the manual toothbrush.18 In a six-month, single-blinded study comparing use of a sonic or powered brush (Sonicare and Braun Oral-B) by 66 patients, 54 of whom completed the study, it was found that supragingival plaque removal was greater with the sonic brush. In addition, by six months, the reduction in gingival inflammation reached 31.9% for the sonic brush and 18.1% for the powered brush, and probing depth reductions were 15.8% and 7.2%, respectively.19 Bader and Boyd found a rotary powered brush to be more effective than a sonic brush.20 A recent in vivo single-blinded, randomized crossover study with a sonic brush (Spinbrush Sonic) found 88.9% whole-mouth plaque reduction compared to the control.21

One study compared the volume of dental biofilm and fluoride retention following brushing with a rotation-oscillation, sonic or manual brush or a manual brush plus flossing. Forty-seven subjects were randomized to a sequence of trials with each method and used fluoride or fluoride-free dentifrice with a washout of seven days between tests. Sonic brushing resulted in the least remaining plaque, with a 43% to 65% reduction compared to all other treatments. With respect to fluoride retention, use of a sonic brush resulted in greater fluoride concentration compared to all other treatments. With respect to fluoride retention, use of a sonic brush resulted in greater fluoride retention from the first day, and after a week resulted in 40% greater fluoride concentration than any other treatment, the least effective being manual brushing and flossing (which demonstrated a reduction in fluoride retention on day 1).22

Interdental plaque removal
Interdental cleaning is associated with lack of compliance23,24 and has been reported to have relatively poor efficacy with a number of methods used. Interdental cleaning aids include floss as well as interdental brushes, picks, woodsticks and irrigators.

Floss is known to be difficult for patients to use, which can result in inadequate plaque removal even with compliance. Some studies have found the efficacy of floss to be negligible.

Separate literature reviews using MEDLINE-PubMed and Cochrane database-sourced publications have been conducted to determine the effectiveness of interdental aids as adjuncts for interproximal plaque removal. For flossing, eleven publications met all eligibility criteria. Analysis showed that in the majority of the studies, no additional benefit was seen with the use of floss, and the investigators concluded that dental professionals should determine for individual patients whether recommending floss is useful and if patients can floss adequately. For interdental brushes, nine publications were found to meet all inclusion criteria, with use of interdental brushes shown to remove more interdental plaque than brushing alone, resulting in improvements in plaque and bleeding- upon-probing scores and probing pocket depth.25,26 For woodsticks, seven publications met all inclusion criteria. It was concluded that woodsticks did not reduce the level of interdental plaque or improve gingival indices. They were, however, found to reduce bleeding.27 Finally, a separate publication analysis on oral irrigation found seven publications that met all inclusion criteria. It was found that oral irrigation did not reduce visible plaque compared to brushing alone. Nonetheless, the researchers were able to conclude from the publications that the trend was positive for improvements in gingival health with oral irrigation compared to brushing only (Table 2).28 The American Dental Association recommends using either floss or an interdental cleaner daily.29

A sonic subgingival cleaner (soniPick Sonic Interdental Plaque Remover) with three bristle lengths was introduced as an adjunct to improve plaque removal. In vitro testing found that this device resulted in greater subgingival plaque removal with any of the bristle tip lengths, as measured by removal of artificial plaque from pressure-sensitive paper inserted 3 mm under mock gingivae, compared to use of a manual, multi-tufted, flat toothbrush with the bristle tips at a 45 degree angle at the gingival margin.30 Irrespective of efficacy, each of these techniques requires an additional step.
Table 2. Literature review of interdental plaque removal aids

