ARTICLE

ABSTRACT

Aim: To compare the effectiveness of two toothbrush designs in tooth brushing by nurses of individuals with cerebral palsy. Methods: Following instruction, nurses brushed the teeth of 21 individuals with a single-headed-toothbrush, and 22 with a triple-headed-toothbrush. After one month, the nurses brushed their patients with the other toothbrush, following instruction. Tooth brushing performance skill was evaluated and scored using the TB-PS-I/Ashkenazi index following the first brushing as well as on a recall visit one month later. Results: After 1 month, 7.6% of the nurses required further instruction following brushing with the triple-headed toothbrush compared to 15% after brushing with the single-headed. Reductions in plaque and gingival indices were greater after using the triple- headed than single-headed toothbrush. More nurses preferred the triple-headed toothbrush (75.5% compared to 22.6%). Conclusion: Brushing by nurses of cerebral palsy patients was more effective and instruction better retained with a triple-headed compared to single-headed toothbrush.

KEY WORDS: oral-hygiene, plaque, gingivitis, handicapped, health-providers

The effect of toothbrush design on the ability of nurses to brush the teeth of institutionalized cerebral palsy patients

Moran Yitzhak, DMD;[1] Haim Sarnat, DMD, MSc;[2] Meir Rakocz, DMD, MHA;[3] Yaniv Yaish, DMD;[1] Malka Ashkenazi, DMD[4]*

[1]Graduating student, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Tel-Aviv, Israel; [2]Professor emeritus in Pediatric Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Tel-Aviv, Israel; [3]Division of Pediatric and Hospital Dentistry, The Chaim Sheba Medical Center, Tel Hashomer, Israel; [4]Formerly, Senior Lecturer in Pediatric Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Tel-Aviv, Israel; Currently, Pediatric Dentistry Dental Clinic, Petach-Tikva, Israel.
*Corresponding author e-mail: Malka.ashkenazi@gmail.com

Spec Care Dentist 33(1): 20-27, 2013

Introduction

Cerebral palsy (CP) is characterized by palsy, muscle weakness and uncontrolled, unpredictable, uncoordinated and unmanageable movements. Of those affected, some suffer from mental retardation (45%), speech impairment (50–75%), vision impairment (20–50%) and convulsions (35–60%).[1] Spastic patients may also suffer from uncontrolled oral and perioral muscles, which cause difficulties in mastication and swallowing, and contribute to increased accumulation of food debris in the oral cavity. Moreover, some consume anticonvulsant medications (such as Phenitoin) that increase gingival overgrowth, especially in the presence of inadequate oral hygiene.[1] Several clinical studies found individuals with CP to suffer more frequently from high bacterial plaque accumulation, gingivitis and gingival overgrowth than healthy children.[2-5]

Appropriate toothbrush design has been shown to increase the effectiveness of tooth brushing. The manual triple-headed toothbrush (Dr. Barman "Superbrush", Dentaco AS, Haukeland, Norway) was designed to simultaneously clean the lingual, buccal and occlusal tooth surfaces. Two separate studies found this toothbrush to be superior to the single-headed toothbrush in reducing bacterial plaque, gingival and bleeding indices in normal and handicapped children, aged 4 to 15 years old.[6,7] In contrast, Sauvetre et al. reported comparable effectiveness of bacterial plaque removal following tooth brushing with a conventional, electric or triple- headed toothbrush in CP children. The authors concluded that even brushing with a triple- headed toothbrush required minimal skill that the handicapped participants were evidently lacking.[8]

Transferring the responsibility of tooth brushing to another person has also been shown to increase effectiveness.[1,5,9] Nevertheless, even the tooth brushing of children with CP by a nurse is a complicated task. Difficulties start with the seating of the patients, uncontrolled movement of the tongue,

©2012 Special Care Dentistry Association and Wiley Periodicals, Inc.
doi: 10.1111/j.1754-4505.2012.00311.x

increased gag reflex, the tendency to firmly close jaws, making it difficult to insert the toothbrush into the mouth, the presence of dyskinetic movements and difficulty in spitting. Moreover, speech problems often hinder communication with these individuals. Many of the nurses in institutions for the handicapped are immigrants who do not speak the native language fluently, thus exacerbating communication problems.

