Role of brushing technique and toothbrush design in plaque removal

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Abstract – Twenty-four adults participated in an intraindividual crossover experimental study to compare the plaque removing ability of straight multitufted and V-shaped brushes. Twelve of the participants had loss of periodontal tissue resulting in open but healthy interdental areas while the other 12 displayed no periodontal breakdown. In part 1 the participants were asked to brush their teeth using their own brushing technique and length over two 12-day periods during which time they, at random, used one brush for the first and the other brush for the second period. In part 2 the participants were professionally brushed by two dental assistants using four brushing techniques (The Bass, The Roll, The Circular Scrub and The Horizontal Scrub) randomly assigned to the four quadrants of the mouth. Cleaning was performed once a day for two 5-day periods, during which time the participants refrained from brushing and interdental cleaning. Initial toothbrush assignment was randomized. At the beginning of the study and each test period no plaque or gingival inflammation was visible. At the end of each period the accumulated plaque was registered. The results showed that there was no difference between the two brushes tested in the unsupervised part. The plaque removing ability when using either of the brushes varied between participants. When professionally used the straight multitufted and V-shaped toothbrushes did not show any difference in plaque removal on buccal and lingual surfaces. Interproximally the V-shaped toothbrush was better at plaque removal than the straight one. However, plaque still remained after brushing with the V-shaped toothbrush, which indicates that toothbrushing always must be supplemented with interdental aids and that the shape of brushes as well as the techniques used are of little importance. Interproximal areas with tissue breakdown and loss of interdental papillae accumulated more plaque than those with no periodontal tissue breakdown.

Key words: brushing technique; dental plaque removal; hygiene, dental; professional toothbrushing; toothbrush design.

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The toothbrush is an indispensable aid in the maintenance of gingival health. Toothbrushes have been designed in a large number of different ways. However, as yet no

conclusive data are available about the ideal design of toothbrushes or brushing method.

From clinical studies testing the cleaning efficiency of different toothbrushes where the same brushing method was used (1, 2) or testing different brushing methods where the same type of toothbrush was used (3–10), no significant conclusions can be drawn as to which toothbrush or method was superior to others.

Several investigators (4, 6, 7, 11, 12) found the Horizontal Scrub method to be the least and the Charters' method the most time-consuming. No difference could be shown between different brushing techniques according to their plaque removal effectiveness (4, 6, 10–12). The Roll technique has been found the least effective method for plaque removal (3, 6, 8, 14–16). O'Leary (17) claimed the Bass technique to be the method of choice for cleaning lingual surfaces of mandibular molars and premolars.

Arai & Kinoshita (18) studied the plaque removing ability of various toothbrushes and brushing methods and found hard manual toothbrushes to be superior in plaque removal combined with any of the six tested brushing methods (The Roll, The Bass, The Horizontal Scrub, Charters', Stillman's, Fone's). The Fone's and Scrub methods were the most effective techniques.

In an in vitro study comparing a multitufted with a V-shaped brush of the same brand by using a model dentition, Nygaard Östby *et al.* (19) found 1) the vertical brushing method to have better interdental access than the horizontal method regardless of brushing method or bristle design used and 2) the V-shaped toothbrush to have better interdental access than the straight multitufted one regardless of technique used. For interdental access soft bristle toothbrushes were superior to medium and hard ones.

The aim of the present study was to compare intraindividually the plaque removing ability of straight and V-shaped toothbrushes of the same stiffness (soft) either used by the participants themselves or used by professional cleaners (dental assistants) performing the brushing with four different techniques (The Bass, The Roll, The Circular Scrub and The Horizontal Scrub methods).

A further aim was to compare the cleaning ability interdentally when the interproximal areas were intact and where the interdental papillae did not fill the interproximal area.

