

The Oral-B CrossAction Manual Toothbrush: A 5-Year Literature Review

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ABSTRACT

Tooth-brushing, the most widespread means of cleaning teeth and maintaining gingival health, is greatly affected by technique and brushing time, both factors that are difficult to influence. The vertical bristles of conventional toothbrushes remove plaque from flat, accessible surfaces but are less effective at the gingival margins and in approximal areas, where accumulation of plaque encourages gingivitis and deterioration of periodontal health. Optimization of the design of brush heads has focused on improving elimination of plaque from these inaccessible areas.

The design of the Oral-B CrossAction manual toothbrush incorporated significant advances based on extensive scientific and ergonomic research. The arrangement of the bristle tufts, which are positioned at 16° from the vertical along the horizontal brush head axis according to a patented design, ensures that bristles operate at the optimum angle throughout the brushing cycle. Tuft arrays are designed to minimize bristle-to-bristle interference, maximize contact with the tooth surface and enhance penetration into approximal spaces to remove supragingival plaque. Data published in 2000 demonstrated the superiority of the CrossAction brush in a laboratory comparison of more than 80 toothbrushes, and 3 clinical papers have evaluated plaque removal and gingival health. The current review, covering the original studies and more recent data, confirms the clinical superiority of the CrossAction brush over 15 benchmark manual toothbrushes. The consistent and reproducible benefits of CrossAction justify the original rationale for the design of this brush.

MeSH Key Words: dental plaque/therapy; oral hygiene standards; toothbrushing/instrumentation

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Personal oral hygiene performed with a manual toothbrush is currently the most widespread method for controlling plaque, cleaning the teeth and maintaining gingival health. The design of the modern conventional manual toothbrush can be attributed to Dr. Robert Hutson, a Californian periodontist, who in the early 1950s developed the multi-tufted, flat-trimmed, end-rounded nylon filament brush that became known as the Oral-B manual toothbrush. The trademark Oral-B

emphasized that this was an oral brush, designed to clean all parts of the oral cavity, not merely a toothbrush. That original design — a plastic handle with carefully end-rounded vertical nylon filaments — was used in various forms for many years and, with minor design modifications, remains the mainstay of plaque removal worldwide. However, effectiveness depends not only on toothbrush design but also on brushing technique and the frequency and time spent brushing.¹

Tooth-brushing technique has a significant effect on plaque removal, but it is very difficult to influence personal tooth-brushing behaviour to maximize efficacy. A simple scrubbing technique is most commonly employed and is used consistently during brushing.² Most people brush their teeth for a shorter-than-optimal period, many of them using techniques that are inadequate to remove plaque from the gingival margins and approximal surfaces, areas that are important in maintaining periodontal health.³⁻⁵ Given these constraints, a practical approach to improving dental health is to develop a more effective toothbrush, one that has the potential to remove plaque more completely from tooth surfaces, is less dependent on tooth-brushing technique and provides positive sensory cues that may improve motivation and possibly increase brushing time.

Plaque accumulates on the gingival third of the teeth and remains at the gingival margins and on the approximal surfaces of premolars and molars because these areas are hard to reach during routine brushing; these are the same areas predominantly associated with gingivitis and other gum diseases.⁶ The challenge, therefore, has been to design a brush with enhanced capability to remove plaque from these areas and thereby improve general oral health. In recent years several different toothbrush designs have been evaluated in laboratory studies and clinical trials.^{2,7-10} Although performance data from some of these studies have shown statistically significant differences in plaque removal, practical improvements have in many instances been inconsistent and small. Furthermore, data on the removal of approximal plaque frequently go unrecorded, so objective assessment of this critical aspect of toothbrush efficacy can be difficult.

Toothbrush development appeared to have reached a plateau in terms of optimization, and a radically different design approach was needed to facilitate further advances. The Oral-B CrossAction brush was developed with this objective in mind, and its design has been the subject of a rigorous program of laboratory studies and clinical trials.² In total, 14 single-brushing studies and 2 long-term (3-month) clinical trials compared the performance of the Oral-B CrossAction brush with that of standard commercial toothbrushes, and the advantages of the Oral-B CrossAction brush for plaque removal and gingival health were reported in a series of papers published in 2000.⁸⁻¹⁰

The current review examines the original studies and more recent data to assess whether the rationale for the design of the Oral-B CrossAction can still be justified and whether the clinical superiority of this brush — one of the most studied manual toothbrushes — over other commercially available brushes remains consistent and reproducible in light of more recent developments.

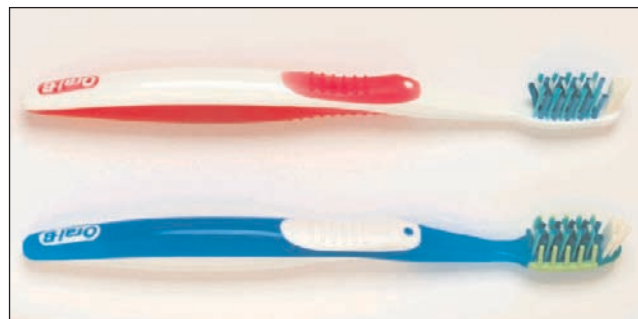


Figure 1: Oral-B CrossAction and Oral-B CrossAction Vitalizer.

Rationale for Product Development

For a better understanding of how toothbrush bristles act on the tooth surface, especially in the approximal area, novel laboratory methods using robotic techniques were developed.² This research showed that the point of greatest interproximal penetration occurs when the direction of brushing changes. Bristles that sweep across the tooth surface in one direction angle back into the interproximal space, moving down and back up the adjoining approximal surface. With conventional vertical bristles, this phenomenon is limited because only a few bristles are correctly positioned at the interproximal junction when the brush changes direction.

These observations led researchers to hypothesize that if the bristles were already angled toward the direction of travel, the entire brushing action could be made more effective. Early research showed that small angles (up to 12° from vertical) did not provide markedly greater interproximal penetration than conventional vertical bristles. However, as the bristle angle was increased above 12°, the bristles penetrated both more deeply and more frequently, enhancing the cleaning potential for the hard-to-reach approximal surfaces. It was also discovered that arranging the bristles into tall, thin, elliptical tufts reduced bristle-to-bristle interference, allowing greater coverage of the tooth surface.

