

Plaque removal with triple-headed vs single-headed manual toothbrushes—a systematic review—

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Abstract

Objective: The aim of this systematic review was to establish the effectiveness of brushing with a triple-headed manual toothbrush compared to a single-headed manual toothbrush on plaque removal.

Materials and methods: The MEDLINE-PubMed and Cochrane-CENTRAL databases were searched. The inclusion criteria were clinical trials conducted with humans without fixed orthodontic appliances who were not dental care professionals. Papers that evaluated the effect of toothbrushing with a triple-headed manual toothbrush compared to a single-headed manual toothbrush on plaque removal were included. Data were extracted from the eligible studies, and a descriptive analysis was performed.

Result: The search retrieved 15 eligible publications including 18 relevant comparisons. Heterogeneity was most obvious with respect to the person who performed the brushing, either the participants themselves or a caregiver responsible for daily oral hygiene. Additionally, participant characteristics such as age and individual disabilities varied. A lack of appropriate data and a variation in the indices used allowed only a descriptive analysis. Of the 14 comparisons with self-performed brushing by the participants, the majority showed no difference between triple-headed and single-headed toothbrushes, with a few favouring the triple-headed. In the comparisons in which a caregiver performed the brushing, three of the four showed that the triple-headed toothbrush performed significantly better on the reduction in plaque scores.

Conclusion: From this review emerges the recommendation that the use of a triple-headed manual toothbrush instead of a single-headed manual toothbrush might be favorable with respect to plaque removal in case a care-dependent individual is brushed by a caregiver.

KEYWORDS

disability, plaque, single-headed toothbrush, systematic review, triple-headed toothbrush

1 | INTRODUCTION

Dental plaque, the biofilm that forms and remains on tooth surfaces, is considered the principal etiological factor associated with the two main oral diseases: dental decay and periodontal disease.¹ The cornerstone of the prevention and control of these oral diseases is therefore the removal of plaque on a daily basis. The most widespread means of controlling plaque at home is the toothbrush.² Currently, numerous variations of the manual toothbrush are available on the market. A systematic

review of single-headed toothbrushes showed that brush-head design influences effectiveness. Irrespective of the brush-head design, the overall weighted mean effectiveness was calculated to be a 42% plaque score reduction during a brushing exercise.³ Therefore, it appears that there is certainly room for improvement in the efficacy of manual toothbrushes. One unconventional design of the manual toothbrush is the triple-headed toothbrush; the manufacturers of this toothbrush claim that its use makes it easier to brush properly. The main design feature of these multiheaded brushes is that when placed on the occlusal surface,

all three surfaces of the tooth are cleaned simultaneously. Consequently, it is suggested that this could improve the efficacy of the brushing exercise (<http://drbarmans.com/>; <http://www.dentrust.com/>).

Compared to the general population, those individuals who have intellectual disabilities appear to have poorer oral health and higher plaque levels.⁴ It has been questioned whether adequate plaque removal with a conventional toothbrush is realistic for this group.⁵ Based on a systematic evaluation of the literature, it has been suggested that the greatest opportunity to improve oral health for people with disabilities lies in the development of effective prevention.⁴ This should focus particularly on strategies to improve the daily hygiene procedures performed by a caregiver and to encourage self-care. Consequently, a triple-headed toothbrush design has been recommended for disabled individuals because it allows for easier bristle placement and access.⁶ However, others have concluded that even brushing with a triple-headed toothbrush requires minimal skill that individuals with disabilities may be lacking.⁷

Currently, it remains unclear whether the use of a triple-headed instead of a single-headed toothbrush could be a strategy to improve oral hygiene in the general population and among individuals with physical and/or intellectual disabilities. What is currently lacking is a structured evaluation of the triple-headed toothbrush's plaque-removing ability. Therefore, the aim of this review was to aggregate and critically appraise the literature concerning the effectiveness of the triple-headed manual toothbrush compared to the single-headed manual toothbrush with respect to plaque removal.

2 | MATERIALS AND METHODS

This systematic review was prepared and described in accordance with the Cochrane Handbook for Systematic Reviews of Interventions⁸ and the guidelines of Transparent Reporting of Systematic Reviews and Meta-analyses (PRISMA).^{9,10} The protocol that details the review method was developed "a priori" following an initial discussion among the members of the research team.

2.1 | Focused question

What is the effectiveness of a triple-headed manual toothbrush compared to a single-headed manual toothbrush on plaque removal?

2.2 | Search strategy

A structured search strategy was designed to retrieve all relevant studies. The National Library of Medicine, Washington, D.C. (MEDLINE-PubMed) and the Cochrane Central Register of Controlled Trials (CENTRAL) were searched from inception to August 2016 for appropriate papers that answered the focused question. The Journal of Disability and Oral Health was hand searched from initiation to August 2016. Furthermore, the reference lists of the included studies were hand searched to identify additional potentially relevant studies. No further hand searching was performed with the exception of the

Box 1 Search terms used for PubMed-MEDLINE and Cochrane-CENTRAL. The search strategy was customized according to the database being searched.