Material and methods

Twenty-four adult individuals aged 20–49 yr participated in the study. The participants were selected from among patients previously treated for periodontal disease, dental students and clinical instructors in periodontology at the University of Umeå, Sweden. All individuals were well trained in performing oral hygiene measures. Half of the participants had interproximal loss of periodontal tissue with open interproximal areas whereas the other half displayed no periodontal tissue breakdown.

During a preparatory period of 2–4 wk prior to the start of the study, the teeth of the participants were cleaned mechanically once a day until gingival health was established.

At the start and end of each test period the amount of supragingival plaque was assessed by registrations of 10 surfaces of each tooth according to the method developed by Bergenholtz *et al.* (20), which is a modification of the Silness & Löe (21) PII where the amount of plaque is scored on only four surfaces on each tooth. All registrations were carried out by one and the same dentist without knowledge of the procedure performed. All together, four teeth were scored in each quadrant of the mouth.

In the first part of the study the toothbrushing was performed by the participants themselves (unsupervised brushing). The participants were instructed to brush their teeth twice a day using

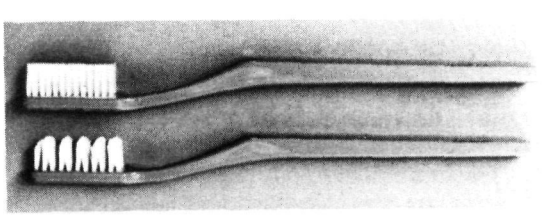

Fig. 1. Multitufted (above) soft and V-shaped (below) soft toothbrushes used in study.

their own technique and length of brushing. No interdental cleaning aids were allowed. The participants were given the straight multitufted or a V-shaped toothbrush (Jordan A/S, Oslo, Norway) (Fig. 1) on a random basis to be used for each of the two 2-wk periods. The toothbrushes were of the same stiffness (soft, tested according to the method described by NYGAARD ÖSTBY *et al.* (19)). Presence of plaque was registered after each of the two periods in the same ways as performed in the second part of the study (professional brushing). The second 2-wk period was not initiated until gingival health had been reestablished as described earlier.

During the second part of the study consisting of two 1-wk periods the participants were brushed once a day by two specially trained dental assistants (professional brushing). The toothbrushing was carried out with a straight multitufted and a V-shaped toothbrush of the same stiffness (soft – tested according to the method described by NYGAARD ÖSTBY *et al.* (22)). The participants were divided into two groups where each of the participants within the same group was brushed 3 min by the same dental assistant during each of the two 5-day periods. During the test periods the participants were not allowed to perform any form of oral hygiene measures.

Four different methods of brushing were tested: the Roll technique, the Bass technique, the Circular Scrub technique and the Horizontal Scrub method. All four methods of brushing were used in each participant at the same time. The mouth was split into four quadrants and each brushing method was randomly allotted to each quadrant. The randomization of brushing method to each quadrant of the mouth varied from participant to participant but was always the same in each individual throughout both test periods.

Registration of plaque was performed after each 5-day test period. Usually 2 days elapsed between the two test periods. Prior to the start of the second test period remaining plaque was removed and the participants received the other toothbrush, chosen by randomization.

STATISTICAL ANALYSIS

Results obtained were evaluated by the SPSS computer programs (23).

The initial plaque registrations according to BERGENHOLTZ *et al.* (20) were handled according to the four following "indices".

A. The sum of the index values for the 4 teeth in a quadrant was calculated and used for further analysis. The comparisons were made using breakdowns (means and standard deviations in subgroups) and analysis of variance techniques.
B. The tooth was used as the measuring unit with the plaque registrations according to the PII scores 0, 1, 2 or 3. Each surface was analyzed separately. Different cross tabulations were made according to the aims of the study. *P*-values were calculated by chi-square analysis.
C. The tooth was used as the measuring unit for plaque registrations according to "no visible plaque" (PII index scores 0 or 1) or "visible plaque" (PII index scores 2 or 3). The statistical analyses were performed in the same way as above.
D. The tooth was used as the measuring unit for plaque registrations according to "no plaque" (PII index score 0) or "plaque" (PII index scores 1, 2 and 3).