On the basis of extensive laboratory and ergonomic research findings, the Oral-B CrossAction brush head was developed with tufts of bristles angled at 16° in both directions to provide a brushing action that penetrates, lifts and sweeps plaque away on both forward and backward strokes. Beals and others² used a robotic cleaning effectiveness test for a direct comparison of the new design with an identical experimental toothbrush with vertical bristles and found that the Oral-B CrossAction was significantly ($p < 0.001$) more effective in penetration (by 9.6%) and cleaning effectiveness (by 15.5%) per brush stroke. The CrossAction design has been further enhanced by the inclusion of 2 lateral rows of nonlatex rubber nubs to improve cleaning and to massage the gums for the stimulation of healthy gingival tissue (CrossAction Vitalizer).¹¹ Both CrossAction brushes are illustrated in Fig. 1.

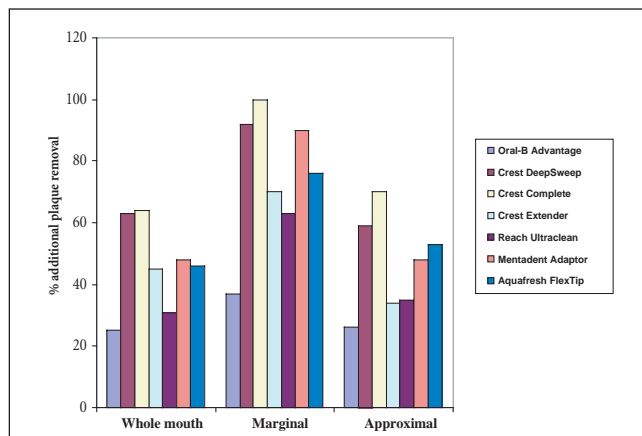


Figure 2: Percentage additional plaque removal by Oral-B CrossAction relative to that of 7 other commercial manual toothbrushes (reprinted from Sharma and others⁸ with permission of the *American Journal of Dentistry*).

Summary of Study Results

Removal of Plaque and Control of Gingivitis

Several independent studies have compared the performance of the Oral-B CrossAction toothbrush, in terms of efficacy in plaque removal and gingivitis control, with that of other commercially available manual toothbrushes. The key studies representing this body of work are summarized in **Table 1**. All single-use studies, which examined plaque removal, were conducted on generally healthy adult subjects with inclusion and exclusion criteria that ensured an acceptable level of oral hygiene. The longer-term gingivitis trials used similar inclusion and exclusion criteria in subjects with a predefined level of gingival inflammation (mild to moderate).

The investigations listed in **Table 1** included 2 independent but similar clinical studies^{8,9} comparing the performance of Oral-B CrossAction with 2 separate groups of 7 commercial manual toothbrushes. Together, these single-use studies yielded compelling evidence in support of the predictive ability and clinical relevance of the laboratory investigations of Beals and others.² In the first study, Sharma and others⁸ evaluated plaque with the Rustogi and others Modified Navy Plaque Index (RMNPI)²¹ in areas that are commonly missed by tooth-brushing and that are associated with gingivitis development, namely the gingival margin and approximal surfaces.⁷ The Oral-B CrossAction brush significantly outperformed the 7 comparison brushes in whole-mouth plaque evaluations. Importantly, on the key gingival margin and approximal surfaces, the Oral-B CrossAction removed significantly more plaque than comparable manual toothbrushes in every case ($p < 0.001$) (**Table 2** and **Fig. 2**).

In the second study, Cronin and others⁹ obtained similar results with a different assessment index, the Proximal/Marginal Plaque Index (PMI).²⁰ In individual comparisons with another 7 manual toothbrushes, the Oral-B

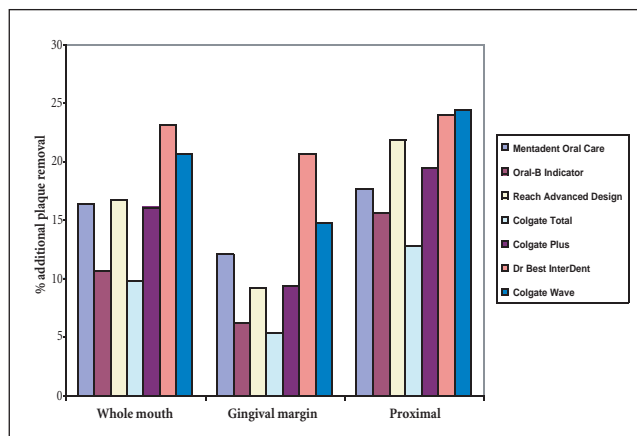


Figure 3: Percentage additional plaque removal by Oral-B CrossAction relative to 7 other commercial manual toothbrushes (reprinted from Cronin and others⁹ with permission of the *American Journal of Dentistry*).

CrossAction brush was significantly more effective for all plaque scores (**Table 3** and **Fig. 3**). The percentage difference in favour of CrossAction ranged from 12.8% to 24.0% for whole-mouth plaque, from 5.3% to 20.6% for the gingival margin, and from 12.8% to 24.5% for proximal surfaces.

In 2 independent 12-week studies, Sharma and others¹⁰ compared the Oral-B CrossAction with 2 manual toothbrushes, the Dr. Best InterDent and the Crest DeepSweep. The extended period of these studies enabled assessment of plaque accumulation and gingival health (**Table 4**). Plaque assessments (with the RMNPI) were conducted for the whole mouth, the gingival margin and the approximal surface at 6 weeks and 12 weeks. Oral-B CrossAction was significantly more effective than either of the 2 comparator manual toothbrushes ($p \leq 0.004$ and $p < 0.001$ for InterDent and DeepSweep, respectively). A concurrent reduction in gingivitis score (Modified Gingival Index [MGI]) was reported for all 3 brushes tested in both studies. In the comparison with the InterDent brush, the reduction in MGI was greater with the CrossAction brush at 6 and 12 weeks. The CrossAction brush reduced gingivitis from baseline by 13.7% at week 6 and by 23.1% at week 12, the latter difference being highly significant ($p < 0.001$); corresponding values were 11.7% and 17.4%, respectively, for the Dr. Best InterDent brush. In the comparison with the DeepSweep brush, the corresponding data were 9.5% and 18.1% for CrossAction and 2.0% and 5.1% for DeepSweep; the reductions in MGI with the CrossAction brush were highly significant at both 6 and 12 weeks ($p < 0.001$). These results support data from the single-use plaque removal studies comparing the same brushes,^{8,9} in which the Oral-B CrossAction gave similar superior performance. The 3-month results, showing that Oral-B CrossAction removed significantly more plaque from the interdental area and gave greater control of