<table>
<thead>
<tr>
<th>Method</th>
<th>Studies</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Flossing</td>
<td>11 studies</td>
<td>No additional benefit in majority of studies</td>
</tr>
<tr>
<td>Interdental brushes</td>
<td>9 studies</td>
<td>Remove more plaque than brushing alone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improvements in plaque, bleeding-upon-probing scores and probing pocket depth</td>
</tr>
<tr>
<td>Woodsticks</td>
<td>7 studies</td>
<td>Reduced bleeding</td>
</tr>
<tr>
<td>Oral irrigation</td>
<td>7 studies</td>
<td>Positive trends in gingival health</td>
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Compared to manual brushes, powered and sonic brushes have been found to offer superior interdental plaque removal in a number of studies (with the only extra step being a simple change of the brush head to an interdental brush head, for some models). One study found that use of such a brush head in a powered rotation-oscillation brush resulted in superior plaque removal and control of gingivitis compared to manual brushing plus flossing and use of interdental toothpicks (woodsticks).31 Yankell et al. found in in vitro testing that a sonic brush (Sonicare) demonstrated greater ability to access interproximal areas compared to either a powered brush (Braun Oral B) or a manual brush.32 A recent single-blinded, randomized crossover in vivo study with a sonic brush (Spinbrush Sonic) found that its use resulted in plaque reduction in hard-to-reach areas ranging from 69% to almost 98%. The greatest reductions were found in lingual interproximal areas.33 These results are significant given the inability of patients to reach difficult-to-access areas of the dentition.

Orthodontic patients and children

Powered and sonic brushes may offer help to orthodontic patients and children who do not brush for long enough or may have difficulty brushing manually. Comparative studies have been conducted in vitro, in situ and in vivo with orthodontic patients on the use of manual, powered and sonic brushes as well as interdental aids. Sander et al. assessed the ability of sonic and rotating brushes to remove artificial plaque in vitro from plastic surfaces simulating teeth with multibracket appliances. The reduction in plaque was determined using before and after photo analysis. In this study, it was found that brushing efficacy, defined as plaque removal, was dependent not on the type of brush but on the individual brush. The investigators also concluded that longer brushing times and mastery of a proper brushing technique were still required.34 In orthodontic patients, a comparison of manual and sonic toothbrushes, sonic toothbrush plus an electronic interdental flosser, and sonic toothbrush plus manual flossing was documented; while improvements occurred in the first four weeks, the only treatment regimen offering longer-term effects was use of a sonic toothbrush and an electric interdental flosser, mainly attributable to the flosser, and only in patients with poor oral hygiene.35 In another study, use of a sonic toothbrush resulted in a 57% reduction of supragingival plaque in orthodontic patients who had gingivitis, versus 10% for manual brushing.36 Costa et al. also studied plaque and gingival indices for reductions with either manual or sonic/ultrasonic brushes. Both types were found to provide reductions; however, for orthodontic and dental implant patients, a greater reduction was found with sonic brushes.37

For children, the more attractive and easier a brush is to use, the more, in principle, they will be motivated to use the brush. For this reason, children’s manual and powered toothbrush designs have incorporated pop culture characters and names, flashing lights, tunes, and other visual and aural displays aimed at attracting children.

One concern with powered and sonic brushes has been their effect on the shear bond strength of orthodontic brackets. A number of in vitro studies has been conducted concluding that use of powered and sonic brushes did not negatively influence the shear-bond strength of orthodontic brackets. Garcia-Godoy and de Jager, in an in vitro study using orthodontic brackets bonded to the enamel surface of extracted teeth, determined that the shear bond strengths were the same whether manual, sonic or powered brushes were used in a method equivalent to two years of regular use.38 Ultrasound
toothbrushes and rotation-oscillation toothbrushes were also found in in vitro studies to be safe for orthodontic brackets and dental restorations. No significant effect was found on orthodontic brackets with any of the brushes tested.39

**Sonic toothbrushes and mechanism of action**

Sonic toothbrushes utilize the principles of fluid dynamics to accomplish dental biofilm removal. A study assessing the ability of fluid pressure and dynamic shear forces to remove dental biofilm was conducted by Stanford et al. In situ samples were allowed to develop dental biofilm for 16 hours, then removed and tested in vitro for 5, 10 or 15 seconds with the bristles held 2 mm or 3 mm from the surface. After brushing, the residual bacterial count was assessed. Similar testing was performed with another electric toothbrush (Interplak) held 3 mm from the surface of similar samples. Plaque reduction using the sonic brush was 56% to 78% compared to control samples, and no reduction was found using the electric toothbrush 3 mm from the tooth surface. (It should be noted that powered brushes are not intended for use 3 mm from the tooth surface.) The investigators also assessed the results using scanning electron microscopy and concluded that sonic toothbrushes could remove dental biofilm through fluid dynamics when held up to 3 mm from the tooth surface.40

