

Ability of elementary school children to perform sulcular toothbrushing as related to their hand function ability

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Abstract

Sixty children were selected randomly to participate in the study. Subjects consisted of ten boys and ten girls each from the first, third and sixth grades. Each hand function was tested and a time score obtained for the subject using the non-dominant and dominant hand. Each subject performed each hand function task, and the performance was timed and recorded. During the next three weeks, subjects were given specific instruction and practice sessions in sulcular toothbrushing. Subsequent to instruction and practice sessions, subjects were evaluated on their ability to perform the specified brushing skills. Results of the hand function and toothbrushing evaluations were correlated. Hand function was shown to be an age-related factor in the subject's ability to perform sulcular brushing. Findings further indicated only sixth graders could master the skills required for sulcular brushing.

Introduction

Various studies have been made of the toothbrushing habits of children. Investigations have been directed primarily toward the ability of children to perform different methods of toothbrushing, and performance has been determined by the effectiveness of plaque removal. Although little research evidence supports the superiority of one toothbrushing method over another, the tendency has been to teach children the roll stroke technique.^{1,2} To date, no studies have examined the procedural steps involved in specific toothbrushing methods, the manual skills required to perform each step, or the relationship between the

procedure and the manual skills development of children at different age levels.

Kimmelman and Tassman observed the toothbrushing of 57 children and concluded that the horizontal scrub was the stroke used most frequently. They also found the brushing performance of children under age seven was shorter and more haphazard than children above age seven. Similarly, children under age five brushed less than twenty seconds and some could not wield the brush. There was a tendency for children more often to brush teeth in the lower arch and to favor certain areas such as the facial surfaces of lower anterior teeth. These findings were substantiated in later investigations. In a study of pre-school children, McClure compared the effectiveness of brushing using the roll technique and the horizontal scrub method. The study also compared the ability of the child and the parent to brush the child's teeth effectively. Conclusions supported the work of Kimmelman and Tassman: (1) some three- and five-year-old children were completely unable to wield the toothbrush; (2) scrubbing horizontally was more effective than the roll method when either the child or parent brushed the teeth; (3) most children used the horizontal scrub method when not given instruction; (4) the buccogingival regions on maxillary molars and the linguogingival regions of mandibular teeth retained the greatest amount of stained plaque; and (5) incisal and occlusal two-thirds of facial and lingual surfaces were those brushed most frequently.

Similar findings that the scrubbing method may be useful with pre-schoolers were reported by Sangnes, Zachrisson and Gjermo who compared the plaque removal effect of controlled toothbrushing with four-

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and five-year-old children using the roll and scrub techniques. Results showed brushing with the scrub technique significantly lowered plaque scores on buccal and lingual surfaces. Differences in techniques on proximal surfaces were not statistically significant. The authors suggested that brush placement using the roll technique was more complicated and time consuming, whereas children using a horizontal scrub technique could be involved in active brushing with more ease for a longer period of time. The authors indicated that further study was needed to identify the age at which children can be expected to brush correctly.

As in previously reported studies, Rugg-Gunn and MacGregor¹ found five- and 11-year-old children to prefer brushing with a horizontal stroke. Anterior facial surfaces and teeth in the mandibular arch were brushed more frequently.

Research conducted on the toothbrushing performance of children in the 11 to 15 age range is more controversial. Anaise studied the ability of children 11 to 14 years of age to remove stainable plaque from buccal and lingual surfaces. Brushing methods taught were roll, Charter's, horizontal scrub and modified Stillman's. Results supported previous studies on younger children. Effective plaque removal was related to the complexity of the method used. The highest Patient Hygiene Performance values were associated with Charter's method with differences found statistically significant both on buccal and lingual surfaces. The lowest plaque scores were obtained by those using the horizontal scrub method. In contrast, Robinson's study of fifth and sixth graders showed they had the practical skills required to remove plaque adequately, with or without flossing, using either the scrub or Bass method of toothbrushing.

The findings suggest the need to examine various methods of toothbrushing in relation to the manual dexterity required to perform the method, and the motor skill development of children at different age levels. The following study was designed to:

1. Determine the age at which the majority of elementary school children have sufficient motor skill development to perform sulcular toothbrushing given instruction and supervised practice sessions.
2. Relate toothbrushing ability to a standardized hand functioning test.