Table 1 Summary of studies comparing the efficacy of Oral-B CrossAction with manual and battery-operated toothbrushes

Study profile					Difference in reduction from baseline: CrossAction vs. comparator	
Author and subjects	Study design	Comparator	Site in mouth	Index	Plaque (PMI, RMNPI, TMQHI)	Gingivitis (MGI, L-SGI, GSI)
Cronin and others ⁹ Approximately 100 healthy men and women enrolled per study; age 18–65 yr	7 independent studies: single-use, randomized, crossover, examiner-blinded	7 leading manual brushes ^a	Whole mouth	PMI	$p < 0.001$ ^b	Not assessed
			Gingival margin		$p < 0.001$ to $p \leq 0.045$ ^b	Not assessed
			Approximal		$p < 0.001$ ^b	Not assessed
Nathoo and others ¹² 61 healthy men and women completed study; age 21–65 yr	Study 1: single-use, examiner-blinded	Colgate Actibrush (powered brush)	Supragingival margin	RMNPI	$p < 0.01$ ^c	Not assessed
	Study 2: 3-week and 6-week examiner-blinded	Colgate Actibrush (powered brush)	Supragingival margin	RMNPI, L-SGI	$p < 0.01$ ^c	3 weeks: NS 6 weeks: $p < 0.01$ ^c
Sharma and others ⁸ Approximately 75 healthy men and women enrolled per study; mean age (across studies and treatment sequence groups): 32.2–38.6 yr	7 independent studies: single-use, randomized, crossover, examiner-blinded	7 leading manual brushes ^d	Whole mouth	RMNPI	$p < 0.001$ ^b	Not assessed
			Gingival margin		$p < 0.001$ ^b	Not assessed
			Approximal		$p < 0.001$ ^b	Not assessed
Sharma and others ¹⁰ Approximately 100 healthy men and women enrolled per study; age 18–65 yr	Studies 1 and 2 (both 6-week and 12-week): randomized, parallel-group, examiner-blinded	(1) Dr. Best InterDent (2) Crest DeepSweep	Whole mouth	RMNPI, MGI	(1) Wk 6 and 12: $p \leq 0.004$ ^b (2) Wk 6 and 12: $p < 0.001$ ^b	(1) Wk 12: $p < 0.001$ ^b (2) Wk 6 and 12: $p < 0.001$ ^b
			Gingival margin		(1) Wk 6 and 12: $p \leq 0.004$ ^b (2) Wk 6 and 12: $p < 0.001$ ^b	Not assessed
			Approximal		(1) Wk 6 and 12: $p \leq 0.004$ ^b (2) Wk 6 and 12: $p < 0.001$ ^b	Not assessed
Cronin and others ¹³ 91 healthy men and women analyzed; age range (across treatment sequence groups): 22–63 yr	Single-use, randomized, crossover, examiner-blinded	Dr. Best X-Activ	Whole mouth	PMI	$p < 0.001$ ^b	Not assessed
			Gingival margin		$p < 0.001$ ^b	Not assessed
			Approximal		$p < 0.001$ ^b	Not assessed
Cronin and others ¹⁴ Study 1: 71 healthy men and women enrolled; mean age 41 yr	Study 1: single-use randomized, crossover, examiner-blinded	Colgate Actibrush (powered brush)	Whole mouth	PMI	$p < 0.001$ ^b	Not assessed
			Marginal		$p < 0.001$ ^b	Not assessed
			Approximal		$p < 0.001$ ^b	Not assessed
Cronin and others ¹⁴ Study 2: 113 healthy men and women enrolled; age 18–70 yr	Study 2: 12 wk randomized, parallel-group, examiner-blinded	Colgate Actibrush (powered brush)	Whole mouth	PMI, L-SGI	NS	NS
			Approximal		NS	NS
			Buccal		$p < 0.05$ ^b	NS
			Lingual		NS	NS
			Marginal		NS	NS
Dörfer and others ¹⁵ 82 healthy men and women analyzed; age 21–60 yr	Single-use, randomized, crossover, examiner-blinded	Dr. Johns Spin Brush Classic (powered brush)	Whole mouth	RMNPI	$p < 0.001$ ^b	Not assessed
			Marginal		$p < 0.001$ ^b	Not assessed
			Approximal		$p < 0.001$ ^b	Not assessed
Singh and others ¹⁶ Study 1: 30 healthy subjects (sex not stated) analyzed; age 18–70 yr	Study 1: 2-wk, randomized, crossover, examiner-blinded	Colgate Total Professional	Facial and lingual surfaces	RMNPI	$p < 0.001$ ^e	Not assessed