The following strategy was used in the search:
<{ toothbrush } AND {triple headed}> OR <brands>

<{Toothbrushing [Mesh] OR toothbrush OR toothbrushing OR toothbrush* [textword]}>

AND

{(multi head*) OR (two head*) OR (duo head*) OR (triple head*) OR (trio head*) OR (three head*) [textword]}>

OR

<(super brush) or superbrush or dentrust OR (surround toothbrush) [textword]>

The asterisk () was used as a truncation symbol.*

Cochrane worldwide hand searching program, which is uploaded to CENTRAL. For details regarding the search terms used, see the Box 1.

2.3 | Screening and selection

The titles and abstracts of the studies obtained from the searches were screened independently by two reviewers (SKS, DES) to select studies that potentially met the inclusion criteria. No language restrictions were imposed. Based on the title and abstract, the full-text versions of potentially relevant papers were obtained. These papers were categorized (SKS, DES) as definitely eligible, definitely not eligible or questionable. Disagreements concerning eligibility were resolved by consensus, and if disagreement persisted, the decision was resolved through arbitration by a third reviewer (GAW). The papers that fulfilled all of the inclusion criteria were processed for data extraction.

The included studies met the following criteria:

- A randomized controlled clinical trial (RCT) or a controlled clinical trial (CCT) study design.
- Conducted in humans without fixed orthodontic appliances.
- Compared the effect on plaque removal of toothbrushing with a triple-headed and a single-headed manual toothbrush.
- Triple-headed toothbrushes had a design with the bristles of the vestibular and oral brush head in an oblique angle towards the gumline.
- Toothbrushing was performed by either the participants themselves or by a parent, nurse or other caregiver responsible for daily oral hygiene. Dental care professionals were excluded as participants and as caregivers.

2.4 | Assessment of heterogeneity

The following factors were considered to explain the heterogeneity of the outcomes of the different studies: study design and evaluation period, subject characteristics, brushing regimen and industry funding.

2.5 | Quality assessment

Two reviewers (SKS, DES) independently scored the individual methodological qualities of the included studies using the checklist presented in the Appendix S1. In short, a study was classified as having a low risk of bias when random allocation, defined inclusion/exclusion criteria, blinding of the examiner, balanced experimental groups, identical treatment between groups (except for the intervention) and reporting of follow-up were present. Studies that met five of these six criteria were considered to have a moderate risk of bias. If two or more of these six criteria were absent, the study was considered to have a high risk of bias as proposed by van der Weijden et al.¹¹ and described in detail by Keukenmeester et al.¹²

2.6 | Data extraction and analysis

The characteristics of the population, intervention, comparison and outcomes were extracted independently from all the studies by two reviewers (SKS, DES) using a specially designed data extraction form. Means and standard deviations were extracted if available. In the case of missing or incomplete numerical data, the original authors were contacted if possible and respectfully asked to provide these additional data. Disagreement between the reviewers was resolved through discussion and consensus. If a disagreement persisted, the judgement of a third reviewer (GAW) was decisive.

As a summary, a descriptive data presentation was used for all the studies. The data were summarized and analysed using vote-counting.¹³ Subanalyses were performed based on the individual performing the toothbrushing (participant or other) and the participants' characteristics (disability, age).

2.7 | Grading the body of evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE)^{14,15} system was used to rank the evidence. Three reviewers (SKS, DES, GAW) rated the quality of the evidence and the strength and direction¹⁶ of the recommendations according to the following aspects: risk of bias, consistency of results, directness of evidence, precision of data, publication bias and magnitude of the effect. Any disagreement between the reviewers was resolved after additional discussion.

3 | RESULTS

3.1 | Search and selection results

The search of the MEDLINE-Pub Med and Cochrane-CENTRAL databases resulted in 134 unique papers (for details, see Figure 1). The screening of the titles and abstracts resulted in 13 papers, for which the texts were obtained and read in full. The hand search of the Journal of Disability and Oral Health revealed one additional paper (Kaschke et al.¹⁷), as did the hand search of the reference lists of the selected papers (Bloch-Zupan & Maniere¹⁸). Altogether, 15 eligible studies¹⁷⁻³¹ describing 18 comparisons were included in this systematic review.