The compliance of nurses regarding their own oral hygiene was studied by Zadik *et al*. They found that nurses had a relatively high frequency of tooth brushing and flossing but a low frequency of periodic examination and scaling.[10] Gil-Montoya *et al*. investigated the awareness and commitment of nurses to maintain oral hygiene of adult institutionalized patients in Spain. Dental plaque was detected in 90% of the patients, and gingivitis in more than half, even though 97% of the nurses reported receiving instruction for maintaining oral hygiene.[11] Though tooth brushing of handicapped individuals is usually performed by another person, we have not found any studies that evaluated the effectiveness of tooth bushing on institutionalized or extern CP residents by their nurses.

Studies evaluating tooth brushing performance have generally assessed the total duration of tooth brushing[12-14] and/or tooth brushing performance in only a few segments of the arch.[13-15] However, detailed evaluation of tooth brushing at follow-up appointments is important to highlight specific tooth brushing problems, to follow progress, and to improve the weak points in performance. Recently, a new tooth brushing performance skill index (TB-PS-I, Ashkenazi index) was introduced for evaluating, by direct observation, tooth brushing performance.[16,17] The TB-PS-I evaluates two criteria: correct placement of the toothbrush on each segment (even once) ("reach"), and the performance of a sufficient number of horizontal strokes (8–10) in each segment ("stay").

The aim of this study was four-fold:

1. To compare, by means of the Ashkenazi index, at time of instruction, and one month later, the ability of nurses to follow tooth brushing instructions for CP residents using manual single-headed and triple-headed toothbrushes.
2. To compare the improvement in bacterial plaque and gingival indices following one month of tooth brushing using two types of toothbrushes.
3. To compare the improvement in bacterial plaque index and gingival index in institutionalized and extern individuals with CP, and according to the severity of CP.
4. To evaluate the difficulties associated with the tooth brushing of individuals with CP.

Methods

Study population

The study included 43 individuals with CP and 53 of their nurses (the number of nurses was higher than that of the residents since they worked in shifts). The individuals with CP were 28 (65%) males and 15 (35%) females, aged 4–31 (mean age was 11.65, median 11 years). Of them, 24 (55.8%) were institutionalized and the remaining (19) externs (resided in the institute until late afternoon and slept at home). The residents were randomly assigned to two research groups by the toss of a coin: group A comprised 21 residents and group B, 22. The distribution of residents in these groups according to gender, age, institutionalized or externs, was similar (data not shown), as was their distribution according to the severity of CP (see below).

An exclusion criterion was gingival recession over 2 mm, which precludes reaching the gingival margin with the triple- headed toothbrush. We did not set a minimum number of teeth as an inclusion criterion. Nevertheless, most of the participants had all their teeth. The individuals with missing teeth (1–2 missing teeth) were all in the mixed dentition phase.

Of the 55 nurses working in the institution, 53 agreed to participate, all of them were women aged 19–61 years (mean age 42.04 ± 13.34 years) who worked in the institution for 0.4–20 years (mean 8 years), and who gave their written consent to participate in the study. Their mean number of years of education was 13.5 (range 12–17). All were right-handed. Two nurses worked in each room of 4–6 CP residents, in three shifts. The nurses did not switch shifts or rooms. The Ethics Committee of Tel Aviv University and the Israel Ministries of Education and Health approved the study; written informed consent was obtained from the parents of the participants with CP and from the nurses.

Classification of patients according to the severity of CP

The severity of CP was classified by three levels according to the following criteria: very high (lack of cooperation, resistance to opening the mouth or to insertion of a mouth prop, increased gag reflex and chronic cough associated with sputum, which causes difficulty in breathing); high (inability to brush teeth because of uncontrolled hand movements, increased gag reflex and easily fatigued); medium (cooperative, opens mouth on request, and only mild resistance to a mouth prop).

Study design

This is a prospective crossover study. The nurses of group A (n = 26) were first instructed in brushing teeth using a manual single-headed toothbrush (Paro M27, Paro, Switzerland) (Figure 1); and those of group B (n = 27), using a manual triple-headed toothbrush (Dr. Barman's Superbrush, DENTACO, AS, Haukeland, Norway) (Figure 1). After 1 month, the groups switched: nurses of group A were instructed in brushing with a manual triple-headed toothbrush, and those of group B with a manual single-headed toothbrush. Parents of extern children were invited to the school and instructed on how to correctly brush their children's teeth. Every day, these children were sent home with their toothbrushes and brought them back the next morning.