Materials and Methods

Sixty children from an elementary school in eastern Iowa participated in the study. Ten boys and ten girls each were selected randomly from the first,

third, and sixth grades. The respective mean age of children in each grade was 6, 8, and 11.

The children were given no formal toothbrushing instruction prior to the study. The parents received a written statement of the purpose of the study, and signed a consent form which did not identify the manual dexterity test or the toothbrushing method to be taught.

The study was administered by three dental hygiene faculty members and two graduate students from The University of Iowa. Prior to conducting the study, examiners were calibrated by duplicating the administration of the hand function test and the toothbrushing steps to be taught.

Assessment of Hand Functioning Ability

A standardized hand function test^{7,8} was given initially to all subjects. The test was selected because it 1) is administered with ease and in a short period of time; 2) utilizes equipment readily available; 3) provides objective measurement of standardized tasks with established norms to compare subjects' performance; 4) assesses broad aspects of hand function commonly used in activities of daily living; and 5) provides documentation on a continuum of ability within each category of hand function tested. Each function was tested and a time score obtained for the subject using both the non-dominant and the dominant hand. Functions tested were 1) simulated page turning; 2) manipulation of small objects; 3) simulated eating; 4) stacking checkers; 5) moving large objects; and 6) moving large weighted objects. Instructions were written and read to each subject to insure consistency of explanation of task to be performed. Each subject performed each task, and the performance was timed in seconds and recorded.

Instruction and Assessment of Ability To Perform Sulcular Toothbrushing

One week after the hand function test, each subject was given an Oral B 20 multitufted toothbrush. First, the subject was told that the instructor would demonstrate in the subject's mouth what he or she was to do. As the instructor provided a standardized demonstration, the subject was to watch closely in a large table mirror. The specific area in which the subject was to work, such as the maxillary anterior teeth, was identified before the demonstration began. The instructor demonstrated and gave verbal explanations. Upon completion of the task, the subject was asked if there were any questions before practicing what had been demonstrated. The instructor then observed the subject perform the task as demonstrated according to the following criteria: 1) bristle tips directed apically; 2) bristle placement at a 45-degree angle to tooth; 3)

Table 1. Dominant hand function mean scores of experimental and standardized subjects

AGE	6-7				8-9				10-11			
	SEX		SEX		SEX		SEX		SEX		SEX	
GROUP	ST	EX	ST	EX	ST	EX	ST	EX	ST	EX	ST	EX
Card Turning	7.9	6.02	8.2	6.41	6.1	6.18	6.6	5.61	4.5	4.53	5.0	4.34
Small Objects	7.7	6.30	7.4	6.16	6.2	5.79	6.7	6.22	5.8	5.69	5.7	6.17
Stack Checkers	4.9	3.89	4.6	3.32	3.8	2.93	3.8	3.02	3.1	1.95	3.4	2.81
Simulated Eating	11.4	11.29	11.4	9.38	11.0	7.96	10.9	8.69	7.5	7.29	7.7	8.83
Moving Large Objects	4.7	3.92	4.5	4.40	3.6	3.20	3.7	3.14	3.3	2.96	3.2	2.66
Moving Large Weighted Objects	5.1	4.38	4.7	4.55	3.8	3.61	3.9	3.50	3.4	3.03	3.2	2.98
TOTAL	42.5	35.84	40.9	35.48	32.1	29.76	35.7	29.86	28.0	25.45	28.5	27.79

ST=Standardized scores^a

EX=Experimental subject scores

bristles introduced into sulcus; and 4) bristles vibrated. The subject was told to continue brushing in the designated area for three minutes. The instructor provided assistance if necessary during the three minute practice period.

For the next three weeks subjects received identical brushing instructions but practiced on mandibular anterior facial surfaces, mandibular posterior buccal surfaces, and maxillary posterior buccal surfaces, respectively. During these sessions, instructors observed each subject practice until the technique was mastered, or for three minutes, whichever came first. (Each of the three instructors provided instruction and practice for a specific group of children at each age level during all practice sessions.)

The fifth week involved an evaluation of the subjects' ability to perform brushing skills on all areas in which they had received instruction and practice. The post-instruction evaluation was performed by the same three instructors. However, the groups were rotated so the examiner for each child was not the same individual who provided instruction, and each evaluator observed an equal number of subjects from each of the other instructor groups. Observations were recorded for each area of the mouth and for each of the four functions included in sulcular toothbrushing. (Performance criteria were recorded as: 0 = never performs correctly, 1 = performs correctly occasionally, 2 = always performs correctly.) For each sub-

test, the child received a score of 0-8. Figure 1 is a copy of the evaluation recording form.