3.2 | Heterogeneity

The design of the included studies exhibited extensive heterogeneity. Information regarding heterogeneity in study design and evaluation period is shown in detail in Table 1. Two brands of triple-headed toothbrushes were evaluated in the eligible studies; Superbrush® (DENTACO, Norway)^{17,18,20,22-27,29-31} and Dentrust® (Dentrust, USA).^{19,21,28} As control in the majority conventional single-headed toothbrushes with flat trim bristle designs from several brands were used. One study²⁷ used a multilevel single-headed toothbrush and another²⁴ a brush with an angled bristle tuft arrangement. Regarding the brushing regimen, the most obvious heterogeneity was the person performing the brushing. Of the fourteen self-performed-brushing comparisons, three evaluated the effect with disabled participants, six with children and five with adults. In the four caregiver-performed-brushing comparisons, two included disabled subjects and two included children. Subject characteristics differed considerably; five comparisons included subjects with varying degrees of physical and/or intellectual disabilities, further referred to as "disabled individuals." Eight comparisons included healthy children, and five comparisons involved healthy adults. The brushing regimen varied widely regarding instruction, from no instruction up to extensive hands-on training. Brushing duration varied from not specified up to 3 minutes, and the frequency of the daily toothbrushing exercise ranged from not specified to twice daily. A variety of plaque indices and their modifications was used. The Quigley & Hein plaque index was used in five papers,^{17,22-24,27} the Simplified Oral Hygiene Index of Green & Vermilion in three,^{28,30,31} Silness & Løe in three,^{18,20,29} Turesky, Gilmore & Glickman in two,^{19,21} the Rustogi modification of the Navy Plaque Index in one²⁶ and one study only scored plaque as present or absent per tooth surface.²⁵ Three papers^{20,23,24} acknowledged the manufacturer of the Superbrush® for their support. The donation of toothpaste by GlaxoSmithKline Corp. Brentford, UK was mentioned once.³⁰ None of the papers included a disclosure statement regarding conflict of (financial) interests.

3.3 | Methodological quality and risk of bias assessment

The methodological quality and potential risk of bias of the included studies were assessed using a checklist as presented in Appendix S1. As the studies focused on the use of an unconventional design of toothbrush with three brush heads, blinding those who brushed to the intervention was not possible. Based on a summary of the proposed criteria, the estimated potential risk of bias was low for six studies,^{19,21-24,28} moderate for eight studies^{17,20,25-27,29-31} and high for one study.¹⁸

3.4 | Study outcomes results

The results of the data extraction for plaque removal are presented in Appendix S2. The available data did not allow for a meta-analysis due to missing and irretrievable data and a complex variety of plaque

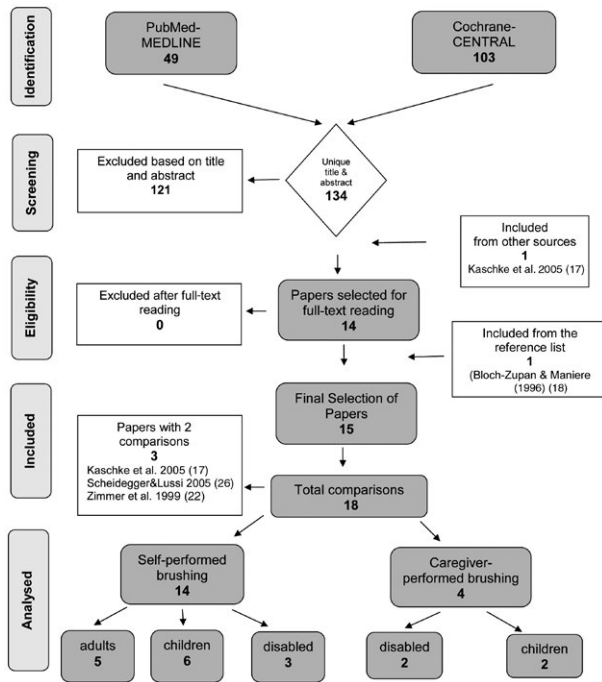


FIGURE 1 Flowchart of the search and selection process

score parameters. Therefore, only a descriptive analysis was performed, which is shown in Table 2. In total, 14 comparisons evaluated the effectiveness of a triple-headed toothbrush compared to a single-headed toothbrush in individuals who brushed themselves. None of these resulted in a significant result in favour of the single-headed toothbrush. Subanalysis showed that of the three comparisons among self-brushing participants with disabilities, one showed a significant result in favour of the triple-headed toothbrush. For children and adults, this was two of five and one of five, respectively. Of the four comparisons in which the participants were brushed by another person, three^{17,30,31} showed a significant difference in plaque removal in favour of the triple-headed toothbrush. The fourth²⁸ reported the triple-headed brush to be better but provided no statistical analysis to support this statement.