At the start of the study, the basic plaque index of each participating



Figure 1. Types of toothbrushes evaluated: Single- headed toothbrush (M-27, Paro Switzerland), and triple-headed (Dr. Barman, Superbrush, Dentaco AS, Norway).

individual with CP was evaluated and recorded by two dentists (MY or YY) immediately after dyeing the teeth with disclosing solution (RED-COTE, John D. Butler Company, Chicago, IL, U.S.A.). All scoring during the study period was performed in the presence of two dentists; one examined the resident and the other recorded the results while also contributing to determination of the final score. Each disagreement was discussed until a unanimous decision was reached.

The plaque index (PI) was evaluated according to the simplified oral hygiene index, developed by Greene and Vermilion (0–3 degrees).[18,19] Gingival health was evaluated according to the modified gingival index (GI) of Lobene *et al*. and Fischman (0–4 degrees).[18-20]

The surfaces of selected teeth included in the evaluation of plaque and gingival indices were: buccal surfaces of teeth (in parenthesis universal tooth number system) 55 (1d), 53 (3d), 51 (5d), 63 (8d), 65 (10d), 73 (13d), 83 (18d) in primary or mixed dentitions or teeth 16 (3), 13 (6), 21 (9), 24 (12), 26 (14), 43 (27), 33 (22), in permanent dentition; and lingual surfaces of teeth 85 (11d),75 (20d), 83 (18d), 71(15d) in primary or mixed dentitions or 46 (30), 44 (28), 31 (24), 36 (19) in permanent dentition (Figure 2). The examination was performed while the residents were seated on their personal wheelchair or while lying down on their bed/mattress, as they usually do during day time. The examination was carried out in a lighted

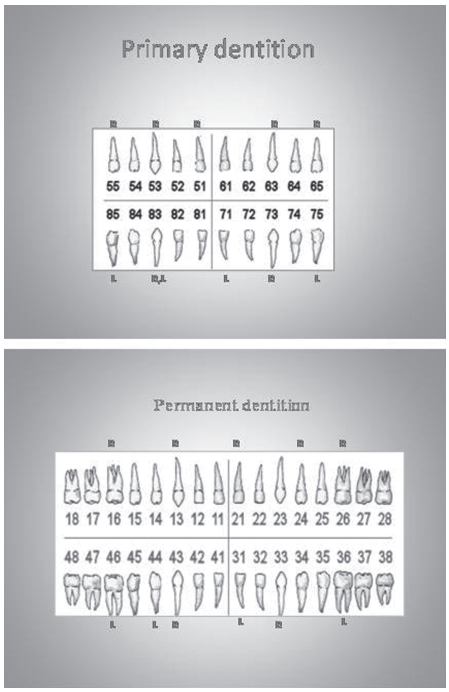


Figure 2. Graphic diagram of the examined primary and permanent teeth. B = Buccal surface examined; L = Lingual surface examined

room, using a disposable mirrolite (Kudos, Yuen Long, Hong Kong).

Immediately after the clinical evaluation, the participating nurses were individually instructed by one of the two dentists who performed the clinical evaluation on how to brush their patients' teeth. The instruction for tooth brushing included an explanation of the purpose of brushing and a demonstration of the technique on a plastic model and on their patients' teeth.

Brushing instruction for the single-headed toothbrush was according to the horizontal scrub technique,[16-19] that is, to brush the buccal aspect in each arch in five segments (right molars and premolars, right canines, anterior teeth, left canines and left molars and premolars) and the lingual/palatal aspect in three segments (right molars and premolars, anterior including the canines, left molars and premolars), to place the toothbrush partially on the gingiva and partially on the teeth, and to perform 8–10 back and forth brushing strokes on each segment; for a total of eight segments in each arch.

Brushing instruction with the triple-headed technique comprised performing 8–10 horizontal strokes in five segments in each arch (anterior, two canines, and two posterior segments), to place the toothbrush on the occlusal surfaces, and to perform about 8–10 back and forth brushing strokes on each segment.[16]

Immediately after demonstration, the nurses brushed the residents' teeth under the supervision of one of the dentists. Tooth brushing performance was evaluated as described below. In case the bacterial plaque was not removed completely; further instruction was provided to verify that all visible bacterial plaque was removed. By the end of the session, any visible bacterial plaque was removed by tooth brushing. Nurses were instructed to brush residents' teeth twice daily, morning and evening, immediately after meals.

After each month of tooth brushing with each type of toothbrush, the residents' plaque and gingival indices, and the nurses' tooth brushing performance were re-evaluated. Improvement in the plaque and gingival indices was calculated in relation to baseline data. Data were combined from groups A and B for each toothbrush, and means calculated. At the end of the study the nurses were asked to select from a list the characterizations that applied to each toothbrush type, and to state the toothbrush type they preferred (Table 6). The toothbrushes and toothpaste (Sensodyne Digimon, kindly donated by Glaxosmithkline Corp. Brentford, England, 1100 ppm F^-) were provided free of charge.

