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## Effect of toothbrush grip on plaque removal during manual toothbrushing in children

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**Abstract:** Toothbrushing is fundamental to oral hygiene. Children differ in manual dexterity and their grip on toothbrushes. We videotaped toothbrushing sessions and observed the grip type, duration of brushing, and brushing technique used among 100 children aged 8-12 years. We then investigated the association between grip type and plaque removal, using plaque scores obtained at various time points. We further examined the effect on plaque scores of standardizing both brushing technique and duration among the same participants. The most common grip was the distal oblique, followed by the oblique; the spoon and precision grips were rare, and no child used a power grip. Mean brushing duration for most children was  $1.43 \pm 0.85$  min, and the most common brushing technique was horizontal scrubbing. We conclude that grip preference is inherent and that the distal oblique grip was better than the oblique grip in removing plaque. (J Oral Sci 54, 183-190, 2012)

Keywords: grip; brushing; plaque; videotaping; oral hygiene.

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### Introduction

The three basic circles of the triad of Paul Keyes (1) illustrate the basic etiologic factors of dental caries. One

factor is the microorganisms that accumulate and form biofilm, known as dental plaque, which has a role in the etiology of gingivitis (2-5). Studies have confirmed the high prevalence of gingival inflammation in children (6,7). Rapidly progressive periodontal conditions that result in loss of primary and permanent teeth are increasingly frequent, and the important risk factors for caries are associated with attitudes and behaviors. Strategies to control caries include effective oral hygiene practices that reduce biofilm development and a low-sugar diet to restrict periods of acidic challenge to teeth (8,9). Skill in toothbrushing develops from a young age to adolescence, and children are typically given increasing responsibility for their toothbrushing from the age of approximately 6 years.

Toothbrush design, brushing duration, parental involvement, and the brushing method, manipulative skill, and manual dexterity of the child are the most cited determinants of the effectiveness of toothbrushing. Nevertheless, it is generally believed that toothbrushing is inefficient among children younger than 10 years, perhaps due to lack of motivation and poor manual dexterity, which are normal at this age (10). Video techniques are commonly used in developmental psychology (11) but have rarely been used in dental research. Previous research using video recordings of toothbrushing sessions involved young adults or schoolchildren who were unaware that they were being filmed (12-15). Beals et al. (16) documented the interaction between the human hand and toothbrush during a toothbrushing session. They observed five grips, namely, the distal oblique and power grips, which use the palm of the hand, and the oblique, precision, and spoon grips, which rely on the fingers (Fig. 1). A few studies (16-18) have documented the relation-

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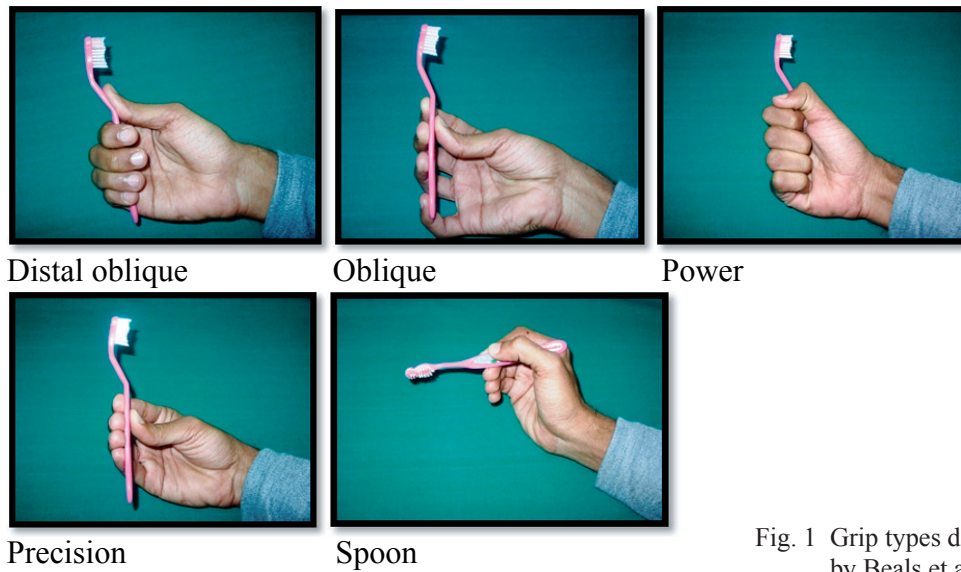


Fig. 1 Grip types described by Beals et al. (16)

ship between the grips used by children and the manual dexterity of the children, but none has examined the association of grip with effective plaque removal.