The letter for each "index" is used as reference in the following text.

Results

PART 1 – UNSUPERVISED TOOTHBRUSHING

The unsupervised cleaning performed by the participants themselves did not differ whether the straight or the V-shaped toothbrushes were used. However, there were great variations in the amount of plaque remaining in relation to the various participants. Some of the participants removed plaque better when using the straight, others when using the V-shaped toothbrush (Table 1).

Table 1

Unsupervised toothbrushing. The relation between plaque removing ability, interdental area, participant and type of toothbrush

Interdental area	Toothbrush: Straight Better	No diff.	V-shaped Better	Total
Filled	5	1	6	12
Open	8		4	12
Total	13	1	10	24

Table 2

Professional toothbrushing. Comparisons of residual plaque after use of the V-shaped toothbrush and the straight brush, using the mean score sums for each of the 10 surfaces of four teeth in a quadrant (index A)

Tooth surface	V-shaped toothbrush		Straight toothbrush		
	Mean	SD	Mean	SD	*P*-value
MB	5.4	2.5	6.2	2.0	0.02*
BM	1.9	2.1	2.2	1.8	0.31
B	0.3	0.6	0.3	0.9	0.79
BD	2.5	2.2	3.0	1.8	0.08
DB	5.6	2.2	6.2	1.9	0.02*
DL	5.6	2.3	6.0	2.1	0.20
LD	2.8	2.6	3.2	2.5	0.25
L	0.6	1.3	0.8	1.4	0.37
LM	3.1	2.7	3.2	2.5	0.87
ML	5.7	2.4	6.4	2.0	0.03*

PART 2 – PROFESSIONAL TOOTHBRUSHING

After professional toothbrushing the V-shaped toothbrushes showed a greater plaque-removing ability compared to the straight one on all interdental and axial surfaces and independent of the brushing method used.

According to Table 2, where results are shown for "index A", significant differences between the brushes tested were found on the mesiobuccal, distobuccal and mesiolingual surfaces ($0.05 > P > 0.01$).

For the mesiobuccal surfaces Table 3 shows "index A" for the two toothbrushes and the four methods used. As can be seen the differences in plaque removing ability favor the V-shaped toothbrush independent of the method used. The same conclusion can be drawn concerning other interdental and axial surfaces.

On buccal surfaces *more* plaque remained in quadrants brushed with the Roll technique. On linguomesial surfaces the Bass method showed a slightly greater plaque removal ability than other brushing methods tested. Regarding the interproximal areas there was significantly and generally speaking more plaque formed in open than in interproximal areas with no periodontal tissue breakdown.

Using the index B (Table 4), significant differences between the two brushes in favor of the V-shaped were *also* found on the mesiobuccal, buccodistal, distobuccal and mesiobuccal surfaces.

Table 5 shows the results for the mesiobuccal surfaces cleaned with the toothbrushes and the four methods tested when index B is used.

When analyzing index A concerning the methods tested the above results are also valid. The Bass technique showed more

Table 3

Professional toothbrushing. Comparison between the four brushing methods used for the V-shaped and the straight toothbrush using the sum of the index values in a quadrant on mesiobuccal surfaces (index A)

Method	V-shaped toothbrush Mean	Straight toothbrush Mean	Difference
The Bass	5.2	6.0	0.8
The Roll	5.7	6.5	0.8
The Circular	5.3	5.9	0.6
The Horizontal	5.6	6.5	0.9

Table 4

Professional toothbrushing. Comparisons between the V-shaped (V) and the straight (S) toothbrush using the tooth as the unit (index B). Frequency tables. MB = mesiobuccal, BD = buccodistal, DB = distobuccal and ML = mesiolingual surfaces