Another study confirmed that using airy bubbles against mature dental biofilm on a solid surface resulted in removal of the biofilm where the bubbles collided with it. The amount removed in a given time was found to vary with the rate of collision of the bubbles against the biofilm and the surface area of the bubbles. The investigators attributed the biofilm removal to fluid dynamic shear forces and determined that a fast bubbly flow could be expected to remove biofilm.41 Parini et al. found that low-velocity flowing bubbles in fluid could remove a film of Streptococcus mutans from a glass surface better than fluid in the absence of bubbles.42

It has been hypothesized that sonic brush-head motion would generate bubbles in a dentifrice so that ultrasound beamed into the slurry would cause the bubbles to expand and contract in a manner that would dislodge the plaque bacteria adherent to the tooth surface. Pitt conducted an experiment in which a submerged biofilm of Streptococcus mutans was subjected to sonic energy between 80 and 1000 Hertz. It was found that the intensity of the acoustics influenced biofilm removal when convective fluid flow was present, but that removal was negligible without this fluid flow (up to 2% over 10 minutes). Introducing gas bubbles into the fluid resulted in almost 100% biofilm removal with intensive sonic activity.43 Pitt et al. concluded from their in vitro study on dental biofilm and sonic acoustic waves that the dynamics of fluid flow with bubbles can be expected to remove dental biofilm in vivo and recommended maximum fluid velocity.44 It has also been found that bubbles are most effective when they collide with the biofilm at an angle of between 5 and 45 degrees.45

Busscher et al. concluded that a high percentage of bacterial pairs that were adherent to each other were removed by noncontact sonic brushing at a distance of up to 6 mm from the surface on which the bacteria had colonized.46 In a similar study, electric, manual and sonic brushes were compared for their ability to remove adhering and nonadhering streptococci and actinomycetes. It was found that sonic brushes removed almost all adhering bacterial pairs, while manual and powered brushes did not and removed less of the coadhering than the nonadhering bacteria. It was also found that the presence of fluoride was immaterial to the amount of bacteria removed by any of the tested brushing methods.47

Figure 6. Action of sonic toothbrushes

A recent literature review by Stoodley et al. on the mass transport of agents to the biofilm and teeth found that dental biofilm influences the delivery of caries preventives, specifically fluoride. It was found that increasing the rate of flow in a fluid overlying biofilm resulted in increased delivery of the agent to penetrate and cross the layer of biofilm.48
Dentifrices

Plaque reduction can be achieved by the mechanical activity of toothpaste slurry in combination with a toothbrush and/or by using chemotherapeutic agents to reduce the volume of plaque. Soft or ultra-soft toothbrush bristles are recommended. Studies have variously demonstrated greater or lesser abrasivity with manual or powered brushes, notably on eroded (demineralized) dental hard tissue.49,50 However, it was found that, specifically with regard to erosion, the abrasiveness of toothpaste slurry was more predictive of abrasion than the stiffness of the filaments of manual brushes.51 The abrasives in modern dentifrices consist of fine, rounded particles that gently help remove dental biofilm and stain. Frequently used cleaning agents in dentifrices include baking soda (sodium bicarbonate), calcium carbonate and calcium phosphate. The radioactive dentin abrasivity (RDA) of current dentifrices is typically in the range of 70 to 100 RDA, with baking soda offering a lower RDA of 30 to 40. Non-baking soda dentifrices with an RDA of 70 to 110 are safe and effective for dental biofilm and stain removal when used appropriately with a toothbrush, as are baking soda dentifrices with a lower RDA of 30 to 40. While it has low abrasivity, baking soda has excellent cleaning ability even when compared to higher-RDA agents.52 Clinical trials with use of a manual brush with baking soda dentifrices at concentrations ranging from 20% to 65% demonstrated baking soda’s ability to remove plaque. Increased plaque reduction was found with baking soda dentifrice, with higher concentration of baking soda resulting in more plaque reduction. In addition, for all concentrations of baking soda, incremental plaque reduction was found on the harder-to-reach-and-brush proximal and lingual surfaces. It is believed that cleaning power rather than abrasivity is an important factor in the effectiveness of baking soda. Baking soda readily dissolves intraorally and is known to impart a “clean” feeling. The investigators suggested that the large, soft crystals of baking soda, with a lower RDA than a typical fluoride dentifrice, may displace plaque more than other dentifrices or may affect the biofilm’s polysaccharide matrix, or the baking soda may disrupt bacterial adhesion by blocking calcium bonds involved in co-adhesion and simultaneously release calcium dioxide gas.53