Table 1 Continued

Study profile					Difference in reduction from baseline: CrossAction vs. comparator	
Author and subjects	Study design	Comparator	Site in mouth	Index	Plaque (PMI, RMNPI, TMQHI)	Gingivitis (MGI, L-SGI, GSI)
Singh and others ¹⁶ Study 2: 56 healthy men and women analyzed; age 18–65 yr	Study 2: 6-wk independent, parallel-group, examiner-blinded	Colgate Total Professional	Facial and lingual surfaces	RMNPI, L-SGI	3 wk: NS 6 wk: $p < 0.05^e$	3 wk: $p < 0.05^e$ 6 wk: $p < 0.05^e$
Haun and others ¹⁷ Study 1: 121 healthy men and women analyzed; age 18–71 yr	Study 1: 9-period (over 2 months; each brush 3 times), randomized, crossover, examiner-blinded	(1) Colgate Navigator and Crest SpinBrush Pro (powered brush)	(1) All surfaces; buccal; lingual	TMQHI	(1) $p < 0.001^f$	Not assessed
Haun and others ¹⁷ Study 2 (5-period): 30 healthy subjects (sex not stated) analyzed; age 18–70 yr Study 2 (6-period): 28 healthy subjects (sex not stated) analyzed; age 18–70 yr	Study 2: 5-period and 6-period single-use, crossover, examiner-blinded	(2) 2 independent studies: 7 manual brushes ^g	(2) All surfaces	TMQHI	(2) $p < 0.05^{b,h}$	Not assessed
Williams and others ¹⁸ Study 1: 40 healthy men and women enrolled; age 18–70 yr	Study 1: 4-period single-use, randomized, crossover, examiner-blinded	(1) Crest SpinBrush Pro (powered brush)	(1) All surfaces; buccal; lingual	TMQHI	(1) $p < 0.001^i$	Not assessed
Williams and others ¹⁸ Study 2: 32 healthy subjects (sex not stated) enrolled; age 18–70 yr	Study 2: 8-period single-use, crossover, examiner-blinded	(2) 7 leading manual brushes ^j	(2) All surfaces	TMQHI	(2) $p < 0.05^{b,k}$	Not assessed
Nathoo and others ¹⁹ 78 healthy men and women; age 18–67 yr	4-wk randomized, balanced-group, examiner-blinded	Colgate 360 ^o	Whole mouth	RMNPI, L-SGI, GSI	$p < 0.05^l$	NS
			Interproximal sites		$p < 0.05^l$	
			Gumline sites		NS	
Sharma and others ¹¹ 3 studies of healthy men and women (53 in study 1, 64 in study 2, 65 in study 3); age 18–70 yr	Each of 3 studies: single-use, crossover, examiner-blinded	Study 1: Oral-B Vitalizer Study 2: Oral-B Advantage Study 3: Crest SpinBrush Pro (powered brush)	Whole mouth	RMNPI	$p < 0.001^m$	Not assessed
			Gingival margin		$p < 0.001^m$	Not assessed
			Approximal		$p < 0.001^m$	Not assessed

PMI = Proximal/Marginal Plaque Index;²⁰ RMNPI = Rustogi and others Modified Navy Plaque Index;²¹ TMQHI = Turesky and others Modification of Quigley and Hein Index;^{22,23} MGI = Modified Gingival Index;²⁴ L-SGI = Löe and Silness Gingival Index;²⁵ GSI = Gingivitis Severity Index;¹⁹ NS = not significant

^a Mentadent Oral Care, Oral-B Indicator, Reach Advanced Design, Colgate Total, Colgate Plus, Dr. Best InterDent, Colgate Wave

^b In favour of Oral-B CrossAction

^c In favour of Colgate Actibrush

^d Oral-B Advantage, Crest DeepSweep, Crest Complete, Crest Extender, Reach UltraClean, Mentadent Adaptor, Aquafresh Flex Tip

^e In favour of Colgate Total Professional

^f Crest SpinBrush Pro better than Colgate Navigator and Oral-B CrossAction ($p < 0.001$); Oral-B CrossAction significantly better than Colgate Navigator ($p < 0.001$)

^g Oral-B Indicator, Crest Extender, Colgate Wave, Colgate Navigator, Colgate Motion (powered), Oral-B Advantage, Colgate Total Professional

^h Oral-B CrossAction significantly better than Colgate Wave, Colgate Navigator, Colgate Motion (powered), Oral-B Advantage, Colgate Total Professional

ⁱ In favour of Crest SpinBrush Pro

^j Colgate Total Professional, Dr. Best Plus, Mentadent Technic, Mentadent Plus, Dr. Best Schwingkof, Dr. Best InterDent, Colgate Navigator

^k Oral-B CrossAction significantly better than Mentadent Technic, Mentadent Plus, Dr. Best Schwingkof, Dr. Best InterDent, Colgate Navigator

^l In favour of Colgate 360^o

^m In favour of Oral-B CrossAction Vitalizer

gingivitis, demonstrated the longer-term benefit of Oral-B CrossAction in maintaining gingival health.

In 2 single-use studies, Haun and others¹⁷ and Williams and others¹⁸ compared plaque removal by Crest

SpinBrush Pro, a battery-powered toothbrush, and groups of 7 manual toothbrushes. Each of these 2 preliminary studies used randomized, controlled, examiner-blinded crossover designs. The Oral-B CrossAction brush was

Table 2 Mean plaque reduction (difference in plaque before and after brushing)^a (based on Sharma and others⁸)

Comparison	Mean difference in plaque before and after brushing ^b ± SD		
	Whole mouth	Gingival margin	Approximal
Oral-B CrossAction vs. Oral-B Advantage	0.45 ± 0.08 vs. 0.36 ± 0.09	0.52 ± 0.16 vs. 0.38 ± 0.17	0.77 ± 0.16 vs. 0.61 ± 0.21
Oral-B CrossAction vs. Crest DeepSweep	0.44 ± 0.07 vs. 0.27 ± 0.08	0.50 ± 0.17 vs. 0.26 ± 0.14	0.78 ± 0.15 vs. 0.49 ± 0.19
Oral-B CrossAction vs. Crest Complete	0.46 ± 0.08 vs. 0.28 ± 0.08	0.51 ± 0.17 vs. 0.25 ± 0.14	0.78 ± 0.18 vs. 0.46 ± 0.18
Oral-B CrossAction vs. Crest Extender	0.42 ± 0.08 vs. 0.29 ± 0.08	0.46 ± 0.15 vs. 0.27 ± 0.14	0.71 ± 0.16 vs. 0.53 ± 0.17
Oral-B CrossAction vs. Reach UltraClean	0.38 ± 0.08 vs. 0.29 ± 0.08	0.39 ± 0.17 vs. 0.24 ± 0.14	0.66 ± 0.17 vs. 0.49 ± 0.20
Oral-B CrossAction vs. Mentadent Adaptor	0.37 ± 0.07 vs. 0.25 ± 0.08	0.40 ± 0.14 vs. 0.21 ± 0.12	0.65 ± 0.18 vs. 0.44 ± 0.20
Oral-B CrossAction vs. Aquafresh Flex Tip	0.38 ± 0.08 vs. 0.26 ± 0.08	0.44 ± 0.16 vs. 0.25 ± 0.12	0.69 ± 0.19 vs. 0.45 ± 0.20