3.5 | Grading the body of evidence

Table 3 shows a summary of the various aspects that were used to rate the quality of the evidence and the strength of the recommendations according to the GRADE working group (GRADE 2011)¹⁴ and interpreted according to Smiley et al.¹⁶ These are presented separately for self-performed brushing and caregiver-performed brushing. The risk of bias varied among the studies from low to high, and reporting bias was considered to be possible. The data from the self-brushing comparisons were “rather inconsistent,” “generalizable” and “imprecise.” The effect of a triple-headed toothbrush over a single-headed toothbrush was either absent or sparsely in favour of the triple-headed design. Altogether, the level of certainty was rated to be “low,” resulting in an expert opinion not favouring the triple-headed over a single-headed toothbrush. When the participants were brushed by caregivers,

the data were considered to be “rather consistent,” “generalizable” and “rather precise.” The level of certainty was rated as “moderate,” resulting in a weak recommendation in favour of the triple-headed toothbrush design.

4 | DISCUSSION

4.1 | Major findings

This is the first review aggregating the evidence on the plaque removal effectiveness of the triple-headed toothbrush design. The outcomes emerging from this review were obtained after a comprehensive systematic literature search without filters or language restrictions. Among the fifteen included studies involving eighteen comparisons, considerable heterogeneity was present. Based on a descriptive analysis of the statistical outcomes, there appears to be no clear indication to recommend the use of a triple-headed toothbrush over a single-headed toothbrush for those participants who perform the brushing themselves. It is worthy of note that none of the included comparisons indicated that a triple-headed brush is less effective than a single-headed manual toothbrush. For those comparisons in which a caregiver was brushing the teeth of a care-dependent person, a weak recommendation favouring the use of a triple-headed toothbrush emerged.

4.2 | Justification of choices made during the search and selection process

The focus of this review was on plaque removal for which single-use or short-term studies are generally considered appropriate. The included papers had a study design that varied in duration from single use up to 6 months, but the majority were short-term and evaluated plaque removal only. For assessing gingival health, the recent ADA acceptance guideline on toothbrushes (2016) requires an evaluation period of at least 30 days. Four of the included studies^{17,20,21,31} also evaluated levels of gingival health, but only two fulfilled the ADA criteria regarding study duration. Interestingly, in both studies^{21,31} the triple-headed toothbrush group showed significantly lower gingivitis levels compared to the single-headed toothbrush group; after a 6-month evaluation period in a group of self-brushing healthy adults²¹ and after 30 days of caregiver-performed brushing of cerebral palsy patients.³¹ The other studies^{17,20} evaluating gingival health had a two or 3 weeks follow-up and showed inconclusive results. The reason for the lack of finding an effect may be sought in an evaluation period that was relatively too short. Consequently no firm conclusions on the effect of a triple-headed toothbrush with respect to gingival health can be drawn. In short, this review can serve as a proof of principle for the effectiveness of the triple-headed toothbrush on plaque removal, the outcome of which warrants further research to evaluate its contribution to oral health in care-dependent individuals.

Brushing by a dental care professional, either as participant or as caregiver, was an exclusion criterion. Due to their professional knowledge and skills they were considered optimal brushers and thus would

