What constitutes **new technology?**

**Water flossing revisited**

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**Dental school graduates** from the 1960s, 1970s and 1980s have probably heard of the Waterpik Water Flosser, but ask them to tell you what it does or whether it is effective, and they generally either do not know or else believe that it is not very effective at removing plaque. Graduates after 2000 may not even know what this technology is or what it does.

The hydrodynamic therapy action of an oral irrigator is not a new concept to the dental profession. The innovations lie in our improved understanding of the pathogenesis of oral disease, the role of plaque as a biofilm, and applying clinical evidence to make clinical decisions. Recent and ongoing research and applications have shown how the oral irrigator is a self-care product that warrants attention in the 21st century.

The original oral irrigator (known as a dental water jet, and more recently a water flosser) was developed by Dr Gerald Moyer, a Fort Collins, Colorado, dentist, and Dr John Mattingly, a hydraulic engineer at Colorado State University (Figs. 1 & 2). Moyer was looking for a product that could clean areas of the oral cavity that are not readily assessable by traditional methods such as toothbrushing and dental flossing. Together they designed a device that provided a controllable pulsating water stream for the targeted delivery of a solution and the self-cleansing of inaccessible areas by the patient. The current terminology, "water flosser," will be used throughout this article.

The water flosser delivers a pulsating stream of water or other solution that results in successive compression and decompression phases of the gingival tissue (Fig. 3). The solution strikes the tooth at the gingival margin, the *impact zone*, and is deflected subgingivally and interdentally, the *flushing zone* (Fig. 4). It was anecdotally believed that the water flosser was simply flushing out debris without removing plaque or having a positive impact on oral health. However, as early as 1969, studies were reporting significant plaque and calculus reduction in groups using the water flosser. More recently, significant plaque reduction has been demonstrated in studies with subjects with mild to moderate gingivitis, periodontitis, orthodontic appliances and diabetes.

The above studies used the traditional validated plaque indices, which provide a 1-D perspective; the presence of plaque is determined by disclosing solution. In 2009, Dr Bill Costerton and his team took this a step further to evaluate the removal of biofilm from the tooth surfaces using a water flosser. This *ex vivo* study utilised periodontally involved teeth that were extracted and inoculated with saliva to grow new biofilm over existing deposits. The teeth were treated with a water flosser for three seconds at medium pressure and then prepared and viewed under a scanning electron microscope (SEM). The removal of biofilm was evident as seen in Figures 5a & b, with almost 100 per cent removal from treated areas.

**Self-care technology**

Brushing is considered the first line of defense for maintaining good oral hygiene. Some power brushes are quite sophisticated; they help the user know when to change quadrants, when the two-minute brushing time is reached, and how the user is doing. They offer power selections that include cleaning action, massaging action or a gentle stroke for sensitive areas. There are different bristle configurations, brush-head sizes and designs, and angles and contours for cleaning the line angles, pits, fissures and posterior regions.
Careful analysis determines the individual recommendation of the right toothbrush for each patient. Toothbrushing targets only supragingival plaque, however. Numerous studies have indicated that significant plaque can remain after brushing. And all toothbrushing, whether power or manual, fails to clean interdentally, an area that the patient must address separately. It can be argued that interdental cleaning should be the first step, since that is the area where the risk of periodontal disease and infection is higher.

While dental floss is not a state-of-the-art technology, it is still considered the first choice for interdental cleaning among dental professionals. A major problem is that patients do not like to floss, tend to avoid the practice, and often demonstrate a technique that is less than adequate. Dentists and dental hygienists need to find alternative methods to accomplish interdental cleaning.

There are many products available that are designed or marketed to clean between the teeth and to motivate individuals to perform this task; how effective are they, and can they be used easily by most individuals? Interdental brushes have been shown to reduce plaque and gingivitis, but require a large enough embrasure space for access. Even the smallest designs may not fit into all interdental spaces or effectively clean the proximal surface concavities of the teeth. Floss holders are designed to make it easier to use floss, but do not eliminate all the dexterity challenges that patient’s face. Wooden sticks, rubber tips and toothpicks are not interdental cleaners.

The recent advent of “water flosser” as a descriptor is based on clinical findings from three studies (Table 1). The first study in this group was published in 2005, and demonstrated that the water flosser with a classic jet tip and either a power toothbrush or a manual toothbrush were significantly better at reducing bleeding and gingivitis when compared with a manual toothbrush and string floss. This was followed by a 2008 study that compared the efficacy of a water flosser with an orthodontic tip and a manual toothbrush to a manual toothbrush and string floss in 11- to 17-year-olds with fixed orthodontics. The water flosser group had significantly reduced plaque and bleeding over four weeks compared with the string floss group. The most recent study published in 2011 found that the water flosser with either the classic jet tip or a tip with individual bristle tufts was up to twice as effective as dental floss in as little as two weeks. The differences between the tips and floss were even more dramatic at four weeks.

How does a water flosser stand out from other self-care products?