To ensure uniformity of instruction by the two dentists, an instruction form was designed by one of the authors (MA) and provided the dentists. On the first day of the study, immediately after instructing the nurses on how to brush correctly the resident's teeth, the reliability of the TB-PS-I was examined while the nurses brushed the teeth of 8 residents. The inter-rater agreement was 95%. These scores on the first day were not included in the study. In addition, in another pilot study, 4 residents (44 teeth) were evaluated by the two examiners for

Table 1. Mean plaque index values at baseline and after one month brushing with a single-headed or triple-headed toothbrush.

Segment	Baseline PI*	PI after one month follow-up ± SD				Differences between the two groups. ANOVA with repeated measures.	
		Single- headed toothbrush group (Group A)		Triple- headed toothbrush group (Group B)			
	PI ± SD**	PI ± SD	Percentage of reduction	PI ± SD	Percentage of reduction	Percentage of reduction	*p*
Total	2.14 ± 0.6	1.77 ± 0.56	17.28	1.3 ± 0.53	39.25	26.55	$p < 0.001$
Maxillary teeth	1.97 ± 0.6	1.71 ± 0.62	13.12	1.26 ± 0.62	36.04	26.3	$p < 0.001$
Mandibular teeth	2.28 ± 0.52	1.83 ± 0.62	19.74	1.32 ± 0.65	42	27.86	$p < 0.001$
Lingual	2.37 ± 0.54	1.94 ± 0.7	18.14	1.36 ± 0.6	42.61	29.9	$p < 0.001$
Buccal	1.98 ± 0.8	1.61 ± 0.56	18.68	1.2 ± 0.6	39.39	25.46	$p < 0.001$

*PI = plaque index; **SD = Standard deviation.

Table 2. Mean plaque and gingival indices values at baseline and after one month brushing with a single-headed or triple-headed toothbrush, according to severity of CP.

Severity of CP (Number of individuals)	Baseline		After one month of tooth brushing				Differences between the two groups (ANOVA with repeated measures)	
			With single- headed toothbrush		With triple- headed toothbrush			
	PI* ±SD**	GI# ± SD	PI ± SD	GI ± SD	PI ± SD	GI ± SD	PI	GI
Medium (29)	1.95 ± 0.56	2.08 ± 0.21	1.6 ± 0.46	1.8 ± 0.22	1.21 ± 0.54	1.37 ± 0.22	$p < 0.001$	$p < 0.001$
High (7)	2.41 ± 0.54	2.18 ± 0.9	1.96 ± 0.56	1.85 ± 0.75	1.31 ± 0.52	1.48 ± 0.87	$p < 0.001$	$p < 0.001$
Very high (7)	2.6 ± 0.4	2.71 ± 0.65	2.17 ± 0.66	2.06 ± 1.0	1.45 ± 0.47	1.58 ± 0.9	$p < 0.001$	$p < 0.001$
Total	2.14 ± 0.6	2.24 ± 0.52	1.77 ± 0.56	1.86 ± 0.54	1.3 ± 0.53	1.42 ± 0.55	$p < 0.001$	$p < 0.001$

*PI = plaque index; #GI = gingival index; **SD = Standard deviation.

plaque and gingival indices. The inter-rater reliability for assessing plaque and gingival indices ranged from 93 to 95%. This is in addition to the fact that every datum was collected actually by two dentists.

Tooth brushing performance skill index (TB-PS-I/ Ashkenazi index) (16–17)

Nurses' tooth brushing performance skill was evaluated as described previously according to two criteria: correct placement of the toothbrush on each segment (even once) ("reach"), and the performance of a sufficient number of horizontal strokes (8–10) in each segment ("stay"). One point was assigned for each criteria performed according to instruction. Therefore, the maximum score for the horizontal scrub technique was 32 points (16 points for reaching the 5 buccal and 3 lingual segments in the upper and lower arches, and 16 for sufficient strokes in each segment). The maximum score using the triple- headed toothbrush was 20 points. An overall tooth brushing performance skill index (TB-PS-I) was calculated for each tooth brushing technique as the percent of points achieved of the maximal possible points. The instructor also recorded whether brushing was performed systematically, and whether additional instructions were required.[16,17]

Statistical analysis

Differences in PI and GI, before and after tooth brushing, were evaluated by analysis of variance ANOVA with repeated measured.