TABLE 1 Overview of the included studies processed for data extraction

Authors (y) (ref)	Study design, duration (per TB) Brushing by whom	# Participants baseline (end), gender, age (mean/range)	Groups (Brand)	Instructions and Regimen	Conclusions of the original authors
Yitzhak et al. (2013) (31)	RCT Crossover design No washout 1 mo per TB Brushing by nurses/parents	43 (43) Cerebral palsy patients Israel ♀: 15 ♂: 28 Mean age: 11.65 Age range: 4-31	3H-MTB (Dr. Barman's Superbrush, DENTACO, AS, Haukeland, Norway) 1H-MTB (Paro M27, Paro, Switzerland)	Instruction: Hands-on Regimen: twice daily Brushing duration: nr	Brushing by nurses of cerebral palsy patients was more effective and instruction better retained with a triple-headed compared to single-headed toothbrush.
Levin et al. (2012) (29)	RCT Parallel 1 wk Self-brushing	200 (190) Adults Israel ♀: ? ♂: ? Mean age: 20.2 Age range: 18-21	3H-MTB (Dr Barman's Superbrush Medium, DENTACO) 1H-MTB (Paro M27, Paro)	Instruction: Hands-on Regimen: nr Brushing duration: nr	The triple-headed toothbrush was found to promote easier toothbrushing and plaque removal both before and after receiving toothbrushing instructions
Telishevsky et al. (2012) (30)	RCT Parallel, cluster 1 mo Brushing by parent	68 (55) Children Israel ♀: ? ♂: ? Mean age: 5.1 Age range: 3.5-7	3H-MTB (Dr. Barman's Superbrush Medium [small size 10.8/6.3 mm], Dentaco, AS, Haukeland, Norway) 1H-MTB (Paro M27, Paro, Switzerland)	Instruction: Hands-on Regimen: twice daily Brushing duration: nr	A triple-headed toothbrush promotes more consistent toothbrushing by parents than does a single-headed toothbrush.
Oliveira et al. (2011) (28)	RCT Crossover design Washout 1 wk Single use Brushing by parent	20 (20) Children Brazil ♀: ? ♂: ? Mean age: 4 Age range: 4	3H-MTB (DenTrust, New-Port, RI, USA) 1H-MTB (Bitufo22, Itupeva, São Paulo, Brazil)	Instructions: Verbal and on model Regimen: single use Brushing duration: 2 min	The triple-headed toothbrush showed a better performance than the conventional toothbrush.
Miolin et al. (2007) (27)	RCT Crossover design No washout 1 wk per TB Self-brushing	38 (34) Adults Switzerland ♀: 18 ♂: 16 Mean age: 74 Age range: 65-82	3H-MTB (Superbrush, adult model Denta Co AS Minde/Bergen, Norway) 1H-MTB (Elmex interX, adult model/medium bristles Gaba AG, Therwil, Switzerland)	Instruction: Not specified Regimen: twice daily Brushing duration: 1 min	The overall plaque removal was similar for the 3H-MTB and the 1H-MTB.
Kaschke et al. (2005) (17)	CCT Crossover design Washout 2 wk 2 wk per TB Self-brushing/ Caregiver brushing	12 (12) self-brushing 12 (12) brushing by caregiver Intellectually and/or physically disabled Germany ♀: ? ♂: ? Mean age: ? Age range 18-45	3H-MTB (Superbrush, Dentaco, Norway) 1H-MTB (Oral-B 35)	Instruction: Verbal and written Regimen: ns Brushing duration: ns	The three-headed brush performed better in plaque removal for those adults who required help to brush their teeth.
Scheidegger & Lussi (2005) (26)	CCT Crossover design No washout 2 mo per TB Self-brushing	47(43) Children Switzerland ♀: 21 ♂: 22 Mean age ♀: 7.4 ♂: 6.9 Age range: 5-9	3H-MTB (Superbrush,, Dentaco, Norway) 1H-MTB (medium) 1H-MTB (soft)	Instruction: Not specified Regimen: ns Brushing duration: ns	Significant improvements in plaque removal in children can be achieved following good brushing instructions regardless of the toothbrush design used
Azrak et al. (2004) (25)	RCT Parallel 3 mo Self-brushing	29 (29) Children Germany ♀: 15 ♂: 14 Mean age: 4.5 ±0.5 Age range: 4-5	3H-MTB (Superbrush, Dentaco, small) 1H-MTB (Elmex29)	Instruction: Hands-on Regimen: ns Brushing time: ns	The three-headed toothbrush could be an alternative to the conventional toothbrush

(Continues)

TABLE 1 (Continued)

Authors (y) (ref)	Study design, duration (per TB) Brushing by whom	# Participants baseline (end), gender, age (mean/range)	Groups (Brand)	Instructions and Regimen	Conclusions of the original authors
Doğan et al. (2004) (24)	RCT Crossover design Washout 1 wk 1 wk per TB Self-brushing	30 (30) Mildly mentally disabled Turkey ♀: ? ♂: ? Mean age: 12.4 ^a Age range: 6-18	3H-MTB (Superbrush, Dento Co. AS Junior/Regular) 1H-MTB (Cross Action, Oral-B 35 compact, 40 regular)	Instruction: Not specified Regimen: twice daily Brushing duration: 3 min	3H-MTB gave a significantly lower PI than 1H-MTB.
Kiche et al. (2002) (23)	RCT Crossover design Washout 4 wk 4 wk per TB Self-brushing	108 (78) Children United Kingdom ♀: (40) ♂: (38) Mean age: (9.3) Age range: 7-10	3H-MTB (Superbrush, Dentaco, Norway) 1H-MTB (not specified)	Instruction: Video Regimen: ns Brushing duration: ns	Significant improvements in plaque removal in children can be achieved following good brushing instructions regardless of the design of the toothbrush used.
Zimmer et al. (1999) (22)	RCT Crossover design Washout 1 wk 1 wk per TB Self-brushing	12 (12) Children 6-12 y Germany 12 (12) Adults 37-60 y Germany	3H-MTB (Superbrush, Denta Co AS, Minde/Bergen, Norway) 1H-MTB (Elmex Super 29/39 Wybert GmbH, Lörrach, Germany)	Instruction: not specified Regimen: twice daily Brushing duration: 3 min.	3H-MTB was more effective in plaque removal than the 1H-MTB in both age groups.
Bloch-Zupan & Maniere (1996) (18)	CCT Crossover design No washout 1 wk per TB Self-brushing	29 (25) Children France ♀: 14 ♂: 11 Mean age: 10.36 ^a Age range: 4-15	3H-MTB (not specified) 1H-MTB (not specified)	No instruction given Regimen: ns Brushing duration: ns	Plaque index is lower after 1 wk of use at home of the 3H-MTB compared to the 1H-MTB.
Yankell et al. (1996) (21)	RCT Parallel 6 mo Self-brushing	113 (93) Adults USA ♀: ? ♂: ? Mean age: ? Age range: 18-60	3H-MTB (Dentrust, [Oral Logic, Minot ND]) 1H-MTB (Oral-B P35, Oral-B Laboratories, Belmont CA)	No instruction given Regimen: ns Brushing duration: 1 min	There were no significant differences between the two groups on plaque removal. After 6 mo, the 3H-MTB group was significantly better than the 1H-MTB group on gingivitis reduction.
Sauvetre et al. (1995) (20)	CCT Parallel design 3 wk Self-brushing	25 (25) Mentally retarded Belgium ♀: ? ♂: ? Mean age: ? Age range: 18-40	3H-MTB (Superbrush, regular) 1H-MTB (Oral-B P 35)	Instruction: not specified Regimen: twice daily Brushing duration: ≥ 1 min	No significant difference in plaque removal or gingivitis prevention was found between the two types of toothbrushes.
Yankell et al. (1994) (19)	RCT Crossover design Washout 3-4 d Single use Self-brushing	25 (25) Adults USA ♀: ? ♂: ? Mean age: ? Age range: 18-60	3H-MTB (Dentrust, [Oral Logic, Seattle, WA]) 1H-MTB (Crest Complete, Procter & Gamble, Cincinnati OH)	Instruction: only placement 3H-MTB shown on model Regimen: supervised brushing Brushing time: 3 min	The groups exhibited similar levels of plaque removal.