The inclusion of baking soda in dentifrices has been found to benefit plaque removal, especially in hard-to-reach areas.

Another option that has been investigated is intraoral recharging with liquid toothpaste onto the brush head during brushing (the IntelliClean System). This was found in a small, single-blinded, randomized crossover study to result in a greater reduction of colony-forming bacteria and gram-negative anaerobes compared to conventional brushing without redosing, and also an increase in the amount of surfactant present in the gingival crevicular fluid.54 Interestingly, Lea et al. found that the load (0, 1 or 2 Newtons) and toothpaste used for powered toothbrushing significantly influenced the bristle vibration of the brush. The study used scanning laser vibrometry to determine the effects of sonic and other powered brushes (Oral-B Sonic Complete; Oral-B Professional Care 8000 Series; Sonicare Elite and UltraSonicex). For all brushes except the Sonicare, the displacement amplitudes of the bristles were affected by a load of 1 Newton without use of toothpaste; with toothpaste, all brushes were affected. This could be expected to influence the performance of powered brushes.55

Education

It is not uncommon for patients to attempt to use powered and sonic brushes similarly to the way they use manual brushes, moving them in a horizontal manner across the teeth and disregarding the movement generated by power, and applying too much load (which would typically result in stalling). Patients may say “I didn’t like the electric toothbrush and couldn’t get used to it” for that very reason. The importance of educating patients on the use of any type of toothbrush, not just manual brushes, was underscored in a study by Renton-Harper et al. They found that un instructed de novo use of two different rotation-oscillation brushes and one manual brush resulted in no difference in plaque reduction during the early period of usage.56 Whether a manual, powered or sonic brush is recommended for a given patient, oral hygiene instruction and instructions on use of the toothbrush are required.

Summary

Since prehistoric times, man has devised a variety of methods to clean and whiten the teeth. Toothbrushes are designed for dental plaque (biofilm) removal in as efficacious and safe a manner as possible, with dentifrices offering cleaning ability when used with toothbrushes, as well as delivery of preventive and other agents. When used appropriately, manual, powered and sonic brushes can all be effective for dental biofilm removal. One advantage of powered and sonic brushes in general is their ability to remove a greater amount of plaque in a given period of time and to aid interdental cleaning. Sonic brushes have been shown to have the ability to also remove dental biofilm when held a slight distance from the tooth surface and to help in the delivery of dentifrice agents.

References

3. Miller WD. The microorganisms of the human mouth: The local and general which are caused by them. The SS White Dental Manufacturing Company, Philadelphia, 1890.
21 Data on file.
35 Data on file.


44 Ibid.


Author Profile

Fiona M. Collins, BDS, MBA, MA
Dr. Fiona M. Collins has authored and presented CE courses to dental professionals and students in the US and internationally. She is a past-member of the Academy of General Dentistry Foundation Strategy Board, has been a member of the British Dental Association, the Dutch Dental Association, the American Dental Association, the International Association for Dental Research, and is a member of the Organization for Asepsis and Safety Procedures. Dr. Collins earned her dental degree from Glasgow University and holds an MBA and MA from Boston University.

