A novel power toothbrush with multi-directional, triple zone cleaning technology

AGNIESZKA MIELCZAREK, DDS, PHD, MALGORZATA KLUKOWSKA, DDS, PHD, EVA KAISER, PHD, ULRICH STOERKEL, PHD, CHRISTIAN MANDL, PHD, PAT WALTERS, RDH, MSDH, MSOB & PAUL WARREN, LDS

ABSTRACT: Purpose: Numerous laboratory and clinical studies have proven that certain power toothbrush technologies are more effective in removal of dental plaque and reduction of gingivitis than regular manual toothbrushes. Regardless of this evidence, there is still a large group of individuals who prefer the experience of a manual-like toothbrush. Recently a novel multi-directional power brush has been developed as an alternative for those people who favor the traditional size and shape of a manual toothbrush and prefer the manual brushing technique, but would benefit from the greater cleaning efficiency of the power brush. **Methods:** This unique multi-directional power toothbrush with triple-zone cleaning technology has been tested in multiple clinical trials. This special issue introduces the technical features of the brush and presents four clinical investigations conducted with this power toothbrush versus manual and sonic controls. **Results:** The studies described in this issue demonstrate the superior efficacy of the multi-directional brush in plaque and gingivitis reduction relative to control brushes, even in the hard-to-reach interdental spaces and marginal areas. (*Am J Dent* 2012;25 Sp Is A:3A-9A).

CLINICAL SIGNIFICANCE: Dental professionals should consider this novel multi-directional power brush for patients who prefer a manual toothbrush experience but need improved plaque control and gingival health.

✉: Dr. Malgorzata Klukowska, Procter & Gamble Health Care Research Center, 8700 Mason-Montgomery Road, Mason 45040, OH, USA. E-✉: klukowska.m@pg.com

Introduction

Fifty years ago, electric ('power') toothbrushes were novel and not widely available. Users were in the minority, and many found the toothbrush models to be bulky, inefficient and technically unreliable. For these reasons many consumers returned to their manual toothbrush and dental professionals did not routinely recommend or endorse power toothbrushes for general use. Several decades later, however, the power toothbrush has evolved dramatically in appearance, functionality, and efficiency and has firmly established a prominent position in mainstream consumer oral products. A 2011 industry analysis estimated that at least one-third of all toothbrush expenditures were on power toothbrushes in the United States, underscoring their burgeoning popularity.[1] Both consumers and clinicians are increasingly choosing and recommending power toothbrushes for their thorough cleaning ability, ease of use, and – with some brushes – enhanced compliance due to features such as built-in timers and pressure sensors.

An impressive body of scientific evidence supports the perception that some power toothbrushes control plaque and gingivitis better than their manual counterparts. Numerous independent, peer-reviewed in vitro and clinical investigations have confirmed that certain power toothbrush technologies are indeed more efficacious in removing dental plaque as well as reversing and controlling gingivitis, compared to their manual counterpart.[2-6] A widely-cited 2004 report,[7] updated in 2011,[8] from the independent Cochrane Collaboration concluded that among all types of marketed power brushes, only those with an oscillating-rotating mode of action reduced plaque and gingivitis more effectively than a manual toothbrush. This conclusion was derived from their systematic review and meta-analysis of 42 studies involving approximately 3,800 subjects in both short and longer-term trials. The long-known association between suboptimal dental plaque removal and periodontal disease, coupled with newer research linking periodontal disease to adverse systemic outcomes, validates the importance of offering consumers superior plaque removal tools to aid in their quest for both oral and whole-body health.[9-13]