In this study, we observed and documented the grips used to hold a toothbrush during a toothbrushing session, recorded brushing duration and the brushing techniques used by children during a toothbrushing session, investigated the association between grip type and effectiveness of plaque removal, and assessed plaque reduction after standardizing brushing time and brushing technique among the same group of children.

## Materials and Methods

### Participants

We studied 100 girls and boys aged 8-12 years who sought treatment at the clinics of the Department of Pedodontics and Preventive Dentistry, K. D. Dental College and Hospital, Mathura, India. All children were in good general health and agreed to comply with the study visits and procedures of the study. Informed consent was obtained from parents, and birth certificates were checked to confirm the dates of birth of the children. The study protocol was reviewed and approved by the Institutional Ethical Committee of Kanti Devi Dental College and Hospital, Mathura, Uttar Pradesh, India, affiliated to Dr. B. R. Ambedkar University, Agra, Uttar Pradesh, India, and it was divided into two visits.

### Exclusion criteria

Children were excluded if they had an underlying systemic condition that limited their manual dexterity,

if they had received antibiotics or nonsteroidal anti-inflammatory agents within 1 month before the start of the study, if they were undergoing orthodontic treatment or were wearing a prosthetic appliance, or if they were not using a toothbrush to clean their teeth.

### Study design

Participating children were asked to avoid toothbrushing in the evening and morning before clinical examinations and registration. At the first visit, baseline plaque score ( $Ps_1$ ) was recorded according to the criteria of Sillness and Loe (19). All children were given the same type of toothbrush (Classic Junior, Sinhal Metal Industries Ltd., Delhi, India), which satisfied the British Standard specifications for toothbrushes (BS 5757-1979), and were asked to spread the toothpaste and brush their teeth as they usually did at home. The toothbrushing session was recorded using a digital video camera (DSC-W270, Sony Corp, Tokyo, Japan) that was positioned, on a Simpex Lightweight Tripod 333, at a distance of 10 feet from participants. The participants were unaware that they were being recorded. After brushing, the plaque score was calculated again ( $Ps_2$ ) according to the same criteria (19). Video recordings of the toothbrushing sessions were transferred to a personal computer and were viewed to analyze the hand and grip used to hold the toothbrush, as described by Beals et al. (16). The duration of toothbrushing and the toothbrushing technique used by the children were also analyzed. On the same visit, a standardized method of brushing (the modified Stillman technique) (20) was taught to the children, and they were

Table 1 Distribution of brushing techniques

| Brushing technique               | No. |
|----------------------------------|-----|
| Horizontal scrubbing             | 81  |
| Vertical strokes                 | 0   |
| Horizontal + vertical strokes    | 10  |
| Horizontal + vertical + circular | 1   |
| Total                            | 92  |

Table 2 Distribution of grip types

| Grip           | No. |
|----------------|-----|
| Oblique        | 25  |
| Spoon          | 1   |
| Precision      | 1   |
| Distal oblique | 65  |
| Total          | 92  |

instructed to brush with this method for 7 days using the same brush and the provided toothpaste for 3 min every day. At the second visit, children were instructed to brush their teeth for the same duration using the new technique, and the toothbrushing session was recorded as described above. Plaque score ( $Ps_3$ ) was calculated again in the same manner (19).

We analyzed the grips used by the 100 children, plaque reduction after toothbrushing with the respective grips, and change in plaque score with their usual grips after brushing instruction.

### Statistical analysis

The Statistical Package for Social Sciences (SPSS) Version 11.5 for Windows was used to analyze the data. The independent *t* test was used to compare plaque scores with respect to grip. Comparison of plaque scores at different time points was done using the paired *t* test. A *P* value less than 0.05 was considered to indicate statistical significance.