TB, toothbrush; 3H-MTB, triple-headed manual toothbrush; 1H-MTB, single-headed manual toothbrush; ?, unknown/not provided; ns, not specified; RCT, randomized controlled clinical trial; CCT, controlled clinical trial. wk week, d day

^aCalculated by the authors of this review based on the data presented in the study.

not provide data that would be generalizable to the general public. This supposition is justified by the outcomes of one of the included studies in which the dentist was compared to the mother as caregiver.²⁸ The results showed that with respect to all the measured parameters, the dentist removed significantly more plaque than the mother.

Orthodontic patients were also excluded as a participant group from this systematic review. First, because fixed appliances hamper clinical evaluation. Another reason for exclusion was that specific single-headed manual toothbrushes have been designed for orthodontic patients, and a balanced evaluation would be required to include

TABLE 2 A descriptive summary of the statistical significance of individual study outcomes related to the effect on plaque removal of toothbrushing with a triple-headed manual toothbrush compared to a single-headed manual toothbrush. Self-performed toothbrushing and Caregiver-performed toothbrushing

Toothbrushing	subjects	(ref) Authors (y) Study design, duration per TB	Patient group Age group	Intervention	PI	Control	
Self-performed	Disabled	(17) Kaschke et al. (2005) CCT, 2 wk	intellectually/physically disabled adults 18-45 y	3H-MTB	0	1H-MTB	
		(24) Doğan et al. (2004) RCT, 1 wk	mildly intellectually disabled children 6-18 y	3H-MTB	+	1H-MTB	
		(20) Sauvetre et al. (1995) CCT, 3 wk	intellectually disabled adults 18-40 y	3H-MTB	0	H-MTB	
	Children	(26) Scheidegger & Lussi (2005) CCT, 2 mo	Children 5-9 y	3H-MTB	0	1H-MTB medium soft	
		(25) Azrak et al. (2004) RCT, 3 mo	Children 4-5 y	3H-MTB	+	1H-MTB	
		(23) Kiche et al. (2002) RCT, 4 wk	Children 7-10 y	3H-MTB	0	1H-MTB	
		(22) Zimmer et al. (1999) RCT, 1 wk	Children 6-12 y	3H-MTB	+	1H-MTB	
		(18) Bloch-Zupan & Maniere (1996) CCT, 3 wk	Children 4-15 y	3H-MTB	0	1H-MTB	
	Adults	(29) Levin et al. (2012) RCT, 1 wk	Adults 18-21 y	3H-MTB	0	1H-MTB	
		(21) Yankell et al. (1996) RCT, 6 mo	Adults 18-60 y	3H-MTB	0	1H-MTB	
		(19) Yankell et al. (1994) RCT, single-use	Adults 18-60 y	3H-MTB	0	1H-TB	
		(22) Zimmer et al. (1999) RCT, 1 wk	Adults 23-60 y	3H-MTB	+	1H-MTB	
		(27) Miolin et al. (2007) RCT, 1 wk	Adults 65-82 y	3H-MTB	0	1H-MTB	
	Toothbrushing	Subjects	(ref) Author (y) Study design, duration	Patient group Age group	Intervention	PI	Control
	Caregiver performed	Disabled	(31) Yitzak et al. (2013) RCT, 1 mo	Cerebral Palsy patients 4-31 y	3H-MTB	+	1H-MTB
(17) Kaschke et al. (2005) CCT, 2 wk			intellectually /physically disabled adults 18-45 y	3H-MTB	+	1H-MTB	
Children		(30) Telishevesky et al. (2012) RCT, 1 mo	Children 3-7 y	3H-MTB	+	1H-MTB	
	(28) Oliveira et al. (2011) RCT, single use	Children 4 y	3H-MTB	?	1H-MTB		