In spite of the benefits, consumer research has shown that a segment of adults has not taken advantage of the proven cleaning efficacy of power brushes because some favor the larger head size and feel of their customary manual toothbrush. Additionally, many value their manual brushing 'experience': a predisposition to the amount of toothpaste customarily applied, the ability to brush several teeth at once, and a manual brushing stroke not consistent with most power toothbrushes. In 2000, Beals et al[14] reported that the use of a simple horizontal stroke predominated (69%) in two observational brushing studies of videotaped adults, confirming other research.[15,16] Furthermore, it has been estimated that over 90% of adults employ their personal brushing method, which is generally a "scrub" method.[17,18] Unfortunately, inadequate brushing technique, insufficient brushing duration, and lack of interproximal cleaning have been found in many investigations to be the norm for a majority of manual toothbrush users.[19-25] High global levels of gingivitis, periodontitis, and interproximal caries testify to the fact that many consumers are lacking the skill and/or motivation to adequately and consistently remove or disrupt enough pathogenic plaque (particularly in the hard-to-clean regions) to stave off dental/oral disease using solely a standard, flat-trimmed toothbrush and their usual brushing method.[26-29] While clinicians often prescribe twice daily, 2-minute oral hygiene sessions that include flossing, research reveals that participants regularly skip interproximal cleaning, overestimate brushing durations, and fail to achieve plaque-free tooth surfaces through their normal efforts.[20,21,30-34] Longer and

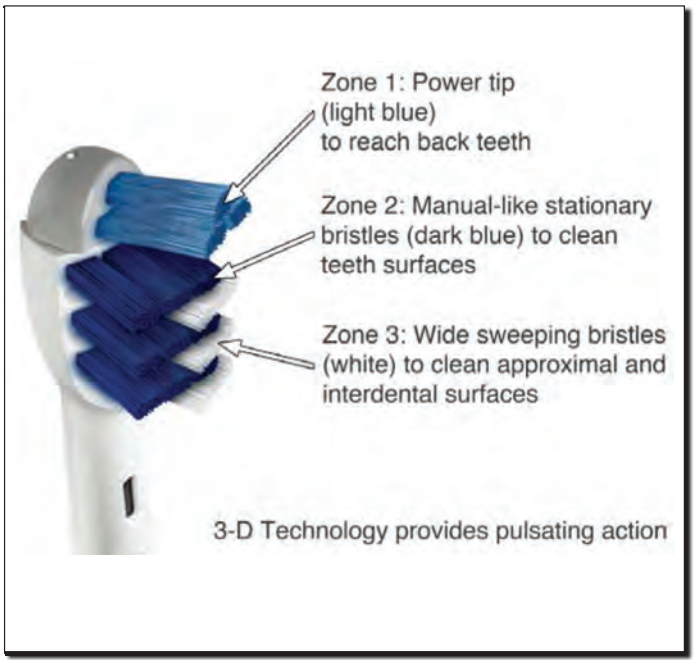

Fig. 1. TriZone multi-directional cleaning technology.

more skilled brushing still remains the ideal, but behavioral modification with respect to changing manual toothbrushing habits is notoriously hard to achieve and sustain.[20,23] A more realistic strategy for enacting better cleaning may be found through advances in toothbrush design to maximize plaque removal, allowing the individual to achieve oral health improvements without having to significantly alter their existing routines such as their personal brushing technique.

Oral-B[a]: Recognized leader in toothbrush innovation

Since its inception in 1950 by Dr. Robert Hutson, a California periodontist, Oral-B's unparalleled record of delivering cutting-edge solutions for better oral health has reflected continuing innovation in the product development of high-performing toothbrushes for the most thorough cleaning. In fact, no other manufacturer has a longer history in the design, research, development, and marketing of manual and power brushes. The first multi-tufted, flat-trim toothbrush with end rounded bristles became the standard against which other brushes were compared. The development of "Indicator bristles" helped consumers recognize when to change their toothbrush thus ensuring optimal performance. The introduction in 1999 of a manual toothbrush with "criss cross" bristles was researched and developed to compensate for inadequate brushing technique.[14] It was designed to provide the best possible interproximal cleaning and clean hard-to-access areas while allowing consumers to maintain their preferred brushing habits.