### Results

Among the 100 children (mean age  $10 \pm 1.29$  years) selected for the study, 92 children retained their grip and eight children modified their grip after learning the standardized brushing technique, i.e., the modified Stillman technique (20). Therefore, data from the latter eight children were analyzed separately from those of the remaining 92 children. Among the 92 children, 87 used their right hand and five used their left hand during the toothbrushing sessions. Mean brushing duration was  $1.43 \pm 0.85$  min for the 92 children and  $1.29 \pm 0.30$  min for the remaining eight children. The brushing techniques

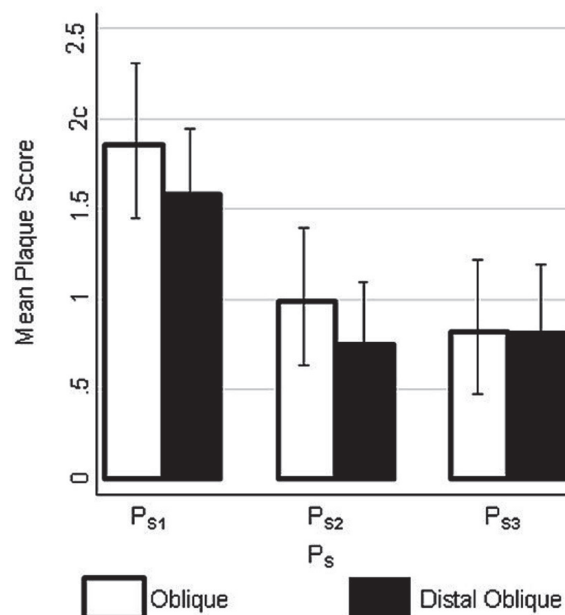


Fig. 2 Plaque scores ( $Ps_1$ ,  $Ps_2$ , and  $Ps_3$ ) by grip type in 92 children

Table 3 Distribution of plaque scores by grip type

| Grip           | No. | $Ps_1$          | $Ps_2$          | $Ps_3$          |
|----------------|-----|-----------------|-----------------|-----------------|
| Oblique        | 25  | $1.85 \pm 0.43$ | $0.99 \pm 0.38$ | $0.82 \pm 0.37$ |
| Distal oblique | 65  | $1.58 \pm 0.35$ | $0.75 \pm 0.32$ | $0.81 \pm 0.36$ |
|                | 90  | $1.65 \pm 0.38$ | $0.81 \pm 0.35$ | $0.81 \pm 0.36$ |

$Ps_1$ : Baseline plaque score,  $Ps_2$ : Plaque score immediately after brushing,  $Ps_3$ : Plaque score immediately after brushing at the second visit (at 1 week interval)

and grips of the 92 children are shown in Table 1 and Table 2, respectively. The most common technique was horizontal scrubbing, and the most common grip was the distal oblique, followed by the oblique, spoon, and precision grips, in descending order of frequency. The remaining eight children preferred the horizontal scrubbing technique, and the most common grip was the distal oblique, followed by the oblique.

The plaque scores at various time points (i.e.,  $Ps_1$ ,  $Ps_2$ , and  $Ps_3$ ) for each grip among 90 children (one child with a spoon grip and one child with a precision grip were not included in the statistical analysis) are shown in Table 3 and Fig. 2. There was a marked reduction in plaque score after brushing; however,  $Ps_3$  did not substantially differ from  $Ps_2$  in the 90 children. Table 4 shows the statistically significant differences between the distal oblique grip group and the oblique grip group with respect to  $Ps_1$  and  $Ps_2$ ; the difference in  $Ps_3$  was not significant.

Table 5 shows plaque scores at the first and second visits for 90 children: 25 children using the oblique grip

Table 4 Comparison of plaque scores for children using oblique (OB) and distal oblique (DOB) grips

|                 | Grip | <i>n</i> | Mean | SD   | <i>t</i> test | <i>P</i> | NS/S |
|-----------------|------|----------|------|------|---------------|----------|------|
| Ps <sub>1</sub> | OB   | 25       | 1.85 | 0.43 | 3.068         | 0.003    | S    |
|                 | DOB  | 65       | 1.58 | 0.35 |               |          |      |
| Ps <sub>2</sub> | OB   | 25       | 0.99 | 0.38 | 3.051         | 0.003    | S    |
|                 | DOB  | 65       | 0.75 | 0.32 |               |          |      |
| Ps <sub>3</sub> | OB   | 25       | 0.82 | 0.37 | 0.154         | 0.878    | NS   |
|                 | DOB  | 65       | 0.81 | 0.36 |               |          |      |