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1. First powered and later sonic toothbrushes were introduced in_________.
   a. the second half of the 19th century
   b. the first half of the 20th century
   c. the second half of the 20th century
   d. none of the above

2. Seminal research in the_________ by Loe and others definitively demonstrated the role of plaque as a bacterial ecology involved in the development of periodontal disease.
   a. 1930s and 1940s
   b. 1940s and 1950s
   c. 1960s and 1970s
   d. all of the above

3. Supragingival plaque contains more aerobic bacteria and acts as a bacterial reservoir for subgingival plaque.
   a. True
   b. False

4. In mature biofilm,_________.
   a. the biofilm structure consists mainly of a polysaccharide matrix containing voids as well as nonvital material of bacterial origin
   b. the bacteria are enveloped by the biofilm structure
   c. no aerobic bacteria are found
   d. a and b

5. Agents that have antibacterial properties include triclosan/copolymer, essential oils, chlorhexidine, xylitol and cetylpyridinium chloride.
   a. True
   b. False

6. Reducing, removing or changing the biofilm is carried out_________.
   a. to try to reduce the bacteria associated with caries and periodontal disease
   b. to freshen the breath
   c. for social acceptance
   d. all of the above

7. An ideal dentifrice should help prevent plaque formation, disrupt plaque and optimize plaque removal.
   a. True
   b. False

8. An ideal toothbrush should_________.
   a. effectively and safely remove plaque from all surfaces of the tooth
   b. be easy to use, ergonomic and patient-friendly
   c. deliver agents in the dentifrice to the tooth surface
   d. all of the above

9. Manual, powered and sonic brushes are all effective at removing dental biofilm provided they are used appropriately.
   a. True
   b. False

10. Historically, patients have been taught the_________ and to angle the brush so that the bristles will be at 45 degrees to the sulcus.
    a. Postillo technique
    b. Bass technique
    c. Base technique
    d. Bassist technique

11. More recent manual brushes include designs with handles and grips that result in the bristles being in a tilted 45 degree angle and help patients brush.
    a. True
    b. False

12. Robinson et al. found from their meta-analysis of studies longer than 28 days in duration that rotation-oscillation brushes reduced plaque and gingivitis more than manual brushes.
    a. True
    b. False

13. One study found that_________ of dental biofilm was removed in_________ seconds with a rotation-oscillation powered brush; the same amount of plaque removal required twice as long with a manual brush.
    a. 65%; 15
    b. 75%; 10
    c. 75%; 15
    d. 85%; 15

14. Zimmer et al. compared two sonic brushes with a manual toothbrush in a single blinded crossover study on 36 teenagers and adults and found the sonic brushes to remove more plaque compared to the manual toothbrush.
    a. True
    b. False

15. With respect to fluoride retention, use of a_________ brush resulted in greater fluoride retention than use of a_________ brush in one study.
    a. powered; sonic or manual
    b. manual; powered or sonic
    c. sonic; powered or manual
    d. none of the above, all were equal

16. Berchier et al. found in a meta-analysis that no additional benefit was seen with the use of floss, and the investigators concluded that dental professionals should_________.
    a. recommend the use of floss for all patients
    b. determine for individual patients whether recommending floss is useful and if patients can floss adequately
    c. not recommend flossing
    d. none of the above

17. Yankell et al. found in in vitro testing that a sonic brush demonstrated greater ability to access interproximal areas compared to either a powered brush or a manual brush.
    a. True
    b. False

18. Children’s manual and powered toothbrush designs have incorporated pop culture characters and names, flashing lights, tunes, and other visual and aural displays aimed at attracting children.
    a. True
    b. False

19. Powered brushes have been found to be safe for orthodontic brackets.
    a. True
    b. False

20. Sonic toothbrushes utilize the principles of_________ to accomplish dental biofilm removal.
    a. hydrotherapy
    b. fluid dynamics
    c. electromagnetic forces
    d. all of the above