In the early 1990s, the Oral-B Plaque Remover was introduced. This was the first toothbrush to feature the oscillating-rotating mode of action and the prophylaxis-inspired small round brush head, now confirmed in over 90 clinical studies to provide superior cleaning efficacy.[35] Over the years, a series of advances including the addition of a visible 2-minute timer, high frequency pulsating movement (Oral-B 3D Plaque Remover, 1998) and later increased oscillations and pulsating frequencies culminated in the premium Oral-B Professional Care Smart Series with SmartGuide class of brushes. Recognizing that motivation and compliance for tooth brushing is critical, the SmartGuide wireless display technology encourages the consumer to become more involved in their brushing experience. Oral-B's commercially-available family of power brushes now encompasses numerous distinct power brush offerings to meet the unique needs and wants of individual consumers with differing preferences.

Why a new power toothbrush?

The 'best' toothbrush is the one the individual will regularly use and enjoy. With this in mind, researchers at Oral-B sought to accommodate a segment of individuals who may or may not be proficient brushers but nonetheless are unwilling to part with their manual brush. These consumers like the manual brush head characteristics and want to keep their familiar brushing technique, and have not adapted to the small brush head and tooth-specific focused cleaning mechanism of most marketed power brushes. Oral-B undertook an extensive research and development program to develop a new power brush that would deliver the brush head and brushing experience this segment of consumers prefer without sacrificing efficacy. A review of exclusive attributes of this recently launched power brush, along with a summary of the supporting pre-clinical and clinical research establishing its effectiveness and consumer acceptance, is outlined below.

NOVEL MULTI-DIRECTIONAL POWER BRUSH

This novel brush, marketed as Oral-B TriZone[a] or Oral-B Deep Sweep/TRICLEAN[a] models in the United States, is characterized by its unique, multi-directional movement derived from the three distinct brush zones, which collectively contain over 2,000 bristles. Each zone collaboratively helps to provide improved plaque removal in three different intraoral regions (Figs. 1, 2).

Zone 1: The power tip for hard-to-reach back teeth - Designed to reach the posterior teeth and anterior lingual surfaces, this moving "toe" features dynamic forward-angled bristles in a multi-tuft design that sweep wide to allow more bristle action for additional access to the interproximal areas. The light blue bristles of the power tip are Indicator filaments which fade over time to signal to the user that it is time to replace the brush head (Fig. 1).

Zone 2: The manual-like stationary bristles for thorough cleaning of the tooth surface - These dark blue bristles are positioned in alternating rows with the white moving interdental rows. Their movement is directed by the manual action of the user, as is the case with a manual toothbrush, allowing the user to control the brushing motion. With the 3-D model, these bristles have an additional pulsating action (Fig. 1).

Zone 3: The wide sweeping-pulsating bristles for interdental cleaning - Moving interdental tufts (white, Fig. 1) work synergistically with the stationary bristles. The result is that the alternating tuft pattern and length places filaments in the critical approximal regions, and bristles sweep perpendicular to manual brushing motion, enabling interdental spaces to be cleaned thoroughly.

The Oral-B power brush is notably distinct as the only power brush to feature the triple-zone cleaning technology. Its

Fig. 2. Oral-B TriZone or Oral-B Professional Deep Sweep + SmartGuide TRICLEAN 5000 (United States).

brush head resembles a manual toothbrush but has multi-directional movement for enhanced plaque removal. Its inventive multi-directional movements are delivered by 7,600-8,800 direction changes per minute, depending on the model, creating shearing forces that combat the tenacity and stickiness of plaque biofilm for excellent cleaning efficacy. Enhancing the effect of premium models is the simultaneous 3-D action provided by 40,000 pulsations to disrupt dental plaque as a precursor to the sweeping action. Integrating these two technologies in the novel multi-directional power brush in a model that would be embraced by manual brush devotees was the result of extensive design modifications and robust laboratory testing, and further, drew inspiration from the documented plaque removal effectiveness of certain other power brush technologies with combined movements. The Oral-B Triumph brush, for example, which employs the oscillating-rotating mode of action in tandem with 3-D pulsating movement, has been consistently shown in independent clinical testing to provide superior plaque removal benefits versus both sonic and manual control toothbrushes.[36-42] The new Oral-B multi-directional power brush presented in this special issue shares the same drive system as Oral-B's popular oscillating-rotating brushes, but the bristle configuration and movement are markedly different.