SD = standard deviation

^aStatistically significant difference between groups for all comparisons (analysis of variance; p < 0.001)

^bEvaluated with Rustogi and others Modified Navy Plaque Index

Table 3 Mean plaque reduction (difference in plaque before and after brushing)^a (based on Cronin and others⁹)

Comparison	Mean difference in plaque before and after brushing ^b ± SD		
	Whole mouth	Gingival margin	Approximal
Oral-B CrossAction vs. Mentadent Oral Care	1.35 ± 0.41 vs. 1.16 ± 0.39	1.39 ± 0.48 vs. 1.24 ± 0.46	1.33 ± 0.41 vs. 1.13 ± 0.39
Oral-B CrossAction vs. Oral-B Indicator	1.34 ± 0.44 vs. 1.21 ± 0.39	1.37 ± 0.47 vs. 1.29 ± 0.44	1.33 ± 0.45 vs. 1.15 ± 0.40
Oral-B CrossAction vs. Reach Advanced Design	1.40 ± 0.40 vs. 1.20 ± 0.36	1.43 ± 0.45 vs. 1.31 ± 0.40	1.39 ± 0.41 vs. 1.14 ± 0.37
Oral-B CrossAction vs. Colgate Total	1.34 ± 0.39 vs. 1.22 ± 0.39	1.38 ± 0.44 vs. 1.31 ± 0.44	1.32 ± 0.40 vs. 1.17 ± 0.39
Oral-B CrossAction vs. Colgate Plus	1.37 ± 0.44 vs. 1.18 ± 0.40	1.40 ± 0.45 vs. 1.28 ± 0.43	1.35 ± 0.45 vs. 1.13 ± 0.40
Oral-B CrossAction vs. Dr. Best InterDent	1.22 ± 0.42 vs. 0.99 ± 0.33	1.29 ± 0.45 vs. 1.07 ± 0.38	1.19 ± 0.43 vs. 0.96 ± 0.35
Oral-B CrossAction vs. Colgate Wave	1.29 ± 0.47 vs. 1.07 ± 0.39	1.32 ± 0.49 vs. 1.15 ± 0.41	1.27 ± 0.48 vs. 1.02 ± 0.40

SD = standard deviation

^aStatistically significant difference between groups for all comparisons (analysis of variance; p < 0.001)

^bEvaluated with Proximal/Marginal Plaque Index

included in these comparisons as a positive control because of its recognized superiority. The results of the first preliminary study,¹⁷ which was conducted in 2 parts, are summarized in Table 5, and the results of the second preliminary study,¹⁸ conducted using a different group of manual toothbrushes and a similar experimental procedure, are given in Table 6.

The better plaque removal with the CrossAction brush (as percent greater plaque removal score) was calculated differently in the 2 studies (see table footnotes), but both showed superior plaque removal by the Oral-B CrossAction brush in all but 2 comparisons; the exceptions were the comparisons with the Colgate Total Professional and Dr. Best Plus brushes,¹⁸ for which the

Table 4 Mean plaque reduction and mean gingivitis reduction (based on Sharma and others¹⁰)

Comparison	Result ± SD		
	Whole mouth	Gingival margin	Approximal
Mean plaque reduction from baseline^a			
Oral-B CrossAction vs. Dr. Best InterDent			
Week 6	0.29 ± 0.11 vs. 0.19 ± 0.10 ^b	0.20 ± 0.16 vs. 0.10 ± 0.11 ^b	0.54 ± 0.26 vs. 0.39 ± 0.24 ^b
Week 12	0.30 ± 0.08 vs. 0.17 ± 0.09 ^b	0.15 ± 0.12 vs. 0.06 ± 0.08 ^b	0.60 ± 0.23 vs. 0.37 ± 0.23 ^b
Oral-B CrossAction vs. Crest DeepSweep			
Week 6	0.23 ± 0.12 vs. 0.05 ± 0.08 ^c	0.18 ± 0.14 vs. 0.04 ± 0.04 ^c	0.45 ± 0.26 vs. 0.13 ± 0.14 ^c
Week 12	0.30 ± 0.09 vs. 0.13 ± 0.10 ^c	0.24 ± 0.15 vs. 0.08 ± 0.09 ^c	0.62 ± 0.24 vs. 0.35 ± 0.22 ^c
Mean gingivitis reduction from baseline^a			
Oral-B CrossAction vs. Dr. Best InterDent			
Week 6		0.29 ± 0.10 vs. 0.25 ± 0.12	
Week 12		0.49 ± 0.13 vs. 0.37 ± 0.12 ^c	
Oral-B CrossAction vs. Crest DeepSweep			
Week 6		0.19 ± 0.12 vs. 0.04 ± 0.07 ^c	
Week 12		0.36 ± 0.15 vs. 0.10 ± 0.09 ^c	

SD = standard deviation

^a Plaque evaluated with Rustogi and others Modified Navy Plaque Index; gingivitis reduction evaluated with Modified Gingival Index

^b Statistically significant difference between groups (analysis of variance; $p \leq 0.004$)

^c Statistically significant difference between groups (analysis of variance; $p < 0.001$)

advantage of the CrossAction brush was numerically but not statistically significant.

In a single-use clinical study, Cronin and others¹³ compared the efficacy of the Oral-B CrossAction brush with that of another manual brush with angled bristles, the Dr. Best X-Activ. In this crossover study, healthy subjects brushed their teeth with the assigned toothbrush for 60 seconds (timed). Plaque levels before and after brushing were evaluated with the PMI. Both toothbrushes were safe, and both significantly reduced plaque levels ($p < 0.001$), but the Oral-B CrossAction was significantly more effective than the X-Activ for whole mouth (percent plaque reduction 39.3% and 35.1%, respectively; $p < 0.001$) and marginal sites (47.8% and 42.5%, respectively; $p < 0.001$), as well as the difficult-to-access approximal areas (35.8% and 32.1%, respectively; $p < 0.001$). For the whole mouth, the CrossAction was 11.8% more effective than the X-Activ, for marginal sites the benefit was 12.6%, and for approximal sites it was 11.4%. It had previously been shown^{8,9} that manual toothbrushes with angled bristles generally remove more plaque than conventional toothbrushes, especially from approximal areas, but in this

study, Cronin and others¹³ showed that toothbrushes with angled bristles are not equally effective with respect to plaque removal.