3H-MTB, triple-headed manual toothbrush; 1H-MTB, single-headed manual toothbrush; PI, plaque index score +, significant difference in favour of intervention (triple-headed toothbrush); 0, No significant difference between the two compared toothbrushes ? =unknown; RCT, randomized controlled clinical trial; CCT, controlled clinical trial. wk week, d day

this variable in the review. Still, it would be interesting to specifically analyse the triple-headed toothbrush in orthodontic patients in future reviews, as some of the studies retrieved for the present review indicate that these may be beneficial in patients with fixed buccal^{6,32} or lingual appliances.³³

Additionally, powered triple-headed toothbrushes were excluded from the present review because as far as these authors know, only one such product is available and only two studies of this product have been performed: one among adults and one with a smaller brush head in children. The results of these two studies indicate that some benefit

TABLE 3 Summary of findings table on body of the estimated evidence profile (GRADE, 2015) and appraisal of the strength of the recommendation regarding the effectiveness of plaque removal by toothbrushing with a triple-headed manual toothbrush compared to a single-headed toothbrush

Summary of findings table on body of the estimated evidence profile		
Determinants of quality	Self-performed brushing	Caregiver-performed brushing
Study design	CCT/RCT crossover/parallel	CCT/RCT crossover/parallel
# comparisons n=18	14	4
Risk of bias	Low to high	Low to moderate
Consistency	Rather inconsistent	Rather consistent
Directness	Generalizable	Generalizable
Precision	Imprecise	Rather precise
Reporting bias	Possible	Possible
Level of certainty (Smiley et al. ¹⁶)	Low	Moderate
Direction of recommendation	No recommendation favouring the triple-headed over the single-headed toothbrush	Weak recommendation in favour of the triple-headed toothbrush

RCT, randomized controlled clinical trial; CCT, controlled clinical trial.

from this design may be expected, but the supporting evidence is meagre. No data regarding this toothbrush are available for disabled individuals. However, a recent 6-month clinical trial showed that a single-headed sonic powered toothbrush was as effective and safe as the single-headed manual toothbrush when used by people with disabilities.³⁴ A triple-headed manual toothbrush was not included in this trial. Four studies within the underlying manuscript^{17,19,22,24} also included a powered single-headed toothbrush group. Two of these four were conducted among participants with disabilities. One study reported favourable results for the powered toothbrush in the hands of a group of disabled schoolchildren.²⁴ The other study concluded that the powered toothbrush performed better only on the vestibular smooth surfaces of disabled participants who were considered capable of performing the brushing themselves; individuals needing help, some or total, from a caregiver removed more plaque with the triple-headed toothbrush.¹⁷ Consequently, there is inconclusive evidence with respect to a powered toothbrush being an appropriate tool for people with disabilities.

4.3 | Toothbrushing skills

According to Frandsen,³⁵ the efficacy of toothbrushing with regard to plaque removal is dictated by three main factors: design of the toothbrush, the frequency and duration of use and the skill of the individual using the brush. When participants with disabilities and subsequent diminished practical skills³⁶ are involved in the studies, an evaluation of toothbrushing skills is relevant. Campanaro et al.³⁷ reported that caregivers perceive a lack of toothbrushing skills as a significant barrier to brushing children with special health care needs. Interestingly, in three of the included studies, toothbrushing skills were assessed using the so-called Tooth Brushing Performance Skill Index (TBPS-I). This validated index evaluates brushing skills via direct observation of two criteria: correct placement of the toothbrush on each segment ("reach") and the performance of a sufficient number⁸⁻¹⁰ of horizontal strokes in each segment ("stay").³⁰ Without

prior instruction, self-brushing healthy young adults performed better on the TBPS-I and removed more plaque with the triple-headed brush.²⁹ Following instruction, TBPS-I assessments were applied to nurses brushing cerebral palsy patients³¹ and to parents brushing their preschool children.³⁰ It was concluded that brushing was more consistent and instruction was better retained when a triple-headed toothbrush was used. Easily acquired and retained brushing skills may attribute to the improved plaque removal efficacy of the triple-headed toothbrush.