S: Significant, NS: Not significant  
 Ps<sub>1</sub>: Baseline plaque score, Ps<sub>2</sub>: Plaque score immediately after brushing, Ps<sub>3</sub>: Plaque score immediately after brushing at the second visit (at 1 week interval), OB: Oblique grip, DOB: Distal oblique grip

Table 5 Comparison of plaque scores at various time points in 90 children

|        |                 | Mean | SD   | <i>t</i> test | <i>P</i> | NS/S |
|--------|-----------------|------|------|---------------|----------|------|
| Pair 1 | Ps <sub>1</sub> | 1.66 | 0.39 | 25.197        | 0.000    | S    |
|        | Ps <sub>2</sub> | 0.82 | 0.36 |               |          |      |
| Pair 2 | Ps <sub>1</sub> | 1.66 | 0.39 | 17.644        | 0.000    | S    |
|        | Ps <sub>3</sub> | 0.81 | 0.36 |               |          |      |
| Pair 3 | Ps <sub>2</sub> | 0.82 | 0.36 | 0.083         | 0.934    | NS   |
|        | Ps <sub>3</sub> | 0.81 | 0.36 |               |          |      |

S: Significant, NS: Not significant  
 Ps<sub>1</sub>: Baseline plaque score, Ps<sub>2</sub>: Plaque score immediately after brushing, Ps<sub>3</sub>: Plaque score immediately after brushing at the second visit (at 1 week interval)

(detailed in Table 6) and 65 using following the distal oblique grip (detailed in Table 7). Overall mean plaque score at baseline (Ps<sub>1</sub>) significantly differed from that immediately after brushing (Ps<sub>2</sub>) and after 7 days (Ps<sub>3</sub>). Similar, significant differences were seen in the 25 and 65 patients using the oblique and distal oblique grips, respectively. However, plaque scores after brushing during the first visit (Ps<sub>2</sub>) were almost equal to those obtained 7 days later. Therefore, plaque scores immediately after brushing (Ps<sub>2</sub>) and those 7 days later (Ps<sub>3</sub>) did not significantly differ.

The plaque scores at various time points, i.e., Ps<sub>1</sub>, Ps<sub>2</sub>, and Ps<sub>3</sub>, for each grip among the remaining eight children are shown in Table 8 and Figs. 3 and 4. Table 9 shows plaque scores at different time points among the 5 children (most of the remaining eight children) who, after learning the new technique, changed their grip from oblique to distal oblique. Statistical analysis revealed that Ps<sub>1</sub> significantly differed from Ps<sub>2</sub> and Ps<sub>3</sub>, but that the difference between Ps<sub>2</sub> and Ps<sub>3</sub> was not significant. Table 10 shows Ps<sub>1</sub>, Ps<sub>2</sub>, and Ps<sub>3</sub> for the 3 children who changed their grip from distal oblique to oblique after learning the

Table 6 Comparison of plaque scores at various time points in 25 children using an oblique grip

|        |                 | Mean | SD   | <i>t</i> test | <i>P</i> | NS/S |
|--------|-----------------|------|------|---------------|----------|------|
| Pair 1 | Ps <sub>1</sub> | 1.85 | 0.43 | 13.730        | 0.000    | S    |
|        | Ps <sub>2</sub> | 0.99 | 0.38 |               |          |      |
| Pair 2 | Ps <sub>1</sub> | 1.85 | 0.43 | 10.626        | 0.000    | S    |
|        | Ps <sub>3</sub> | 0.82 | 0.37 |               |          |      |
| Pair 3 | Ps <sub>2</sub> | 0.99 | 0.38 | 1.737         | 0.095    | NS   |
|        | Ps <sub>3</sub> | 0.82 | 0.37 |               |          |      |

S: Significant, NS: Not significant  
 Ps<sub>1</sub>: Baseline plaque score, Ps<sub>2</sub>: Plaque score immediately after brushing, Ps<sub>3</sub>: Plaque score immediately after brushing at the second visit (at 1 week interval)