The relationship between improvement in PI and GI among institutionalized and externs or among patients with different severity of CP were evaluated by the Pearson Chi Square test.

TB-PS-I between data after brushing with the single- and triple-headed toothbrushes were analyzed using the paired t-test (two-tailed). Correlations between TB-PS-I and the plaque and gingival indices were analyzed with the Pearson Correlation test. The level of significance was set at 5%.

Sample size calculation- Assuming a difference of 5 units of improvement in PI between the two brushes (relative to baseline) and SD of 6.5 units, at least 20 measurements were needed for a power of 90% and a significance of 5%.

Table 3. Mean plaque index values at baseline and after one month brushing with a single-headed or triple-headed toothbrush of institutionalized and externs' patients.

Segment	Home	Baseline	After one month of tooth brushing			
			With single- headed toothbrush		With triple- headed toothbrush	
		PI* ± SD**	PI ± SD	Percentage of reduction	PI ± SD	Percentage of reduction
	Total	2.14 ± 0.6	1.77 ± 0.56	17.29	1.3 ± 0.53	39.25
Total	Institutionalized	2.09 ± 0. 6	1.79 ± 0.53	14.35	1.2 ± 0.34	42.58
	External	2.17 ± 0.6	1.65 ± 0. 6	23.96	1.3 ± 0.7	40.09
p value		*p* = 0.888	*p* = 0.805		*p* = 0.152	
Buccal	Institutionalized	1.92 ± 0.76	1.64 ± 0.57	14.58	1.15 ± 0.43	40.10
	External	2.07 ± 0.85	1.61 ± 0.57	22.22	1.28 ± 0.74	38.16
p value		*p* = 0.645	*p* = 0.923		*p* = 0.310	
Lingual	Institutionalized	2.4 ± 0.48	2.06 ± 0.5	14.17	1.32 ± 0.43	45.00
	External	2.34 ± 0.62	1.8 ± 0.81	23.08	1.42 ± 0.74	39.32
p value		*p* = 0.590	*p* = 0.440		*p* = 0.088	

*PI = plaque index; **SD = Standard deviation

Table 4. Mean gingival index values at baseline and after one month brushing with the single-headed or triple-headed toothbrush.

Segment	Baseline GI*	GI after one month ± SD				Differences between the two groups (ANOVA with repeated measures)	
		Single- headed toothbrush group (Group A)		Triple- headed toothbrush group (Group B)			
	GI ± SD**	GI ± SD	Percentage of reduction	GI ± SD	Percentage of reduction	Percentage of reduction	*p*
Total	2.24 ± 0.52	1.86 ± 0.54	17	1.42 ± 0.55	36.16	23.12	*p* < 0.001
Maxillary teeth	2.23 ± 0.62	1.8 ± 0.64	19.3	1.4 ± 0.54	37.23	22.2	*p* < 0.001
Mandibular teeth	2.34 ± 0.56	1.9 ± 0.59	18.8	1.5 ± 0.52	36	21	*p* < 0.001
Lingual	2.43 ± 0.6	1.97 ± 0.5	18.93	1.46 ± 0.6	40	25.8	*p* < 0.001
Buccal	2.14 ± 0.6	1.79 ± 0.6	16.35	1.41 ± 0.57	34.11	21.2	*p* < 0.001

*GI = gingival index; **SD = Standard deviation.

Results

Severity of CP

The distribution of the residents in the research groups according to CP severity was as follows: group A: medium severity-13 patients, high severity-3 patients, very high severity-5 patients. Group B: medium severity-16 patients, high severity-4 patients, very high severity-2 patients.

Plaque index

At baseline, mean PI values ranged from 1.97 to 2.37 (mean 2.14 ± 0.6) in different teeth segments, with no significant difference between groups A and B (ANOVA; Tables 1-3). The mean basic PI of mandibular teeth was higher by 13.6% than that of maxillary teeth (2.28 vs. 1.97, respectively, $p < .001$; ANOVA), and of the lingual side by 16.5% that of the buccal side (2.37 vs. 1.98, respectively, $p < .001$; ANOVA; Table 1).

After one month brushing with a single-headed or triple headed toothbrush, the mean total PI and mean plaque indices for all segments were reduced. Percentages of reduction in mean total PI, and in mean plaque indices of all segments were significantly greater after using the triple- headed toothbrush, and were more than twice as high as those following brushing with the single-headed toothbrush (Table 1; ANOVA with repeated measures). The improvement of the PI was higher in the lingual and in the mandibular segments than in the buccal segments ($p < .001$) or maxillary segments ($p < .001$), respectively.