4.4 | Heterogeneity

Due to the heterogeneity of the plaque indexes used in the selected studies, the lack of presentation of the numerical data using means and standard deviations and the failure to obtain additional data from the original authors in instances of missing data, it was not possible to perform a meta-analysis. Instead, vote counting was used to merge the results of the included studies. According to the Cochrane Handbook, meta-analyses occasionally use "vote counting" to summarize effects across studies. It is advised to limit vote counting to answering the simple question: "Is there any evidence of an effect?".⁸ The vote-counting method differentiates study results as significantly positive, significantly negative and non-significant. Thus, merging the results of the included studies is possible with minimal statistical data.¹³ The problem with vote counting is, however, that each study and each vote is treated as equal. Comparisons with a positive direction fail to provide an estimate of the effect size of an intervention (ie giving equal weight to comparisons that show a 1% change or a 50% change) and ignore the precision of the estimates from the primary comparisons (ie giving equal weight regardless of the number of participants).¹² The descriptive summary (Table 2a,b) showed that in none of the comparisons was the triple-headed toothbrush less effective than the single-headed toothbrush. Hedges & Olkin assert that vote counting is a reliable method when only studies that show

a positive significant effect are counted.³⁸ Therefore, vote counting was regarded as an appropriate method to evaluate whether there is any evidence of an effect on improved plaque removal when a triple-headed toothbrush is used.

4.5 | Limitations

There are clear limitations related to this review. In particular, the observed heterogeneity and the risk of bias make it challenging to provide a recommendation that is more than an expert opinion. Reporting of the original studies did not allow to make a clear distinction whether participants had intellectual or physical disabilities or both. Neither was it possible to determine to which extent they were disabled. Patients with intellectual disabilities are known to also have diminished practical skills.³⁶ Even after adequate training this could be of impact on the results of those that brushed under supervision or used the toothbrush at home-use.³⁴ More specifically regarding toothbrushing, duration has been shown to be a contributing factor in relation to the efficacy of a brushing exercise.³ As the triple-headed toothbrush simultaneously brushes the occlusal, buccal and oral surfaces, it has been expected that less time is required to brush the teeth.³⁶ However, this improvement in efficiency could not be substantiated in the current review, as brushing duration was not supervised or recorded in most of the included studies.

Furthermore, it has been suggested that the triple-headed toothbrush might not sufficiently reach the sulcular area of elongated teeth, often found in elderly and periodontal patients.²⁹ Elderly individuals who are care dependent and institutionalized were not included as study participants, although they represent a growing portion of the population and may need the assistance of caregivers to maintain oral health. A new triple-headed toothbrush has become available specifically for patients with elongated teeth. The effectiveness of this toothbrush, however, still has to be scientifically evaluated.

4.6 | Recommendations for future research

A meta-analysis could not be performed of the studies included in this systematic review. To assist dental care professionals in providing an evidence-based recommendation for a toothbrush, more publications following the current standards, such as CONSORT 2010^{39,40} and TIDieR 2014,^{41,42} are needed, and suggestions such as those published by Robinson et al.⁴³ should be considered. This would in the future allow for a meta-analysis that takes the data one step further than the present review. Additionally, powered toothbrushes were not included in this systematic review, although it is well known that powered toothbrushes may enhance toothbrushing efficacy. As a next step, the comparison of the triple-headed manual toothbrush versus the powered toothbrush seems of particular interest to broaden the recommendations of dental care professionals. Lastly, it should be noted that trials comparing toothbrush designs generally exclude participants with physical and/or intellectual disabilities. However, considering the oral health disparity that clearly exists within the general population, it is essential that researchers embrace this particular patient group.

5 | CONCLUSION

From this review emerges the recommendation that the use of a triple-headed manual toothbrush instead of a single-headed manual toothbrush might be favorable with respect to plaque removal in case a care-dependent individual is brushed by a caregiver.

6 | CLINICAL RELEVANCE

6.1 | Scientific rationale for the study

To properly clean teeth, toothbrushing must be performed on the buccal, oral and occlusal surfaces. These surfaces are brushed separately with a single-headed toothbrush. It is suggested that a triple-headed toothbrush can clean all three surfaces simultaneously and thus will improve the effectiveness of the brushing exercise.

6.2 | Principle findings

In self-performed brushing, the triple-headed toothbrush did not differ from the single-headed toothbrush. There is moderate certainty that when a caregiver performs the brushing with a triple-headed toothbrush, it results in significantly better plaque removal.

6.3 | Practical implications

Dental care professionals can recommend the use of a triple-headed manual toothbrush to those who are responsible for the daily oral hygiene care of care-dependent individuals.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTION

All authors gave final approval and agreed to be accountable for all aspects of work ensuring integrity and accuracy. S.K.S contributed to conception and design, search and selection, analysis and interpretation, and drafted the manuscript. G.A.W. contributed to conception and design, analysis and interpretation and critically revised the manuscript. E.W.P.B. contributed to analysis and interpretation and critically revised the manuscript. D.E.S. contributed to conception and design, search and selection, analysis and interpretation and critically revised the manuscript.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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