Table 7 Comparison of plaque scores at various time points in 65 children using a distal oblique grip

|        |                 | Mean | SD   | <i>t</i> test | <i>P</i> | NS/S |
|--------|-----------------|------|------|---------------|----------|------|
| Pair 1 | Ps <sub>1</sub> | 1.58 | 0.35 | 20.998        | 0.000    | S    |
|        | Ps <sub>2</sub> | 0.75 | 0.32 |               |          |      |
| Pair 2 | Ps <sub>1</sub> | 1.58 | 0.35 | 14.681        | 0.000    | S    |
|        | Ps <sub>3</sub> | 0.81 | 0.36 |               |          |      |
| Pair 3 | Ps <sub>2</sub> | 0.75 | 0.32 | 1.097         | 0.277    | NS   |
|        | Ps <sub>3</sub> | 0.81 | 0.36 |               |          |      |

S: Significant, NS: Not significant  
 Ps<sub>1</sub>: Baseline plaque score, Ps<sub>2</sub>: Plaque score immediately after brushing, Ps<sub>3</sub>: Plaque score immediately after brushing at the second visit (at 1 week interval)

Table 8 Distribution of plaque scores by grip type in eight children who changed grips

| Grip Type      | <i>n</i> | Ps <sub>1</sub> | Ps <sub>2</sub> |
|----------------|----------|-----------------|-----------------|
| Oblique        | 5        | 1.58 ± 0.26     | 0.85 ± 0.27     |
| Distal oblique | 3        | 1.51 ± 0.20     | 0.67 ± 0.23     |
|                | 8        | 1.55 ± 0.22     | 0.78 ± 0.26     |

Ps<sub>1</sub>: Baseline plaque score, Ps<sub>2</sub>: Plaque score immediately after brushing

new technique; the difference between Ps<sub>1</sub> and Ps<sub>3</sub> was not significant.

### Discussion

The impact of grip on toothbrushing cannot be underestimated. The ability of children to manipulate toothbrushes in the oral cavity varies according to their dexterity at different stages of their physical and neurological development. It is logical to assume that the more efficient the brushing technique, the better the effectiveness of plaque removal from the various surfaces of the teeth. Toothbrushing is not like painting or scrubbing

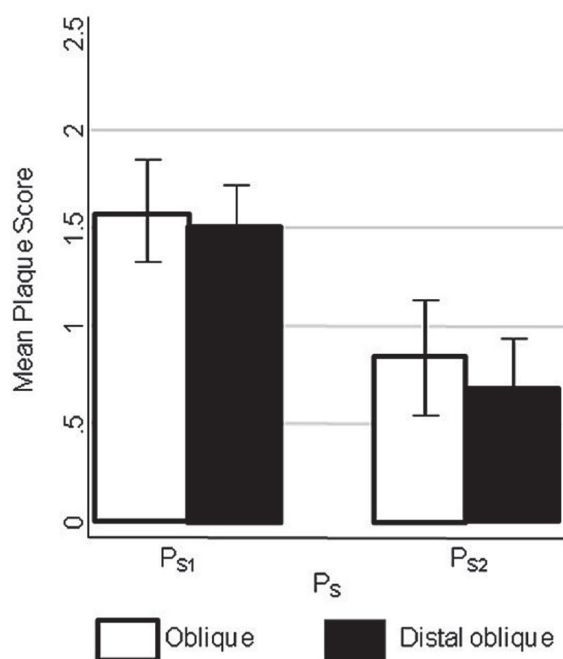


Fig. 3 Plaque scores ( $Ps_1$  and  $Ps_2$ ) by grip type in eight children who changed grip

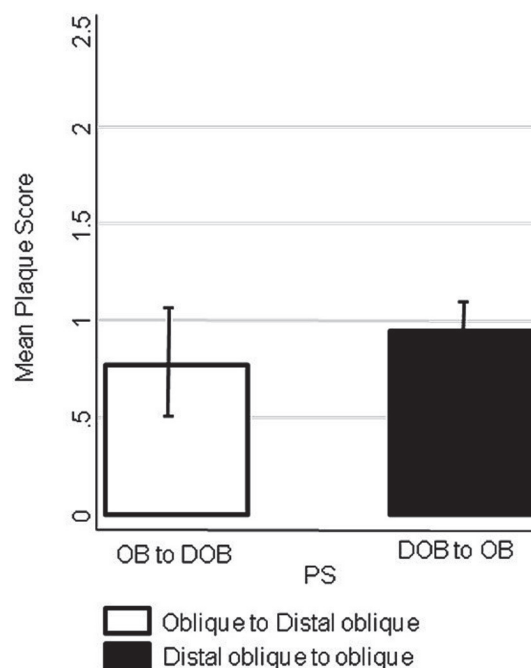


Fig. 4 Plaque scores ( $Ps_3$ ) by grip type in eight children who changed grip

Table 9 Comparison of plaque scores at various time points in five children who changed from an oblique to a distal oblique grip