Results

Subjects in this study obtained scores on the hand function test comparable to the standardized scores. They also performed the tasks in generally less time than those in the standardized group. Results are shown in Table 1.

An ANOVA analysis of variance of dominant hand totals by sex showed no significant difference between scores. It produced an F value of 0.00. The probability of F being greater was .98 ($PR < F = .9811$). The same analysis of variance of dominant hand totals by age and grade did show a significant difference. It produced an F value of 13.20 at a significance level of .0001 ($PR < F = .001$).

The Duncan's Multiple Range Test of dominant hand totals by age and grade also showed differences between the first and third grades at the .05 significance level. However, it did not show significant differences between third and sixth graders on dominant hand totals.

An ANOVA analysis of variance showed no significant difference among the four evaluators. It produced an F value of .96 and a $PR < F$ value of .3878.

On the basis of the above analyses, it was concluded that the subjects of this study had hand function abil-

Table 2. Toothbrushing mean scores

	1ST GRADE X		3RD GRADE X		6TH GRADE X	
	N-9 Female	N-10 Male	N-10 Female	N-10 Male	N-10 Female	N-10 Male
Maxillary Anterior	3.7	4.0	5.1	5.0	6.8	6.2
Mandibular Anterior	3.7	3.8	5.3	5.3	6.7	5.5
Maxillary Posterior	3.6	3.0	4.3	5.0	6.8	6.3
Mandibular Posterior	3.1	2.1	4.7	4.8	6.5	6.6
Bristle tips apical	5.7	4.9	6.3	6.8	7.1	7.7
Bristle tips angulated	2.2	3.1	4.0	4.1	6.6	5.5
Bristle tips in sulcus	1.4	1.6	3.2	3.2	6.2	4.9
Bristle tips vibrated	5.3	3.4	5.9	6.0	6.9	6.5
TOTAL	14.5	12.9	19.4	20.1	27.2	24.6

ity comparable with a standardized group of the same age, and that differences in hand function by age were significant. There were no significant differences found in hand function by sex.

The results of the toothbrushing test showed that as age increased, ability to perform toothbrushing increased. The mean scores by age and sex are presented in Table 2.

An ANOVA analysis of variance of total score by grade level produced an F value of 23.89 which was significant at the .0001 level ($PR < F = .0001$). The Duncan's Multiple Range Test also showed significant differences between total toothbrush scores by grade at a .05 level.

An ANOVA analysis of variance was performed on each of the toothbrushing subtests by grade to determine which of the sub-tests contributed to the total. All of the sub-tests showed significant difference between grades. There were much greater differences between the grade level subjects on posterior subtests, and on bristle tip angulation and placement, than on the other four sub-tests. Results are shown on Table 3.

Further analysis of variance with Duncan's Multiple Range Test for variables by grade showed significant differences at .05 level between first and sixth graders on all toothbrushing subtests. However, there were not significant differences between third and sixth graders on maxillary anterior sub-test or between first and third graders on mandibular anterior sub-tests. Sub-tests of placing the tips apically and vibrating

Table 3. ANOVA analysis of variance of toothbrushing mean scores by grade

Subtests	F value	Significance
Maxillary anterior	8.55	.0006
Mandibular anterior	9.47	.0003
Maxillary posterior	24.64	.0001
Mandibular posterior	32.42	.0001
Bristle tips apical	5.66	.0058
Bristle tips angulated	14.67	.0001
Bristle tips in sulcus	33.97	.0001
Bristle tips vibrated	4.30	.0183
TOTAL	23.89	.0001

the bristles showed no significant difference between first and third graders or between third and sixth graders.

An ANOVA analysis of scores by evaluator showed no significant difference. It produced an F score of 2.75 and $PR < F$ of .0724. Although this approaches a significant value, equal distribution of grade level subjects among evaluators would not affect the variance of mean scores by grade.