The unique brush head is patterned after a manual counterpart in appearance i.e. the brush head size, brush head shape

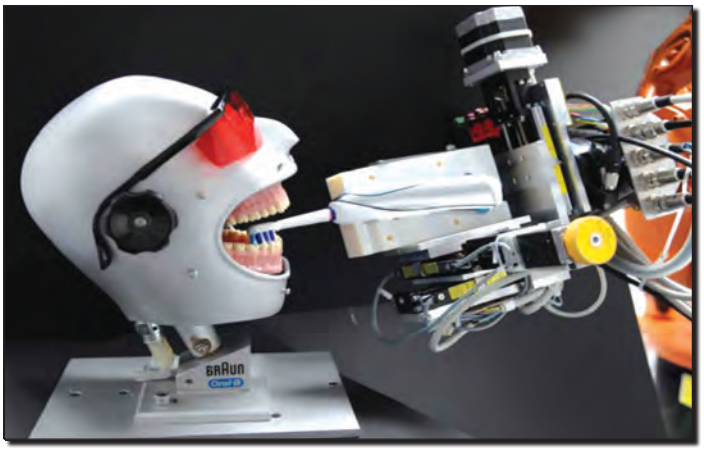

Fig. 3. Robot testing simulates consumer toothbrushing while controlling variables.

and brush head topography, but is smaller to provide good posterior access while allowing paste consumption comparable to manual brushes. It also covers an area 43% wider than an ADA manual toothbrush head during toothbrushing via its wide sweeping bristles. Like the Oral-B Professional Smart Series, the novel multi-directional brush is available with Oral-B's proprietary wireless SmartGuide technology to provide real-time feedback for monitoring brushing pressure, brushing time, charging status, and more.

Evidence of effectiveness: From Prototype to Launch

Laboratory testing

Oral-B's comprehensive consumer research phase demonstrating the unmet need marked the beginning of the vision for an innovative brush with unique specifications. The next stage of development involved the exploration of copious design routes in the development of the most efficacious yet 'manual user-friendly' forerunners. Winning prototype models were then subjected to rigorous laboratory testing before promoting the final forerunners to consumer and clinical evaluations. Oral-B incorporates in vitro robot testing in its investigation of the cleaning performance of new products early in the product development process prior to brush scale up for human assessment (Fig. 3). The robot system is programmed to simulate consumer use of manual or power toothbrushes under standardized and controlled conditions for objectivity, and control of potentially confounding variables such as brushing technique, time, and the 'novelty effect'. The robot test method employed by Oral-B has been clinically evaluated and published, and results show the method can be of value with respect to predicting clinical outcomes.[43,44]

Clinical effectiveness testing

In light of the knowledge that currently marketed power toothbrushes possess wide-ranging modes of action, brush head topographies, filament configurations, etc., the need for sound clinical testing to establish relative cleaning profiles to guide professional recommendations and consumer purchasing is paramount. To evaluate the ability of the new power toothbrush detailed in this special issue to reduce plaque and gingivitis relative to controls, a series of comparative randomized,