The documented research on water flossers is extensive, spanning over 50 years. These studies were designed to address new developments in dentistry. The link between periodontal disease and systemic disease has been studied extensively and reported in the literature; some associations are very strong while others are less conclusive. It is well known that people living with diabetes have an increased risk of periodontal disease that starts earlier and leads to more severe complications in both children and adults. Controlling oral inflammation is important and may be more difficult to accomplish than in non-diabetic individuals. A water flosser was compared with traditional oral hygiene in a cohort of Type 1 or Type 2 diabetic subjects over three months. The group that used the water flosser has significantly better improvements in gingivitis, plaque, and bleeding on probing compared with the group that continued with traditional oral hygiene methods.

Figs. 3 & 4. Before and after using a water flosser on medium pressure for three seconds:
- Biofilm on tooth under SEM (a);
- 99.9% removal of biofilm from tooth surface under SEM (b).
Studies between 1990 and 2000 continued to show the benefits of a water flosser in reducing bleeding, gingivitis and plaque.18–21 Some of the researchers proposed that the significant results from using a water flosser were associated with a change in the host response. With a new focus on host inflammatory modulation, a randomised controlled study was conducted comparing routine oral hygiene with routine oral hygiene plus a water flosser.5 The investigators used traditional bleeding, gingivitis and plaque indices, but also measured pro-inflammatory mediator interleukin-1ß (IL-1ß) and prostaglandin E2, anti-inflammatory mediator interleukin-10, and interferon-gamma, a cytokine key in killing bacteria. The study results demonstrated that the water flosser group had a significant reduction in plaque, bleeding and gingivitis indices plus probing depth compared with the control group. The cytokine profile was changed in the water flosser group, showing a decrease in the pro-inflammatory mediators and an increase in the anti-inflammatory mediators. Since the measurements were taken from gingival crevicular fluid, the researchers prevented a dilution effect by waiting eight hours after the subjects had used the water flosser.

Key findings include:

- Both groups had reduced plaque biofilm compared with baseline, but only the water flosser group had decreased inflammatory mediator IL-1ß.
- The reduction of bleeding on probing correlated with the reduction of IL-1ß not the reduction of plaque.
- The selective reduction of pro-inflammatory mediators demonstrates a modulation effect

In the diabetes study mentioned above, the investigators measured the serum cytokine profile of the subjects. Over the three months of the study, the test group that used the water flosser showed significant reductions in IL-1ß and prostaglandin E2.7

**Conclusion**

The water flosser has an extensive body of evidence that demonstrates its safety and efficacy with multiple patients and different oral care needs, for example gingivitis, orthodontics, implants, crowns and bridges, individuals in periodontal maintenance programmes, and particularly those with good oral health. Studies in the past decade have addressed new areas such as host response, impact on systemic health, and the effect on biofilm at the microscopic level. The water flosser has the ability to provide individuals with an easy and effective way to maintain good oral health by accessing the areas that are not readily reachable and cleansable by traditional methods. Not all oral irrigators, dental water jets or water flossers have the same combination of pulsations and pressure. The overwhelming majority of studies have been done using the Waterpik Water Flosser. Dental professionals need to evaluate the evidence for each specific product, as studies are not transferable between technologies and manufacturers.

**Editorial note:** A complete list of references is available from the publisher. Photographs courtesy of Water Pik, Inc.

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### Table 1

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
<th>Design</th>
<th>No. of subjects</th>
<th>Products used</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnes et al.</td>
<td>Comparison of irrigation to floss as an adjunct to toothbrushing: Effect on bleeding, gingivitis, and supragingival plaque</td>
<td>RCT Parallel Examiner Blind 4 weeks</td>
<td>105 (10 subjects across the groups had to be dismissed owing to illness, antibiotic use or corticosteroid use)</td>
<td>Waterpik Water Flosser (WP-60) with traditional jet tip and water (WF); Oral-B-35 manual toothbrush (Procter and Gamble, MT); Waterpik Sensonic Toothbrush (SR-700, PT); Reach floss, unflavoured, waxed (Johnson and Johnson, FL); Crest Cavity Control toothpaste (Procter and Gamble, MT)</td>
<td>MT + FL</td>
</tr>
<tr>
<td>Sharma et al.</td>
<td>Effect of a dental water jet with orthodontic tip on plaque and bleeding in adolescent patients with fixed orthodontic appliances</td>
<td>RCT Parallel Examiner Blind 4 weeks</td>
<td>106 (1 subject withdrew because he did not want to floss)</td>
<td>Waterpik Ultra Water Flosser (WP-100) with orthodontic tip and water; Oral-B-35 manual toothbrush; Reach floss, unflavoured, waxed; GUM Eez-Thru floss threaders (Sunstar Americas); Crest Cavity Control toothpaste</td>
<td>MT + FL</td>
</tr>
<tr>
<td>Rosema et al.</td>
<td>The effect of different interdental cleaning devices on gingival bleeding</td>
<td>RCT Parallel Examiner Blind 4 weeks</td>
<td>108 (2 subjects withdrew because of scheduling conflicts, 1 moved and 1 withdrew for personal reasons)</td>
<td>Waterpik Ultra Water Flosser (WP-100) with standard jet tip (S) or prototype tip (P) with 3 bristle tufts; Reach floss, unflavoured, waxed; Oral-B Indicator 35 manual toothbrush; Everclean fluoride toothpaste (HEMA, Netherlands)</td>
<td>MT + WF (S)</td>
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**Table 1:** Overview of studies comparing water flosser to string floss. (Reprinted with permission from the Compendium of Continuing Education in Dentistry.)