Surface:	MB		BD		DB		ML	
Toothbrush	V	S	V	S	V	S	V	S
Plaque Index								
0	62	25	199	165	51	28	57	25
1	118	112	125	144	132	109	102	97
2	200	247	60	75	197	247	222	262
3	4	–	–	–	4	–	7	–
	384	384	384	384	384	384	384	384
	$\chi^2 = 24.8$		$\chi^2 = 6.2$		$\chi^2 = 18.5$		$\chi^2 = 18.9$	
	$P = 0$		$P = 0.045$		$P = 0.0003$		$P = 0.0003$	

plaque removal ability compared with the other methods tested on the linguodistal ($P<0.01$) and the mesiolingual surfaces ($P<0.05$).

Using the index A there were no significant differences between the results obtained by the two dental assistants in relation to their brushing techniques. Using the index B number 2, dental assistant had more zeros and 2's compared to number 1 on buccomesial and buccodistal surfaces (Table 6).

Finally, when analyzing the results in terms of visible plaque – no visible plaque or plaque – no plaque (indices C and D) again the V-shaped toothbrushes showed a greater plaque removal ability on the mesiobuccal,

Table 5

Professional toothbrushing. Comparison between the four brushing methods tested for the V-shaped (V) and the straight (S) toothbrush using the tooth as the unit for the analysis (Index B). Mesiobuccal surfaces

Plaque Index	The Bass		The Roll		The Circular		The Horizontal	
	V	S	V	S	V	S	V	S
0	19	7	14	5	16	6	13	7
1	29	29	28	24	30	35	31	24
2	47	60	53	67	50	55	50	65
3	1	–	1	–	–	–	2	–
	96	96	96	96	96	96	96	96
	$\chi^2 = 8.1$		$\chi^2 = 7.2$		$\chi^2 = 5.2$		$\chi^2 = 6.6$	
	$P = 0.04$		$P = 0.07$		$P = 0.08$		$P = 0.08$	

Table 6

Professional toothbrushing. Comparison between the two dental assistants' results are shown for the buccomesial and the buccodistal surfaces using the tooth as the unit for the analysis (index B). Frequency tables. BM = buccomesial and BD = buccodistal surfaces

	BM		BD	
Plaque Index	Dental assistant 1	2	Dental assistant 1	2
0	204 (58%)	258 (62%)	148 (42%)	216 (52%)
1	112 (32%)	96 (23%)	151 (43%)	118 (28%)
2	36 (10%)	62 (15%)	53 (15%)	82 (20%)
3	–	–	–	–
	352	416	352	416
	$\chi^2 = 9.2$		$\chi^2 = 17.8$	
	$P = 0.01$		$P = 0.0001$	

distobuccal, distolingual and mesiolingual surfaces. Using these indices no differences between the two dental assistants were found.

There was also significantly more plaque formed in open than in interproximal areas with no periodontal tissue breakdown.

Analyzing the correlation between methods and toothbrushes in open and intact interproximal areas using indices C and D the plaque removing ability was greater when the Bass technique was used together with the V-shaped toothbrush on linguodistal, linguomesial and mesiolingual surfaces, especially when interproximal areas did not show any periodontal tissue breakdown.

All participants developed gingivitis interdentally after each of the 2-wk periods in part 1. Some of the participants complained about pain when the V-shaped toothbrush was used in part 2, but not in part 1.

Discussion

In the present study the participants brushing their teeth unsupervised obtained similar plaque removal using the straight multitufted or the V-shaped toothbrush, in agreement with results presented by KREMERS *et al.* (10). However, a closer analysis showed that nearly half of the participants removed plaque better with the straight multitufted toothbrush and the other half better with the V-shaped toothbrush.