The results of correlation of hand function total scores with total toothbrushing scores produced a correlation coefficient of .337 which is significant at the .001 level. The toothbrushing total and sub-test score were correlated with hand function total scores. Results are shown in Table 4. Abilities in toothbrushing on posterior teeth, and ability to angulate bristle tips

Table 4. Correlation of hand function test total with toothbrushing scores

<i>Toothbrushing tests</i>	<i>Correlation coefficient</i>	<i>Significance</i>
Maxillary anteriors	.23104	.0783
Mandibular anteriors	.12885	.3308
Maxillary posteriors	.36173	.0049
Mandibular posteriors	.44802	.0004
Bristle tips apical	.20418	.1209
Bristle tips angulated	.25008	.0561
Bristle tips in sulcus	.37626	.0033
Bristle tips vibrated	.21050	.1095
TOTAL	.33656	.0091

and to introduce bristle tips into the sulcus most significantly were correlated with hand functioning.

The only significant correlation between hand function total and toothbrushing total by grade and sex was for third grade males. This produced a correlation coefficient of .755 which was significant at the .01 level. All other correlations of hand function test totals and toothbrush test totals by sex and grade failed to reach a .1 level of significance. In addition none of the hand function sub-tests correlated significantly with any toothbrushing sub-test or with total score.

Discussion

Sulcular toothbrushing required that subjects progress from simple to more complex hand function skills. During initial instructional sessions, first graders had noticeable difficulty with the simple tasks of finding the correct area to brush and apical placement of bristle tips. Initially, the third graders had difficulty adapting the brush to canines and to areas where teeth were missing. Neither the first nor the third grade group was able to place the bristle tips subgingivally or to use small vibrating motions. In contrast, during the first session, sixth graders were able to place bristles in correct position, although they had difficulty angulating the bristles to slip into the sulcus.

After four instruction and practice sessions, all age groups could master placement of bristles in one direction (apical), and one type of brushing motion (vibration). Younger children could not change direction of the bristle tips (angulation), or combine movements to allow bristles to be placed in the gingival sulcus. McClure^{2,3} found that preschool children could perform the horizontal scrub toothbrushing method which also required placement of brush in one direction (facial or lingual), and one brushing motion (horizontal).

Sixth grade children accomplished the more complex tasks of angulating the bristles, and the small motor skill movement of placing bristles in the gingival sulcus. Therefore, only sixth graders could accomplish subgingival plaque removal which is the objective of sulcular toothbrushing. These results support Robinson's⁶ findings that sixth graders could remove plaque effectively using the Bass method of toothbrushing.

Successful performance of sixth grade students in this study suggested that, given instruction and practice, this age student had sufficient hand function ability to perform the task. The inability of first and third grade students to master the skills suggested that toothbrushing ability was related more to age than to instruction and practice. A control group at each age level would have improved the validity of the findings.

Conclusion

Although this study may be criticized for not including an oral hygiene index to measure the effectiveness of toothbrushing, assessment of plaque removal was not the intent of the investigation. The authors felt that inclusion of an additional objective might have interfered with student performance of sulcular toothbrushing according to the specified criteria. As previously stated, other studies had shown that fifth and sixth graders could remove plaque effectively using the Bass toothbrushing technique. Some studies have suggested that children eight years of age and younger do not have sufficiently developed motor coordination to perform complex tasks that require fine motor skills. This investigation supported that assumption.

Results of the study also indicated that hand function was an age-related factor in subjects' ability to perform sulcular toothbrushing. Hand function test scores, however, were not accurate predictors of individual subject's toothbrushing ability which may have been due to the small sample for each age group.

The authors suggest that sulcular toothbrushing requires hand functions that are beyond the ability level of most first graders and many third graders. It therefore is recommended that classroom oral hygiene instruction for children eight years of age and younger emphasize a toothbrushing method which is less complex than sulcular toothbrushing.

References

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Figure 1. Toothbrushing evaluation form.

Date: Evaluator: A B C	Student name:		Grade:		Total
	Maxillary Anterior	Mandibular Anterior	Maxillary Posterior	Mandibular Posterior	
Bristle tips apical	0-1-2	0-1-2	0-1-2	0-1-2	(8)
Bristle tips angulated	0-1-2	0-1-2	0-1-2	0-1-2	(8)
Bristle tips in sulcus	0-1-2	0-1-2	0-1-2	0-1-2	(8)
Bristle tips vibrated	0-1-2	0-1-2	0-1-2	0-1-2	(8)
TOTAL	(8)	(8)	(8)	(8)	(32)

0=never performs correctly
 1=performs correctly occasionally
 2=always performs correctly
 () indicate highest possible score

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