Sharma and others¹¹ recently compared the plaque-removal capability of the most recent version of the CrossAction toothbrush, the Oral-B Vitalizer, with that of the original Oral-B CrossAction Advantage and the Crest SpinBrush Pro (battery-powered). The results of the 3 comparisons (Vitalizer with CrossAction, Vitalizer with Advantage and Vitalizer with SpinBrush Pro) are summarized in Table 7. The Oral-B CrossAction Vitalizer had plaque removal superior to that of the other 2 brushes. In addition, plaque removal with the Oral-B Vitalizer was consistent across all 3 studies, with a mean percentage plaque removal of 76.1% for the whole mouth, 63.2% for the gingival margin, and 88.0% for approximal surfaces.

The consistency of results from the single-use and longer-term studies summarized above are strong evidence that the greater efficacy associated with the CrossAction brush head design is true and reproducible. However, in 2 other studies, the Oral-B CrossAction was not superior to other manual toothbrushes. Singh and

Table 5 Plaque removal scores (based on Haun and others¹⁷)

Part 1				Part 2			
Treatment group	n	Plaque reduction from baseline (adjusted mean ± SE) ^{a,b}	% greater plaque removal score ^c	Treatment group	n	Plaque reduction from baseline (adjusted mean ± SE) ^{a,d}	% greater plaque removal score ^c
Oral-B CrossAction	30	0.48 ± 0.03	37.5	Oral-B CrossAction	28	0.53 ± 0.05	39.6
Oral-B Indicator	30	0.45 ± 0.03	28.2	Oral-B Indicator	28	0.49 ± 0.05	27.8
Crest Extender	30	0.42 ± 0.03	20.5	Colgate Motion	27	0.44 ± 0.05	14.2
Colgate Wave	30	0.38 ± 0.03	8.9	Oral-B Advantage	28	0.43 ± 0.05	13.9
Colgate Navigator	30	0.35 ± 0.03	—	Colgate Total Professional	27	0.42 ± 0.05	10.2
				Colgate Navigator	28	0.38 ± 0.05	—

^a Plaque evaluated with Turesky and others Modification of Quigley and Hein Index (TMQHI); adjusted mean and standard error (SE) from analysis of covariance for crossover design with baseline score as covariate

^b Pairwise comparisons: Oral-B CrossAction > Colgate Wave (p = 0.014); Oral-B CrossAction > Colgate Navigator (p = 0.001)

^c Percent greater plaque removal score is the mean of values for individuals, calculated as (brush–Colgate Navigator)/Colgate Navigator × 100

^d Pairwise comparisons: Oral-B CrossAction > Colgate Motion (battery-powered) (p = 0.018); Oral-B CrossAction > Oral-B Advantage (p = 0.016); Oral-B CrossAction > Colgate Total Professional (p = 0.006); Oral-B CrossAction > Colgate Navigator (p < 0.001)

Table 6 Plaque removal scores for various manual toothbrushes (based on Williams and others¹⁸)

Brush	Plaque reduction from baseline (adjusted mean ± SE) ^a	n	p value ^b	% greater plaque removal score ^c
Oral-B CrossAction	0.67 ± 0.02	32	—	—
Colgate Total Professional	0.66 ± 0.02	31	NS	1.0
Dr. Best Plus	0.63 ± 0.02	32	NS	5.7
Mentadent Technic	0.60 ± 0.02	32	0.015	12.0
Mentadent Plus	0.60 ± 0.02	32	0.011	12.5
Dr. Best Schwingkof	0.59 ± 0.02	32	0.006	13.6
Dr. Best InterDent	0.59 ± 0.02	32	0.004	14.2
Colgate Navigator	0.55 ± 0.02	32	<0.001	20.7

NS = not significant

^a Plaque evaluated with Turesky and others Modification of Quigley and Hein Index (TMQHI); adjusted mean and standard error (SE) from analysis of covariance for crossover design with baseline score as covariate

^b For pairwise comparisons, according to p values, Oral-B CrossAction > Mentadent Technic, Mentadent Plus, Dr Best Schwingkof, Dr Best InterDent, Colgate Navigator

^c Percent greater plaque removal score is the mean of values for individuals, calculated as (CrossAction–brush)/brush × 100

others¹⁶ reported that in short-term single-brushing and longer-term studies, the Colgate Total Professional brush removed more plaque than the Oral-B CrossAction brush. However, the reported reduction in plaque on facial and lingual surfaces with the CrossAction brush (29.03%) in this study by Singh and others,¹⁶ who used the RMNPI, differed from values reported by Sharma and others,⁸ who used the same index (range 56.1% to 68.7%); by Cronin and others,⁹ who used the PMI (46.4% for whole mouth, 53.9% for gingival margin and 43.3% for proximal sur-

faces); and by Haun and others,¹⁷ who used the Turesky and others Modification of Quigley and Hein Index²³ (TMQHI) (removal of 21% more plaque by CrossAction than by Colgate Total Professional).

The second study¹⁹ with results different from those usually reported for Oral-B CrossAction was a 4-week clinical comparison of the Oral-B CrossAction and the Colgate 360° manual toothbrush in terms of gingivitis reduction and plaque removal. Plaque and gingivitis scores were assessed after a 12-hour period of no brushing

Table 7 Mean reduction in plaque and percent difference in plaque removal after single use (based on Sharma and others¹¹)

Comparison	Result ± SD		
	Whole mouth	Gingival margin	Approximal
Mean plaque reduction^a			
Oral-B CrossAction Vitalizer vs. Oral-B CrossAction	0.504 ± 0.067 vs. 0.430 ± 0.089 ^b	0.650 ± 0.165 vs. 0.511 ± 0.164 ^b	0.901 ± 0.131 vs. 0.789 ± 0.187 ^b
Oral-B CrossAction Vitalizer vs. Oral-B Advantage	0.486 ± 0.083 vs. 0.366 ± 0.090 ^b	0.608 ± 0.173 vs. 0.391 ± 0.151 ^b	0.856 ± 0.163 vs. 0.665 ± 0.188 ^b
Oral-B CrossAction Vitalizer vs. Crest SpinBrush Pro	0.479 ± 0.062 vs. 0.322 ± 0.080 ^b	0.637 ± 0.157 vs. 0.363 ± 0.146 ^b	0.881 ± 0.106 vs. 0.621 ± 0.178 ^b
% difference in plaque reduction^c			
Oral-B CrossAction Vitalizer vs. Oral-B CrossAction	11.4	13.8	10.8
Oral-B CrossAction Vitalizer vs. Oral-B Advantage	19.0	21.7	19.2
Oral-B CrossAction Vitalizer vs. Crest SpinBrush Pro	25.1	27.4	26.0

