



Development of an oscillating/rotating/pulsating toothbrush: The Oral-B ProfessionalCare™ Series

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Summary The Oral-B range of power toothbrushes are based on a clinically proven oscillating/rotating action. This review considers the extensive series of laboratory and clinical studies involved in the development of the Oral-B power toothbrushes with three-dimensional (3D) brush head action (i.e. oscillating/rotating/pulsating), now known as the Oral-B ProfessionalCare™ Series. The unique, highly effective cleaning performance of the 3D action incorporated in the D15 and D17 models is proven in both the laboratory and clinical environments, thereby establishing an evidence-based platform for the development of the most recent ProfessionalCare 7000. In the early development phase, *in-vitro* studies indicated that the additional pulsating action and advancements in filament technology improved approximal penetration, where plaque removal is most difficult. *In-vitro* models provide a useful development tool for the rapid assessment of design modifications, while controlling many factors that confound *in-vivo* studies, but the relevance of their findings needs to be confirmed in the clinical situation by direct improvements in oral health. Results from well-controlled, randomised clinical studies in the development programme have demonstrated the superiority of the D15 and D17 models with 3D action over a manual toothbrush and other power toothbrushes of various actions and designs in the improvement of oral health outcomes such as plaque removal (especially from approximal sites), reduction of gingival inflammation, and control of calculus and stain formation, with no greater potential to cause oral tissue abrasion. Furthermore, user acceptance of the oscillating/rotating/pulsating toothbrush may encourage long-term compliance during normal use.

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Evolution of the Oral-B power toothbrush

It is well established that power toothbrushes have the potential to overcome many of the difficulties associated with manual toothbrush use, such as poor brushing technique and lack of compliance, thereby improving oral health^{1,2}. Advances in the design and

technology of power toothbrushes have led to numerous models of fundamentally distinct designs and modes of action with consequently different cleaning profiles³. One design based on the professional instruments used in dental prophylaxis is the Oral-B oscillating/rotating power toothbrush, which features a small, circular brush head for tooth-by-tooth cleaning and easier access to back teeth. Since its introduction, the Oral-B oscillating/rotating power toothbrush has evolved considerably with modifications in brush head design, brush head motion,

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Table 1 Development of the Oral-B range of power toothbrush

Oral-B power toothbrush	Angle of oscillation (°)	Oscillating frequency (Hz)	Pulsating frequency (Hz)
D5/D7	55	47	
D9	55	63	
D15	55	63	170
D17	45	63	340
PC 7000	45	73	340

Oscillating/rotating/pulsating toothbrushes known as the Oral-B ProfessionalCare Series

frequency of movement, and operational features for the purpose of improving cleaning efficacy and gingival condition, and enhancing user acceptability (Tables 1 and 2). The original Oral-B Plaque Remover (the D5, latterly known as the D7) had an oscillating/rotating frequency of 47 Hz (2800 strokes per minute) and an angle of oscillation of 55°. An increase in operating frequency to 63 Hz enhanced the cleaning efficiency of the D9 model⁴. The next development, the D15, incorporated an additional pulsating action at a frequency of 170 Hz along the direction of the long axis of filaments giving three-dimensional or 3D brush head movement, an innovation developed to enhance penetration and plaque removal from approximal areas of the dentition⁵. In addition, advances in filament technology allowed replacement of the straight filaments in the D9 brush head with tufts of crimped filaments for less axial stiffness⁶. The D15 model was followed by the D17, in which the pulsating frequency was increased to 340 Hz and a pressure sensor is featured to stop the pulsations if too much pressure is applied. The brush head of the D17 is similar in size and configuration to that on the D15, but crimped filaments have been replaced by coextruded bifilaments to reduce axial stiffness, so that the filaments are softer and allow the interdental tips to have greater approximal penetration⁷. These bifilaments absorb moisture at different rates to allow greater flexibility and surface area exposure for cleaning. Both the D15 and D17 are included in the Oral-B ProfessionalCare Series and the most recent model to be developed in this range is the Oral-B ProfessionalCare 7000 (PC 7000), which has the same pulsating frequency of 340 Hz as the D17 but an increased oscillating frequency from 63 Hz to 73 Hz. In addition, the D15, D17 and PC 7000 models have a 2-minute timer to encourage recommended brushing time and the PC 7000 features a signal timed at 30-second intervals to indicate adequate cleaning for each quadrant of the dentition. The 2-speed control on the D17 and PC 7000 models provides users with a choice and an opportunity to use a lower speed while they become familiar with operation of the power toothbrush.

The development of the Oral-B power toothbrush has involved an extensive series of clinical studies, in which the oscillating/rotating action of the Oral-B has consistently shown to be highly effective in both

Table 2 Changes in brush head design and filament technology

Oral-B power toothbrush/brush head	Brush head design
D5/EB5, D7/EB7	Filament tufts arranged in 3 circular rings. The outer ring with filaments 8.3 mm long and 0.15 mm in diameter, inner two rings with filaments 7.6 mm long and 0.13 mm in diameter. Straight filaments
D9/EB9	Three tufts of longer filaments (8.3 mm) on either side of the brush head in the outer ring and two inner rings of shorter filaments (7.2 mm). Straight filaments
D15/EB15	Same configuration as D9/EB9, but with eight tufts of axially-soft crimped filaments in the inner field
D17/EB17, PC 7000/EB17	Same configuration as D15/EB15, but with eight tufts of coextruded bifilaments in the inner field

All brush heads are 13.2 mm in diameter with end-rounded filament tufts and 0.15 mm diameter filaments

plaque removal and gingivitis control^{4,8,9}. Indeed, the Cochrane Collaboration conducted a recent independent systematic review across power toothbrushes of different modes of action and confirmed that oscillating/rotating toothbrushes have superior efficacy over manual toothbrushes in reducing both plaque and gingivitis, without compromising safety to oral tissues¹⁰. No other powered brush designs were found to be consistently superior to manual toothbrushes, including those with side-to-side, counter oscillation, circular or ultrasonic action. Given that the clinical experience with the oscillating/rotating D7 has been reviewed previously⁸, the present review considers all the studies involved in the development of the Oral-B power toothbrushes with 3D action (oscillating/rotating/pulsating). Without excluding any study conducted on these toothbrushes, the present review focuses on efficacy and safety relative to earlier Oral-B models, manual toothbrushes, and other electric or power toothbrushes.

Laboratory and clinical development phases of a novel toothbrush

The early development phase of a novel toothbrush relies on the assessment of prototype models or design modifications in the laboratory before their clinical evaluation. Laboratory robot systems are totally controllable and eliminate many factors that potentially confound clinical studies such as variability in brushing technique, manual dexterity, brushing time and brushing force. Initially, the effect on cleaning efficacy of an additional pulsating action and modified brush head in the D15 model was investigated using a laboratory robot brushing system¹¹. The highly reproducible digital imaging technique demonstrated that the oscillating/rotating/pulsating D15 was significantly more effective than the oscillating/rotating D9 in removing plaque substitute from all tooth surfaces, especially occlusal

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