At baseline, the mean PI of patients with very high severity of CP was higher than that of patients with high or medium severity CP ($p < .015$, Table 2). At one month assessment, the mean PI

Table 5. Mean scores for TB-PS-I* and its components ("Reach" and "Stay"), at baseline and following brushing with the two types of toothbrushes.

TB-PS-I	Baseline ± SD**		After one month ± SD		p value (paired t test-two tailed	
	Single- headed toothbrush	triple- headed toothbrush	Single- headed toothbrush	triple- headed toothbrush	Single- headed toothbrush	triple- headed toothbrush
Total	92.22 ± 1.69	92.54 ± 3.11	80.47 ± 1.66	93.66 ± 2.3	$p < 0.001$	$p < 0.001$
Reach	94.22 ± 0.19	93.85 ± 0.68	90.75 ± 1.31	96.19 ± 0.4	$p < 0.014$	$p < 0.083$
Stay	90.21 ± 2.18	91.22 ± 0.88	70.19 ± 1.15	91.12 ± 0.83	$p < 0.001$	$p < 0.847$
Maxillary teeth	90.85 ± 1.86	92.25 ± 1.62	80.09 ± 4.0	94.22 ± 1.16	$p < 0.001$	$p < 0.001$
Mandibular teeth	93.58 ± 3.56	92.82 ± 1.70	80.85 ± 4.0	93.10 ± 1.76	$p < 0.001$	$p < 0.001$

*TB-PS-I = Toothbrush performing skill index **SD = Standard deviation.

Table 6. Characterization by nurses of the single and triple-headed toothbrushes.

Characteristics of toothbrushes	Percent response			
	Triple-headed toothbrush	Single-headed toothbrush	No differences between Toothbrushes	Did not respond
Enables reaching more teeth	69.8	22.6	2	5.6
Enables more efficient removal of plaque	73.6	15.1	7.5	3.8
Significantly decreases bleeding during tooth brushing	66	18.9	11.3	3.8
Significantly decreases the prevalence of gag reflex	58.5	28.3	9.4	3.8
Decreases the time necessary for tooth brushing	84.9	7.5	3.8	3.8
Type of toothbrush you prefer	75.5	22.6	1.9	0

was reduced for all levels of CP severity, with no statistical differences between groups. The mean PI of patients with very high severity of CP improved more following one month brushing with the triple-headed toothbrush group ($p < .001$) (Table 2), abolishing the significant differences among the groups observed at baseline.

There were no statistically significant differences in PI according to residency status, at baseline or one month after brushing with the single-headed or triple headed toothbrushes (Table 3).

Gingival index

At baseline, mean gingival index values ranged from 2.14 to 2.43 (mean 2.24 ± 0.52) in different segments (Tables 2, 4). The mean baseline gingival index of the lower arch and the lingual aspects was higher than that of the upper arch and buccal aspect by 5% and 13.6%, respectively.

Reduction in the gingival index was greater after one month brushing with the triple headed than with the single-headed toothbrush (34.11%–40% vs. 16.35%–19.3%, respectively, $p < .001$; ANOVA with repeated measures). After brushing with the triple-headed toothbrush, the magnitude of improvement in the gingival index for total, buccal, lingual, upper and lower arch values was 2.12, 2.09, 1.36, 1.93, 1.91 times higher than after brushing with the single-headed toothbrush. The improvement of the gingival index was higher in the lingual and in the maxillary segments than in the buccal and mandibular segments, respectively. ($p < .001$).

At baseline, the basic gingival index was similar for the institutionalized and extern patients (in lingual 2.45 vs. 2.44, buccal 2.15 vs. 2.13, respectively). After 1 month brushing with the single- headed toothbrush, no differences were found between individuals according to their residency status (Pearson Chi-Square test). However, after 1 month brushing with the triple-headed toothbrush the mean gingival index in the buccal aspect improved among institutionalized individuals by 1.68 times, and in the lingual aspect by 1.4 times, compared to the mean value among extern individuals. These differences did not reach statistical significance.

No statistically significant difference was found in the extent of improvement in the gingival index between institutionalized and extern patients after brushing with the single-headed or triple-headed toothbrush ($p < .105$).