In order to find if a correlation exists between the shape of the toothbrush and the toothbrushing technique used, two dental assistants were trained to do the toothbrushing using four different methods, one of each randomly assigned to the four quadrants in the mouth. As time was not taken into consideration in the first part of the study two dental assistants were asked to perform the brushing for 3 min. The reason for including 12 persons with reduced interdental papillae and 12 where the papillae filled the interdental spaces was to confirm how effective toothbrushing is in removing plaque interdentally. The results obtained after professional toothbrushing showed a more effective plaque removal than after unsupervised toothbrushing performed by the participants themselves. Still there was no difference be-

tween the two brushes tested according to the plaque removal on buccal and lingual surfaces. The interdental plaque removal was greater when the participants were brushed with the V-shaped toothbrush than with the straight multitufted one regardless of the brushing method used. However, plaque remained interdentally in all cases.

The findings of remaining plaque interproximally are in accordance with those reported by BERGENHOLTZ *et al.* (2), GJERMO & FLÖTRA (24), HANSEN & GJERMO (12) and others, and indicate that toothbrushing alone does not clean the interdental part of the tooth sufficiently. YANKELL *et al.* (25) found that the interdental cleaning was doubled by doubling the brushing time, but still there was 80% plaque remaining interdentally.

In the present study the Roll technique on buccal surfaces was less effective and the Bass method more effective on lingual axial surfaces in plaque removal compared to that obtained with other methods on these surfaces. RODDA (5), FRANDSEN *et al.* (6), HANSEN & GJERMO (12) and others also found the Roll technique to be less effective on buccal and lingual surfaces.

A possible explanation of the inferior plaque removal by the Roll technique may be the rounding and thickening of the marginal gingiva due to the fact that prior to the study the participants in the present study except for one (Roll technique) used the Bass, Circular Scrub or the Horizontal Scrub techniques, which can give a rounded contour of the gingival margin.

Comparing the two dental assistants there are no statistically significant differences regarding their removing capacity when using the mean plaque score (index A) or the visible plaque score (index C) but using index B there are differences regarding buccomesial and buccodistal surfaces. The explanation for such differences could be higher pressure on the brushes during brushing by number 2 dental assistant who obtained more zeros in spite of prior calibration of the two brushers. FRANDSEN *et al.* (6), who also used two professional brushers, found differences in their cleaning ability of the participants in their study.

As the present study was performed as an intraindividual study and the dental assistants were assigned to individuals the above difference between the two dental assistants does not affect the conclusions. The reason for choosing the four brushing methods used in the study was to see if the findings would be in accordance with those reported in the literature (12, 18, 26).

In Part 1 all the participants developed gingivitis interproximally after each of the 2-wk periods of unsupervised toothbrushing, confirming the necessity of interdental cleaning.

The design of part 2 in the present study does not permit conclusions as to the prevention of the development of gingivitis or incidence of trauma from toothbrushes or brushing methods tested. This indicates the need for further research.

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References

1. BAY I, KARDEL KM, SKOUGAARD MR. Quantitative evaluation of the plaque-removing ability of different types of toothbrushes. *J Periodontol* 1967; **38**: 526–33.
2. BERGENHOLTZ A, HUGOSON A, LUNDGREN D, ÖSTGREN A. The plaque-removing ability of various toothbrushes used with the roll technique. *Sven Tandlaek Tidsk* 1969; **62**: 15–25.
3. MCCLURE DB. A comparison of toothbrushing techniques for the preschool child. *J Dent Child* 1966; **33**: 205–10.
4. CURTIS GH, MCCALL CM, OVERAA HI. A clinical study of the effectiveness of the roll and Charters' method of brushing teeth. *J Periodontol* 1957; **28**: 277–80.