|        |        | Mean | SD   | <i>t</i> test | <i>P</i> | NS/S |
|--------|--------|------|------|---------------|----------|------|
| Pair 1 | $Ps_1$ | 1.58 | 0.26 | 4.910         | 0.008    | S    |
|        | $Ps_2$ | 0.85 | 0.28 |               |          |      |
| Pair 2 | $Ps_1$ | 1.58 | 0.26 | 4.196         | 0.014    | S    |
|        | $Ps_3$ | 0.77 | 0.28 |               |          |      |
| Pair 3 | $Ps_2$ | 0.85 | 0.28 | 0.552         | 0.611    | NS   |
|        | $Ps_3$ | 0.77 | 0.28 |               |          |      |

S: Significant, NS: Not significant

$Ps_1$ : Baseline plaque score,  $Ps_2$ : Plaque score immediately after brushing,  $Ps_3$ : Plaque score immediately after brushing at the second visit (at 1 week interval)

Table 10 Comparison of plaque scores at various time points in three children who changed from a distal oblique to an oblique grip

|        |        | Mean | SD   | <i>t</i> test | <i>P</i> | NS/S |
|--------|--------|------|------|---------------|----------|------|
| Pair 1 | $Ps_1$ | 1.51 | 0.21 | 6.871         | 0.021    | S    |
|        | $Ps_2$ | 0.68 | 0.24 |               |          |      |
| Pair 2 | $Ps_1$ | 1.51 | 0.21 | 2.911         | 0.101    | NS   |
|        | $Ps_3$ | 0.95 | 0.13 |               |          |      |
| Pair 3 | $Ps_2$ | 0.68 | 0.24 | 1.527         | 0.266    | NS   |
|        | $Ps_3$ | 0.95 | 0.13 |               |          |      |

S: Significant, NS: Not significant

$Ps_1$ : Baseline plaque score,  $Ps_2$ : Plaque score immediately after brushing,  $Ps_3$ : Plaque score immediately after brushing at the second visit (at 1 week interval)

a wall, as it requires manipulation of the brush around different surfaces of the teeth and in various inaccessible areas, which might not be possible for a younger child. Considerable effort has been made in understanding the relationship between grips (16-18). Whether grip type and brushing technique are closely related in their combined effect on plaque removal is an important point for clinicians.

The present study was divided in two visits. During the first visit, children were asked to brush their teeth using their usual technique. Most children brushed their teeth with horizontal scrubbing. Several studies (21-23)

reported that horizontal scrubbing was the method of choice among young children and that they were unable to use other toothbrushing methods. Mescher et al. (24) reported that 6- and 8-year-old children had difficulty performing sulcular brushing and that hand function was age related.

The development of motor skills associated with toothbrushing behavior in children seems to be age related. Horizontal scrubbing is a suitable technique, when motor skills development is considered. McDonneal and Domalakes (25) reported that younger school children instructed in the roll technique reverted to simple scrub



technique.

Mean brushing duration for the group of 92 children in this study was  $1.43 \pm 0.85$  min. Macgregor and Rugg-Gunn (26) found that overall brushing time was 1.3 min in 85 uninstructed children aged 11-13 years. Das and Singhal (18) reported a mean brushing time of 1.27 min among children aged 9-11 years. In the present study, the most common grip was the distal oblique grip—as was with the case in Beals et al. (16), Mentis and Atukeren (17), and Das and Singhal (18)—followed by the oblique, spoon, and precision grips. No child used a power grip in this study.

Toothbrushing technique normally comprises vigorous horizontal, vertical, and/or circular movements. Horizontal scrubbing successfully removes the plaque from smooth outer and inner surfaces of the teeth; however, it is generally considered detrimental because vigorous scrubbing can encourage gingival recession and, with a dentifrice of sufficient abrasiveness and a hard textured toothbrush, can create areas of tooth abrasion (27). Hence, in the present study children were taught the Modified Stillman technique (20) of toothbrushing, which incorporates a rolling stroke after the vibratory phase. It minimizes gingival trauma and increases the efficiency of biofilm removal from tooth surfaces.