SD = standard deviation

^a Plaque evaluated with Rustogi and others Modified Navy Plaque Index; reduction determined as the difference between RMNPI before brushing and RMNPI after brushing

^b Statistically significant differences between groups (analysis of variance; $p < 0.001$)

^c In favour of Oral-B Vitalizer (calculated with reference to prebrushing value, not shown)

at baseline and at 4 weeks. With both toothbrushes, there were significant reductions in plaque and gingivitis after 4 weeks of use, although plaque reduction from all areas was significantly greater with the Colgate 360° brush than with the Oral-B CrossAction brush. The Colgate 360° brush also removed significantly more plaque than the Oral-B CrossAction in the single-use assessment for whole mouth (38.6% and 33.3%, respectively) and for approximal areas (48.5% and 40.0%, respectively) but not for gumline sites (6.6% and 5.1%, respectively). However, despite the reported differences in plaque control, there were no significant differences between the 2 brushes in gingivitis control after 4 weeks of use. Also, the value for whole-mouth plaque reduction at 4 weeks for the CrossAction brush (45.2%) was well below other published values (60% to 80%),^{6,8–11,17,18}

The plaque data reported by Singh and others¹⁶ and by Nathoo and others¹⁹ and the comparisons with Colgate Total Professional and Dr Best Plus discussed earlier may all be regarded as challenging the benefits that have been repeatedly observed with CrossAction, but they are difficult to reconcile with the background of published data.

Powered Toothbrushes

The general benefits of the Oral-B CrossAction design are further supported by 2 studies that compared its performance with that of powered brushes.

Dörfer and others¹⁵ compared the Oral-B CrossAction brush with the Dr. Johns SpinBrush Classic brush (now

known as Crest SpinBrush). Both toothbrushes significantly reduced plaque levels from baseline ($p < 0.001$), but the Oral-B CrossAction manual brush was significantly more effective in plaque reduction than the SpinBrush for the whole mouth and for marginal and approximal sites ($p < 0.001$).

Cronin and others¹⁴ compared the safety and efficacy of the Oral-B CrossAction brush and the battery-operated Colgate Actibrush in a single-use study and a 12-week parallel-group study. In both studies, the PMI was used for plaque measurement²⁰ and the Löe and Silness gingival index for gingivitis.²⁵ In the single-use study, the percentage plaque reductions for whole-mouth, marginal and approximal sites were 43.5%, 50.2% and 40.7%, respectively, for the Oral-B CrossAction and 35.0%, 42.8% and 31.7% for the Actibrush. A comparison of the group means gave differences between brushes of 8.47%, 7.40% and 8.93% ($p < 0.001$) respectively, in favour of Oral-B CrossAction. By the 4-week point in the longer-term study, plaque levels had declined to a significantly greater extent with the Oral-B CrossAction brush than with the Actibrush ($p < 0.05$). Gingivitis scores for the whole mouth decreased by 2% to 3% after 4 weeks and by 6% to 9% after 12 weeks, and were significantly lower than baseline (Table 8). There were no statistically significant differences in gingivitis control between the 2 groups at any stage.

In comparisons of plaque removal in a single brushing session with the Oral-B CrossAction and the battery-

Table 8 Gingivitis scores in 3-month study (reprinted from Cronin and others¹⁴ with permission of the *American Journal of Dentistry*)

Brush	Mean Löe and Silness gingival index score (SD)				
	Baseline (day 0)	1 month	Mean difference from day 0 ^a	3 months	Mean difference from day 0 ^a
Whole mouth					
Actibrush	1.24 (0.13)	1.21 (0.10)	-0.02 (0.11)	1.14 (0.14)	-0.08 (0.13)
CrossAction	1.23 (0.14)	1.19 (0.12)	-0.04 (0.09)	1.13 (0.17)	-0.11 (0.14)
Approximal					
Actibrush	1.16 (0.12)	1.11 (0.09)	-0.05 (0.10)	1.04 (0.12)	-0.11 (0.12)
CrossAction	1.17 (0.13)	1.11 (0.10)	-0.07 (0.10)	1.03 (0.17)	-0.14 (0.15)
Buccal					
Actibrush	1.21 (0.15)	1.18 (0.12)	-0.03 (0.13)	1.11 (0.16)	-0.09 (0.14)
CrossAction	1.22 (0.18)	1.17 (0.15)	-0.05 (0.10)	1.09 (0.19)	-0.13 (0.15)
Lingual					
Actibrush	1.26 (0.13)	1.25 (0.12)	-0.01 (0.13)	1.17 (0.14)	-0.07 (0.15)
CrossAction	1.25 (0.13)	1.21 (0.13)	-0.04 (0.12)	1.16 (0.18)	-0.09 (0.17)

SD = standard deviation

^a No significant differences between groups (analysis of variance; $p > 0.05$)

powered Crest SpinBrush Pro toothbrush^{17,18} (described above) plaque removal was 28%¹⁷ and 32.8%¹⁸ greater with the Crest SpinBrush Pro. Nathoo and others¹² observed no advantage of the CrossAction brush over the battery-powered Colgate Actibrush in 3 single-use plaque assessments and a separate 6-week plaque and gingivitis study. In the 3 single-use assessments, reductions in plaque (determined by the RMNPI) were 16.7%, 17.6% and 20.0% for the Oral-B CrossAction brush and 34.3%, 33.9% and 36.7% for the Actibrush. However, these CrossAction results were well below values reported elsewhere (e.g., 56.1% to 68.7%⁸ and 66.5%¹¹ with the RMNPI; 41.8% to 49.8% with the PMI⁹). Since no explanation was given for this large discrepancy with results published elsewhere,^{2,8-11,17,18} these data cannot be considered representative of Oral-B CrossAction performance.