5. Rodda JC. A comparison of four methods of toothbrushing. *NZ Dent J* 1968; **64**: 162–7.
6. Frandsen AM, Barbano JP, Suomi JD, Chang JJ, Burke AD. The effectiveness of the Charters', scrub and roll methods of toothbrushing by professionals in removing plaque. *Scand J Dent Res* 1970; **78**: 459–63.
7. Frandsen AM, Barbano JP, Suomi JD, Chang JJ, Houston R. A comparison of the effectiveness of the Charters', scrub and roll methods of toothbrushing in removing plaque. *Scand J Dent Res* 1972; **80**: 267–71.
8. Kardel KM, Bay I. Effekten av instruktion i vertikal og horisontal tandbörstning hos skolebörn. *Tandlaegebladet* 1973; **77**: 59–63.
9. Sangnes G. Effectiveness of vertical and horizontal toothbrushing techniques in the removal of plaque. II. Comparison of brushing by six-year-old children and their parents. *J Dent Child* 1974; **41**: 119–23.
10. Kremers L, Lampert F, Etzold C. Vergleichende klinische Untersuchungen zweier Zahnputsmethoden – Roll – und Bass-technik. *Deutsch Zahnaertzl Z* 1978; **33**: 58–60.
11. Shick RA, Ash MM. Evaluation of the vertical method of toothbrushing. *J Periodontol* 1961; **32**: 346–53.
12. Hansen P, Gjermo P. The plaque-removing effect of four toothbrushing methods. *Scand J Dent Res* 1971; **79**: 502–6.
13. Robinson E. A comparative evaluation of the scrub and Bass methods of toothbrushing with flossing as an adjunct (in fifth and sixth graders). *Am J Public Health* 1976; **66**: 1078–81.
14. Plasschaert AJM, Berendsen WJH. Ein Vergleich von 4 Zahnputzmethoden und ihre Erlernbarkeit im Schulalter. *Deutsch Zahnaertzl Z* 1973; **28**: 1200–8.
15. Sangnes G, Zachrisson B, Gjermo P. Effectiveness of vertical and horizontal brushing techniques in plaque removal. *J Dent Child* 1972; **39**: 94–7.
16. Carter HB, Barnes GP, Woolridge ED. Effect of various toothbrushing techniques on gingival bleeding and dental plaque. *Virginia Dent J* 1974; **51**: 18–29.
17. O'Leary TJ. Oral hygiene agents and procedures. *J Periodontol* 1970; **41**: 625–9.
18. Arai T, Kinoshita S. A comparison of plaque removal by different toothbrushes and toothbrushing methods. *Bull Tokyo Med Dent Univ* 1977; **24**: 177–88.
19. Nygaard Östby P, Edvardsen S, Spydevold B. Access to interproximal tooth surfaces by different bristle designs and stiffness of toothbrushes. *Scand J Dent Res* 1979; **87**: 424–30.
20. Bergenholtz A, Bjorne A, Vikström B. The plaque-removing ability of some common interdental aids. An intraindividual study. *J Clin Periodontol* 1974; **1**: 160–5.
21. Silness J, Löe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand* 1964; **22**: 121–5.
22. Nygaard Östby P, Spydevold B, Edvardsen S. Suggestion for a definition, measuring method and classification system of bristle stiffness of toothbrushes. *Scand J Dent* 1979; **87**: 159–70.
23. Nie NH, Hull CH, Jenkins JG, Steinbrenner K, Bent DH. *Statistical package for the social sciences*. 2nd ed. New York: McGraw-Hill, 1975.
24. Gjermo P, Flöttra L. The effect of different methods of interdental cleaning. *J Periodontol Res* 1970; **5**: 230–6.
25. Yankell SL, Stoller NH, Miller MF, Green PA. Development of a clinical method to compare the plaque removal properties of two toothbrushes. *J Dent Res* 1980; **59**: 448: Abstr. 721.
26. Gibson JA, Wade AB. Plaque removal by the Bass and Roll brushing techniques. *J Periodontol* 1977; **48**: 456–9.
27. Maurice CG, Wallace DA. Toothbrush effectiveness: relative cleansing ability of four toothbrushes of different design. *Illinois Dent J* 1957; **26**: 286–92.