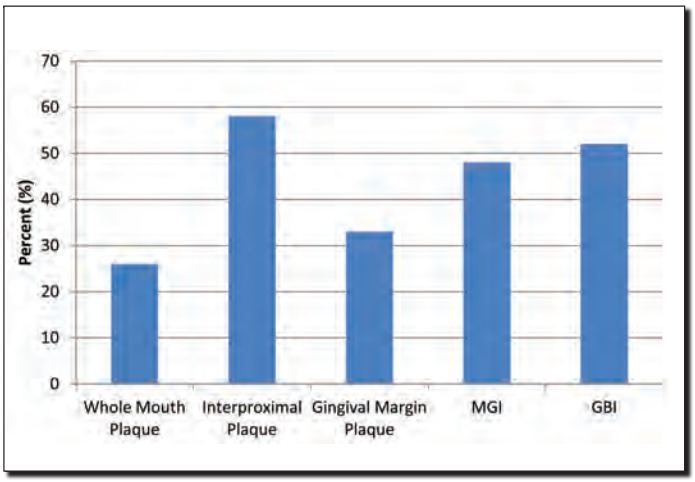

Fig. 4. Percent benefit for multi-directional power toothbrush relative to sonic control for Plaque, Modified Gingival Index (MGI) and Gingival Bleeding Index (GBI) at Week 4.[51]

examiner-blinded clinical trials of varying length, design, and subject populations were fielded.

Plaque removal benefits

Plaque biofilm proliferates rapidly in the absence of skilled oral hygiene, and its bacterial byproducts have been implicated in the inflammation and bleeding on probing seen commonly with plaque-induced gingivitis in a plethora of research over decades.[9-12,45,46] The acid production of undisturbed dental plaque as a contributor to dental caries, particularly in the more difficult to access posterior and interproximal dental surfaces, constitutes another challenge when oral hygiene is not optimal, as is often the case with the typical standard manual toothbrush user.[47]

The potential of the new Oral-B multi-directional power toothbrush to remove dental plaque (both whole mouth and in hard-to-access sub-regions) when compared to both a standard manual reference toothbrush and marketed power brush controls was assessed in four independent single-center clinical trials. The first clinical report in this special issue by Klukowska et al[48] describes a two-treatment, replicate use, single-brushing crossover study in a cohort of generally healthy adults. Following an acclimation period, the novel multi-directional power brush prototype (the only brush in the four reported clinical trials to utilize a 2-D, rather than 3-D, Oral-B brush handle) was compared to an American Dental Association (ADA) manual reference brush[d] for plaque removal efficacy over the four study periods. The results showed that the novel multi-directional power brush yielded a significantly superior mean whole mouth plaque reduction as compared to the ADA manual brush control ($P= 0.003$).

The second clinical investigation of the anti-plaque efficacy of the novel multi-directional power brush relative to a standard manual toothbrush presented in this special issue was conducted as a randomized, parallel group trial over a period of 4 weeks in a population exhibiting mild-to-moderate gingivitis.[49] Subjects brushed twice daily in the home setting, and the test brushes (novel multi-directional power or the ADA manual reference control brush) were assessed for plaque removal effectiveness at Weeks 1 and 4. Use of the Rustogi Modified Navy Plaque Index (RMPNI)[50] allowed for additional sub-analyses of challenging-to-clean intraoral regions. Week 4 study results revealed that the multi-directional power brush was significantly ($P< 0.001$) more efficacious than the manual control brush, with 2.1 times greater whole mouth plaque removal, and 4.7 and 2 times superior plaque benefits for the gingival margin and interproximal regions, respectively.

As described by Goyal et al[51] in the third special issue report, the plaque removal benefits of the new Oral-B multi-directional brush were compared to a commercially available sonic power brush control marketed as cleaning "deep between teeth and along the gumline"[52] (Sonicare Essence[e]) in a 4-week, randomized, parallel group clinical trial in volunteers with evidence of pre-existing gingivitis. Brushing was unsupervised twice daily and plaque was evaluated via RMNPI. In all regions analyzed, at 4 weeks the novel multi-directional power brush statistically significantly ($P\leq 0.001$) outperformed the Sonicare Essence control brush in whole mouth plaque removal (26% better) gingival margin plaque removal (58% superior), and approximal plaque removal (33% better) (Fig. 4).