Safety

In none of the studies discussed above were any adverse events (such as trauma to soft tissue in the buccal cavity) reported. Visual examination of hard and soft tissues before and after brushing indicated that all of the brushes tested were safe. In a study specifically designed to evaluate the comparative trauma caused by the Crest SpinBrush Pro, the Oral-B CrossAction and the Oral-B Indicator over 4 weeks, there were only a few reports of “mild” trauma with no significant differences between brushes.²⁶

Oral Malodor

Tongue-cleaning is recognized as a method of controlling oral malodor. Although the CrossAction brush was

not developed with a special adaptation for brushing the tongue, it has been included in a series of comparative evaluations with Colgate 360°, a toothbrush with an adaptation designed for this purpose. In 3 separate studies²⁷⁻²⁹ the Colgate 360° brush was compared with the Oral-B CrossAction, Oral-B Indicator and Crest SpinBrush Pro brushes for control of biological agents that contribute to oral malodor. In all 3 studies, participants were required to brush normally for 1 minute; those using the Colgate 360° were also instructed to brush the tongue for an additional 10 seconds with the back of the toothbrush. Williams and others²⁷ incubated mouth swab samples to evaluate the effects of brushing on the level of hydrogen sulphide-forming bacteria on the tongue surface. Subjects who used the Colgate 360° had significantly lower levels of these bacteria than those who used the other brushes. In a second study, Williams and others²⁸ evaluated the presence of desquamated epithelial cells in oral rinsate after tooth-brushing. Again, use of the Colgate 360° was associated with the greatest reduction in epithelial cells. In a third study, Williams and others²⁹ evaluated the effect of toothbrush type on reduction in overnight generation of volatile sulphur compounds. The Colgate 360° was again the most effective in reducing levels of these compounds from baseline. Because a different brushing regimen was used with the Colgate 360°, it is not possible to determine whether the apparent superiority of this toothbrush was due to design characteristics or to the brushing instructions given to subjects using it. Hence, the validity of these studies as comparative evaluations of toothbrush design is questionable.

Discussion

The Oral-B CrossAction toothbrush has a unique brush head design with a criss-cross array of angled bristles. This brush has been shown to remove greater amounts of plaque from hard-to-reach approximal surfaces than traditional toothbrushes. The presence of plaque, particularly on the approximal surfaces of molars and premolars, provides a key focus of gingivitis development.³⁻⁵ The consistently high levels of plaque removal from these tooth surfaces achieved by the Oral-B CrossAction toothbrush have been associated with high levels of gingivitis control and confirm that this toothbrush can play an important role in preventive dentistry.

In laboratory comparisons, the Oral-B CrossAction manual toothbrush was statistically superior to 84 leading manual toothbrushes from around the world in terms of both in vitro cleaning efficacy and interproximal penetration.² Single-use clinical studies comparing the Oral-B CrossAction brush with 15 manual toothbrushes have also shown superior plaque removal by the Oral-B CrossAction brush relative to other manual toothbrushes.^{8,9,17,18} In addition, the Oral-B CrossAction brush had better plaque reduction than 2 battery-powered toothbrushes (Actibrush and Dr. Johns SpinBrush Classic) in single-use studies.^{14,15} Much of the literature on the Oral-B CrossAction brush consists of short-term single-use comparisons with other toothbrushes. These studies represent useful comparisons of plaque removal and have provided consistent data demonstrating the superiority of the Oral-B CrossAction brush.

To obtain comparative data on gingivitis control, longer-term studies are needed because visible control of gingivitis is a consequence of continuous effective plaque removal. Sharma and others¹⁰ evaluated the effect of brushing on plaque and gingivitis in a comparison with 2 established manual toothbrushes, the Dr. Best InterDent and the Crest DeepSweep, over 12 weeks in 2 separate studies. Both studies demonstrated the superiority of Oral-B CrossAction in the reduction of gingivitis.

Cronin and others¹⁴ undertook a 12-week comparison of plaque reduction and gingivitis control with the Oral-B CrossAction brush and the battery-powered Actibrush brush. No significant advantage was observed for CrossAction in terms of gingivitis reduction, but the benefits of longer-term studies in determining the progress of plaque removal and gingivitis over time were evident. These studies highlight the need for longer-term evaluations to assess the relative effectiveness of different brushes on gingivitis control.

One important observation from this literature review is that different results may be obtained in different studies for the same make of toothbrush. Such differences could indicate inadequacies in study design,^{30,31} rather than reflecting true differences having clinical consequences.

Consistent and reproducible findings would serve to overcome criticisms of study design, and evidence for such findings was sought in our review of the literature. The studies examined in the current review provide comprehensive and repeated clinical demonstrations of the capabilities of the Oral-B CrossAction in removing plaque and controlling gingivitis; they also provide sound evidence of the superiority of Oral-B CrossAction over many other manual toothbrushes. Performed by a number of independent investigators, these studies provide consistent evidence of the clinical properties of the Oral-B CrossAction toothbrush. On this basis, it was expected that the range of whole-mouth plaque reduction for the Oral-B CrossAction brush in more recent studies would typically agree with that seen in single-use plaque removal studies reported in the year 2000, i.e. 56% to 69% with the RMNPI⁸ and 42% to 50% with the PMI.⁹ Subsequent studies, up to the present day, generally do support the earlier data, demonstrating plaque removal within these ranges after a single use.

Adverse events, in particular to the hard and soft tissues of the buccal cavity, were minimal for both CrossAction and the other manual and battery-powered toothbrushes used in the reported studies. These findings are in accordance with the conclusions of a symposium that reviewed this subject (i.e., the benefits of toothbrushing far outweigh any potential risks).³²

This review has summarized evidence from the published literature for the greater effectiveness of the Oral-B CrossAction toothbrush relative to that of other manual and battery-powered toothbrushes. Dentists and their patients can be confident that the Oral-B CrossAction brush will yield a dependable and repeatable high level of performance in terms of plaque removal. The abundance of consistent published clinical data for this toothbrush provides a valid and reliable benchmark for reviewing the results of other clinical trials and for designing comparative studies with new products. ♦

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