21. Using scanning electron microscopy, Stanford et al. concluded that sonic toothbrushes could remove dental biofilm through fluid dynamics_________.
    a. only when in contact with the tooth surface
    b. when held at a distance of up to 1 mm from the tooth surface
    c. when held at a distance of up to 2 mm from the tooth surface
    d. when held at a distance of up to 3 mm from the tooth surface

22. Increasing the rate of flow in a fluid overlying biofilm has been found to result in increased delivery of the agent to penetrate and cross the layer of biofilm.
    a. True
    b. False

23. Specifically with regard to erosion, the abrasiveness of toothpaste slurry has been found by investigators to be more predictive of abrasion than the stiffness of the filaments of brushes.
    a. True
    b. False

24. It is believed that cleaning power rather than abrasivity is an important factor in the effectiveness of baking soda.
    a. True
    b. False

25. Intrarotational brushing with liquid toothpaste onto the brush head during brushing has been found to result in a greater reduction of colony-forming bacteria and an increase in the amount of surfactant present in the gingival crevicular fluid.
    a. True
    b. False

26. It has been hypothesized that baking soda may affect the biofilm’s polysaccharide matrix, or may disrupt bacterial adhesion by blocking calcium bonds.
    a. True
    b. False

27. Whether a manual, powered or sonic brush is recommended for a given patient, oral hygiene instruction should be provided on use of the toothbrush.
    a. True
    b. False

28. Uninstructed de novo use of rotation-oscillation and manual brushes was found in one study to result in no difference in plaque reduction during the early period of usage.
    a. True
    b. False

29. Frequently used cleaning agents in dentifrices include baking soda (sodium bicarbonate), calcium carbonate and calcium phosphate.
    a. True
    b. False

30. The American Dental Association recommends using either floss or an interdental cleaner daily.
    a. True
    b. False
# Toothbrush technology, dentifrices and dental biofilm removal

**Educational Objectives**

1. Provide a brief overview of dental biofilm development and bacterial growth.
2. Describe the attributes of ideal toothbrushes and dentifrices.
3. Know the considerations involved in selecting a manual, powered or sonic brush.
4. Understand the considerations involved in dentifrice selection with respect to plaque removal.

**Course Evaluation**

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Rating Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Were the individual course objectives met?</td>
<td>Objective #1: Yes No Objective #3: Yes No</td>
</tr>
<tr>
<td>2. To what extent were the course objectives accomplished overall?</td>
<td>5 4 3 2 1 0</td>
</tr>
<tr>
<td>3. Please rate your personal mastery of the course objectives.</td>
<td>5 4 3 2 1 0</td>
</tr>
<tr>
<td>4. How would you rate the objectives and educational methods?</td>
<td>5 4 3 2 1 0</td>
</tr>
<tr>
<td>5. How do you rate the author's grasp of the topic?</td>
<td>5 4 3 2 1 0</td>
</tr>
<tr>
<td>6. Please rate the instructor's effectiveness.</td>
<td>5 4 3 2 1 0</td>
</tr>
<tr>
<td>7. Was the overall administration of the course effective?</td>
<td>5 4 3 2 1 0</td>
</tr>
<tr>
<td>8. Do you feel that the references were adequate?</td>
<td>Yes No</td>
</tr>
<tr>
<td>9. Would you participate in a similar program on a different topic?</td>
<td>Yes No</td>
</tr>
<tr>
<td>10. If any of the continuing education questions were unclear or ambiguous, please list them.</td>
<td></td>
</tr>
<tr>
<td>11. Was there any subject matter you found confusing? Please describe.</td>
<td></td>
</tr>
<tr>
<td>12. What additional continuing dental education topics would you like to see?</td>
<td></td>
</tr>
</tbody>
</table>

**Mail completed answer sheet to:**

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**A Division of PennWell Corp.**,  
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**PLEASE PHOTOCOPY ANSWER SHEET FOR ADDITIONAL PARTICIPANTS.**

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