Another commercially-available sonic toothbrush control, Sonicare's premium-positioned FlexCare with ProResults brush head,[e] was compared head-to-head with the novel multi-directional power brush in a randomized, parallel group clinical study of 8 weeks duration in mild-to-moderate gingivitis sufferers. Klukowska et al[53] detail the methodology and results of this trial as the final clinical report in this special issue. Following twice daily at home brushing with the test brushes, participants assigned to the novel multi-directional power brush experienced 44% significantly greater whole mouth and 77% superior interproximal RMNPI plaque removal ($P\leq 0.003$) at Week 8 compared to subjects using the Sonicare FlexCare control brush.

Collectively, the results of the four clinical investigations corroborate the successful design and functionality of the Oral-B novel multi-directional, targeted triple-zone cleaning technology in reducing all-over plaque and biofilm accumulation in both the harder-to-clean gingival margin and interdental spaces.

Gingivitis reduction benefits

Abundant evidence of the relationship between plaque accumulation and gingivitis has been published. The consequences of neglected plaque in the interdental regions may be the most concerning, with research linking it to attachment loss in such regions as the mandibular molar interproximal sites.[54,55] Periodontal disease and even systemic complications are possible outcomes of chronic gingivitis, accentuating the value of high-performing toothbrushes that compensate for any user skill deficiencies, that penetrate well interproximally, and that can boost compliance.

Three of the four clinical trials presented in this special issue incorporated a parallel group, multi-week design, providing sufficient duration for the evaluation of the gingivitis-reducing effect of the novel multi-directional power brush compared with control brushes. Each utilized two measures of gingival health assessment, the Lobene Modified Gingival Index (MGI)[56] and the Gingival Bleeding Index (GBI),[57] to determine the impact of plaque reduction on pre-existing gingivitis. With previous clinical research generally showing a

corresponding reduction in gingival inflammation and bleeding with clinically meaningful plaque reduction, it was expected there would be a similar gingivitis benefit in the three trials in this special issue where the tested brushes provided significant decreases in plaque versus baseline.

Not surprisingly, in each of the three studies gingivitis reductions were seen in both the Oral-B novel multi-directional power brush and manual or sonic control brush groups, as all brushes provided a statistically significant plaque reduction benefit compared with baseline. The magnitude of the gingivitis benefit, however, was consistently significantly greater for subjects brushing with the new multi-directional power brush across both measured gingivitis clinical outcome parameters. Sharma et al[49] reported subjects brushing for 4 weeks with the multi-directional power brush saw significantly superior reductions in gingivitis compared to manual brushers: 3 times and 1.49 times greater for MGI and GBI, respectively ($P< 0.001$).

When the multi-directional power brush was assessed versus a marketed sonic brush control, the results similarly showed the new brush to produce superior gingivitis reduction. Goyal et al[51] reported in this special issue on a 4-week investigation wherein the novel multi-directional power brush significantly decreased baseline gingivitis 48% better than Sonicare Essence as measured by MGI, and 52% better as quantified by GBI ($P\leq 0.001$). Finally the 8-week results detailed in the final clinical report by Klukowska et al[53] revealed that gingivitis reduction was 30% and 29% greater via whole mouth MGI and GBI, respectively, ($P< 0.001$) for subjects brushing with the Oral-B novel multi-directional power brush than for those assigned to the Sonicare FlexCare with Pro Results brush head.

Safety

The new Oral-B multi-directional power brush has been shown to be safe and well-tolerated, as evidenced by laboratory testing, in-depth consumer research and the results of the four reported clinical trials in this issue, where there were no adverse events associated with use of the new power brush.