There was a marked reduction in plaque scores immediately after brushing among children using an oblique or distal oblique grip, but plaque scores after 7 days (during the second visit) were almost equal to those immediately after brushing. Overall mean plaque score at baseline ( $Ps_1$ ) significantly differed from those immediately after brushing ( $Ps_2$ ) and 7 days later ( $Ps_3$ ) ( $P < 0.05$ ). However, the difference in plaque score after 7 days ( $Ps_3$ ) did not differ from that immediately after brushing ( $Ps_2$ ). There was little difference in plaque scores after 7 days and those immediately after brushing, but plaque scores immediately after brushing were maintained, and  $Ps_3$  was almost equal to  $Ps_2$ . These findings show that the children did not use the technique properly. Nevertheless, the children did at least attempt to maintain their oral hygiene after the first visit, which is evident from the observable reduction in plaque scores for the second visit versus the first visit. Thus, we conclude that the oral hygiene of children can be improved by motivating them and instructing them a new brushing technique. We tried to improve their oral hygiene by teaching them a new technique without changing their usual grips, as grips are inherent and difficult to modify.

The experimental situation, i.e., video recording, may have put some children under pressure, but it is obvious from our analysis of the recordings that the lack of

motor skills might have had a role in some individuals. To our knowledge, there are no data on when children usually develop the motor skills to brush their own teeth. It is generally believed that children need help with toothbrushing until age 10 years. Although electric toothbrushes are better than manual brushes at reducing plaque (28), there is little evidence that electric toothbrushes help children with unacceptable oral hygiene. Perhaps children must acquire adequate knowledge of manual brushing technique before other devices are introduced. If the child lacks the motor or physiological development required for good brushing, parents should help.

In this study, eight children changed their grip during the second visit and thus were analyzed as a separate group. All eight children were right-handed and used horizontal scrubbing technique. Their mean brushing duration was  $1.29 \pm 0.30$  min. Among these eight children, five used an oblique grip and three used an distal oblique grip.  $Ps_2$  was markedly lower than  $Ps_1$  among this group, and  $Ps_2$  and  $Ps_3$  were almost equal.

Among the above eight children, five changed their grip from oblique to distal oblique and three changed from distal oblique to oblique after learning the new brushing technique. Among the five children who switched to a distal oblique grip, the differences between  $Ps_1$  and  $Ps_2$  and between  $Ps_1$  and  $Ps_3$  were statistically significant ( $P < 0.05$ ), but the difference between  $Ps_2$  and  $Ps_3$  was not, which indicates that these children did not properly learn the new technique. Among the remaining three children who switched to an oblique grip, the difference between  $Ps_1$  and  $Ps_2$  was statistically significant ( $P < 0.05$ ), but the difference between  $Ps_2$  and  $Ps_3$  was not, as was the case for the other groups in the study. However, the difference between  $Ps_1$  and  $Ps_3$  was also not significant among these children, in contrast to the results for the remaining 95 children, which clearly showed that the children had completely failed to follow the technique and oral hygiene instructions.

The video recordings of toothbrushing during the second visit confirmed that the children had not adopted the new toothbrushing technique. Sandström et al. (29) evaluated toothbrushing behavior in children aged 6-12 years by recording brushing technique and concluded that plaque removal from the buccal surfaces was poor, averaging 19% for 6-year-olds and 30% for older children. They suggested that brushing results for children aged 8-12 years could benefit from increased toothbrushing time. We believe that it is difficult for children in this age group to learn a new brushing technique, because hand function seems to be related to their age and the development of motor skills. However, it is clear that the

children at least attempted to maintain their oral hygiene after the first visit, as indicated by the obvious reduction in plaque scores from the first visit to the second visit. We attempted to improve their oral hygiene by teaching them an alternative technique, while retaining their usual grip, as grips are inherent and difficult to modify. Further studies with larger sample sizes are needed to establish a relationship between grip and effective plaque removal.

The most common grip was the distal oblique, followed by the oblique grip; spoon and precision grips were rare. The most common brushing technique was horizontal scrubbing, and mean brushing duration among most of the children was  $1.43 \pm 0.85$  min. Grip preference is inherent, but the distal oblique grip was better than the oblique grip for effective plaque removal. Children in this age group had difficulty learning a new toothbrushing technique. No significant reduction in plaque score was observed even after standardizing brushing time and brushing technique.

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