At baseline, the gingival index was correlated with the severity of CP (mean values of 2.71, 2.18, and 2.08 for very high, high and medium severity of CP, respectively, $p < .015$). After one month, improvement in the gingival index was achieved for all grades of severity of CP,

and ranged from 13.5–17% for the single- headed and 25–41.7% for the triple- headed toothbrush. The greatest improvement was obtained in the children with very high severity of CP. For these individuals, improvement after using the triple- headed toothbrush was 1.74 times higher than after using the single- headed toothbrush ($p < .001$). There was no significant difference in the GI between individuals with high and medium severity CP ($p < .105$).

Tooth brushing performance skill index (TB-PS-I/ Ashkenazi index)

At baseline, mean total TB-PS-I scores, as well as component scores ("reaching" and "staying") were comparable with the triple-headed and the single-headed toothbrushes (Tables 4 and 5).

After one month brushing with the single- headed toothbrush, mean total TB-PS-I and TB-PS-I for both maxillary and mandibular arches were decreased by about 10% ($p < .001$; paired *t*-test [two-tailed]). The main deterioration was observed in the "stay" component (20.2%, $p < .001$). In contrast, after brushing for one month with the triple-headed toothbrush, the components of TB-PS-I scores remained the same.

At baseline, the percentage of nurses who brushed the residents' teeth properly based on TB-PS-I was similar following instructions with both types of toothbrushes. However, one month after instruction, the percentage of nurses requiring additional instruction was higher after brushing with the single-headed toothbrush (15%) than with the triple-headed toothbrush group (7.6%; $p < .002$). When asked which toothbrush they preferred, 75.5% of the nurses chose the triple-headed, and 22.6% the single-headed toothbrush (Table 6). According to the nurses, the advantages of the triple-headed toothbrush over the single-headed tooth brush are in removing bacterial plaque, decreasing bleeding during tooth brushing, and decreasing the prevalence of gag reflex and the time required for tooth brushing (Table 6).

Discussion

This study demonstrated that after instruction with a single-headed toothbrush, nurses retained less skill during the following month than after instruction with a triple-headed toothbrush. This is despite the fact that immediately after receiving instructions, nurses brushed their patients' teeth with comparable skill, regardless of the toothbrush design. We found similar differences in the retention of instruction for the two types of toothbrushes when parents brushed their children's teeth.[16] Instruction retention is particularly important in institutional settings, since the frequency of instruction nurses receive there is usually low.

In this study, nurses' ability to brush their patients' teeth was evaluated by direct observation, according to a previously published TB-PS-I/Ashkenazi index.[16] This index was shown to be easily implemented, to correlate negatively with PI and to have high reliability.[16,17] In the current study, as in the previous one, ineffective tooth brushing with the single-headed toothbrush was due mainly to not "staying" long enough on each tooth segment. Accordingly, tooth brushing instruction should emphasize the "stay" component.

One month after instruction, individuals whose teeth were brushed with the triple-headed toothbrush showed lower mean plaque and gingival indices than when they were brushed with the single-headed toothbrush; reductions in plaque and gingival indices in the lingual aspect were more than double. This is despite the difficulty of reaching the lingual surfaces, especially in CP patients. These findings concur with those of Kiche *et al*. and Zimmer[6,21] who reported greater improvement in plague index in the lingual aspect following brushing with the triple-headed toothbrush than with the single-headed toothbrush. The effectiveness of the triple-headed toothbrush is especially impressive considering that it requires only one-third of the time as does the single-headed one. The superiority of the triple-headed toothbrush over the single-headed one, especially in reducing bacterial plaque in the lingual surfaces, is in accordance with previous studies.[22-24] The higher effectiveness of the triple-headed toothbrush may be due to the ease in its handling and to reduced gag reflex stimulation. This may be particularly advantageous for individuals with CP.

The greatest improvement in plaque and gingival indices were observed among patients classified with very high severity of CP; with a mean reduction of 1.1 points, compared to 0.7 for those with less severe CP ($p < .001$). The nurses expressed preference of the triple-headed toothbrush, concurring with previous reports.[16,21] Reasons for their preference may be greater ease of performance and cooperation of patients due to decreased gag reflex during bushing and shorter time required to brush teeth. With the single-headed toothbrush nurses had to perform 10 back and forth strokes in 8 segments in each arch (5 buccal, 3 lingual and 2 occlusal), while in the triple-headed, only five segments.

A shortcoming of the present study is that the evaluator of PI at 1 and 2 months follow-up were not blinded to research group assignments. Clearly, the evaluation of tooth brushing performance could not be blinded.