Consumer acceptance

The clinical effectiveness and safety of the Oral-B novel multi-directional power brush, summarized previously and described in more depth throughout this special issue, were unequivocally established preceding product launch through extensive research. Recognizing that brush effectiveness is irrelevant if the consumer does not use the product, a salient question was investigated through additional consumer analysis: does the new multi-directional power brush succeed in providing those consumers with a preference for a manual toothbrush (regardless of their current ability to remove sufficient plaque to prevent gingivitis) a familiar, manual brushing-like feel and experience while delivering superior cleaning? Two key characteristics raised frequently by the segment with a bias towards manual brushing – brush head attributes and brushing experience – were thoroughly explored.

Qualitative research and product in-use testing demonstrated that consumers typically brushing with a manual toothbrush preferred the novel multi-directional power brush over their usual manual brush as they were able to clearly feel its superior cleaning efficacy. Surveyed consumers valued the multi-directional bristle field as it allowed them to focus less on individual teeth and more on all-over cleaning, similar to manual brushing. Consumers also were enthusiastic about the brush head size for the opportunity to apply their desired amount of toothpaste, in keeping with the volume they are accustomed to using with a manual brush. The ability to use the multi-directional brush like their regular manual brush, including whatever brushing action they were in the habit of performing, made the new power brush fit easily into their typical oral hygiene routine.

In short, feedback showed that consumers found the novel multi-directional power brush both looked and felt more like a manual brush than other power brushes they had used. They valued the 'overall clean' they experienced without sacrificing the familiarity of their manual toothbrush. And in one clinical study,[58] 95% of those participants who had used a manual brush before and were now using the Oral-B novel multi-directional brush did not want to relinquish it at the end of the trial, saying they preferred it to their usual manual brush.

Summary

Two decades of clinical research and several independent systematic reviews have shown the superiority in both plaque removal and gingivitis control of oscillating-rotating power toothbrushes when compared to a manual toothbrush and other power toothbrushes. However, despite this body of evidence, consumer research identified a need within a segment of the population for a highly effective power toothbrush which more closely resembles the feel and experience of a standard manual toothbrush. Oral-B's novel multi-directional power toothbrush provides the solution, and is the result of an extensive, multi-faceted research and development program. Its unique multi-directional, triple-zone cleaning technology confers a wide-sweeping motion that allows the brush head to cover a significantly wider area than a regular manual toothbrush, ensuring all areas are reached, even far back in the mouth. Additionally, the combination of manual motion and power pulsations give tooth surfaces a thorough clean, which consumers report they can feel. This perception of clean has been validated by the impressive results of laboratory evaluations and multiple clinical trials with varied study designs, durations, and subject populations. As presented in the following pages of this special issue, the novel multi-directional power brush significantly outperformed the standard manual or marketed sonic toothbrush control in plaque reduction, and provided a superior, clear-cut advantage in gingivitis reduction in the three studies assessing gingival health. Significantly greater plaque benefits provided by the new multi-directional brush relative to control brushes were directly demonstrated not only for the whole mouth, but also in the critical hard-to-clean interproximal and gingival margin areas. Importantly, those consumers formerly preferring a manual brush enthusiastically embraced the novel multi-directional power brush in both consumer tests and clinical trials.

a. Procter & Gamble Company, Cincinnati, OH, USA.
b. KUKA Robotics, Augsburg, Germany.

c. Frasaco USA, Greenville, NC, USA.
d. American Dental Association, Chicago, IL, USA.
e. Philips Oral Healthcare, Snoqualmie, WA, USA.

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Dr. Mielczarek is an Assistant Professor at the Department of Conservative Dentistry, Medical University, Warsaw, Poland. Dr. Klukowska is a Senior Scientist, Ms. Walters is a Scientific Information Manager, and Dr. Warren is a Director at the Procter & Gamble Company, Mason, OH, USA. Dr. Kaiser is a Principal Scientist, Dr. Stoerkel is a Senior Scientist and Dr. Mandl is a Senior Scientist at The Procter & Gamble Company, Global Research and Development, Kronberg, Germany.

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