References

1. Weddell JA, Sanders BJ, Jones JE. Dental problems of children with Disabilities. In: Mcdonald RE, Avery DR, Dean JA. *Dentistry for the child and adolescent*. 2004; Mosby: Philadelphia, PA, USA 8th edition: 526-30; 543-6.
2. Dos Santos MT, Masiero D, Simionato MR. Risk factors for dental caries in children with cerebral palsy. *Spec Care Dentist* 2002;22:103-7.
3. Soncini JA, Tsamtsouris A. Individually modified toothbrushes and improvement of oral hygiene and gingival health in cerebral palsy children. *J Pedod* 1989;13:331-4.
4. Mann J, Wolnerman JS, Lavie G, Carlin Y, Garfunkel AA. Periodontal treatment needs and oral hygiene for institutionalized individuals with handicapping conditions. *Spec Care Dentist* 1984;4:173-6.
5. Rodrigues dos Santos MT, Masiero D, Novo NF, Simionato MR. Oral conditions

in children with cerebral palsy. *J Dent Child (Chic)* 2003;70:40-6.
6. Zimmer S, Didner B, Roulet JF. Clinical study on the plaque removing ability of new triple headed toothbrush. *J Clin Periodontol* 1999;26:281-5.
7. Azrak B, Barfaraz B, Krieter G, Willershausen B. Effectiveness of a three-headed toothbrush in pre-school children. *Oral Health Prev Dent* 2004; 2:103-9.
8. Sauvetre E, Rozow A, de Meel H, Richebe A, Abi-Khalil M, Demeure F. Comparison of the clinical effectiveness of a single and a triple-headed toothbrush in a population of mentally retarded patients. *Bulletin du Groupement Internationale pour la Recherche Scientifique en Stomatologie et Odontologie* 1995;38:115-9.
9. Pope JE, Curzon ME. The dental status of cerebral palsied children. *Pediatr Dent* 1991;13:156-62.
10. Zadik Y, Galor S, Lachmi R, Proter N. Oral self-care habits of dental and healthcare providers. *Int J Dent Hyg* 2008;6:354-60.
11. Gil-Montoya JA, de Mello AL, Cardenas CB, Lopez IG. Oral health protocol for the dependent institutionalized elderly. *Geriatr Nurs* 2006;27:95-101.
12. Starkey P. Instructions to parents for brushing the child's teeth. *J Dent Child* 1961;28: 42-47.
13. Rugg-Gunn AJ, Macgregor ID. A survey of toothbrushing behaviour in children and young adults. *J Periodontal Res* 1978;13:382-9.
14. Mescher KD, Brine P, Biller I. Ability of elementary school children to perform sulcular toothbrushing as related to their hand function ability. *Peadiatr Dent* 1980;2:31-6.
15. Zeedyk MS, Longbottom C, Pitts NB. Toothbrushing practices of parents and toddlers: a study of home-based videotaped sessions. *Caries Res* 2005;39:27-33.
16. Telishevesky YS, Levin L, Ashkenazi M. Assessment of parental tooth brushing following instruction with single-headed and triple-headed toothbrushes. *Pediatr Dent* 2012;34(4):239-44.
17. Levin L, Marom Y, Ashkenazi M. Bushing skills and plaque reduction using single-headed and triple-headed toothbrushes. *Quintessence International* 2012;43(6):525-31.
18. Fischman SL. Clinical index systems used to assess the efficacy of mouthrinses on plaque and gingivitis. *J Clin Periodontol* 1988;15: 506-10. Review.
19. Wei SH, Lang NP. Periodontal epidemiological indices for children and adolescents: II. Evaluation of oral hygiene; III. Clinical applications. *Pediatr Dent*. 1982;4:64-73.
20. Lobene RR, Weatherford T, Ross NM, Lamm RA, Menaker L. A modified gingival index use in clinical trials. *Clin Prev Dent* 1986; 8:3-6.
21. Kiche MS, Fayle SA, Curzon ME. A clinical trial comparing the effectiveness of a three-headed versus a conventional toothbrush for oral hygiene in children. *Europian Journal of Pediatric Dentistry* 2002;3:33-8.
22. Bastiaan RJ. Comparison of the clinical effectiveness of a single and a double headed toothbrush. *J Clin Periodontol* 1984;11: 331-9.
23. Damle SG, Bhavsar JP. Plaque removing efficacy of individual modified toothbrushes in cerebral palsy children. *J Dent Child* 1995; 62:279-82.
24. Agerholm DM. A clinical trial to evaluate plaque removal with a double-headed toothbrush. *Brit Dent J* 1991;170:411-13.