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Research Article

Effectiveness of Supervised Tooth-Brushing and Use of Plaque Disclosing Agent on Children's Tooth-Brushing Skills and Oral Hygiene: A Cluster Randomized Trial

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Abstract

Background: Dental professionals recommend that parents should brush young children's teeth and supervise older ones to brush because young children are not cognitively developed nor do they have the manual dexterity required to brush their teeth effectively.

Aim: To determine and compare the effect of using plaque disclosing agent while brushing teeth and that of supervised tooth brushing on oral hygiene status, gingival health and tooth brushing skills among 7 - 8 years old primary school pupils in Dar es Salaam.

Methods: This was a cluster randomized controlled field trial with three intervention groups; supervised tooth brushing, use of plaque disclosing agent and a control group. The study was single blinded. Two stage cluster sampling technique was used. The outcomes of the study were improvement in tooth brushing skills, oral hygiene status and gingival health. Paired *t-test* was used to compare intervention outcomes from baseline to follow up while one way analysis of variance (ANOVA) examined the influence of individual intervention on the primary and secondary outcomes.

Results: 245 participants were recruited at baseline but 231 maintained participation to the end, of whom; 87 belonged to controls, 71 to supervised tooth brushing group and 73 to plaque disclosing agent group. At baseline participants' socio-demographics and mean scores of plaque and tooth brushing skills were evenly distributed in the three intervention groups. The mean score for plaque and gingival bleeding dropped and that of tooth brushing skills rose from baseline to follow up ($p = 0.001$). The effect size for the use of plaque disclosing agent resulted into mean difference (95% CI) for plaque score 2.8 (0.8, 4.8) and supervised tooth brushing revealed an effect size for plaque score 2.2 (0.1, 4.1) and tooth brushing skills -1.0 (-1.2, -0.6).

Conclusion: Supervised tooth brushing showed positive effect on pupil's tooth brushing skills and oral hygiene status while use of plaque disclosing agent positively influenced pupils' oral hygiene status and gingival healthy.

Keywords: *Supervised Tooth-Brushing; Plaque Disclosing Agent; Oral Hygiene Status; Oral Hygiene Practices; Tooth-Brushing Skills*

Abbreviations

ANOVA: One Way Analysis of Variance; IRB: Institutional Review Board; MUHAS: Muhimbili University of Health and Allied Sciences; SPSS: Statistical Package for Social Sciences

Introduction

Tooth brushing is a mechanical means of removing dental plaque from tooth surfaces and gums. It is recommended that parents/caregivers should start to clean children's teeth as soon as the first tooth emerges in the oral cavity. They should institute regular tooth brushing upon emergence of the first deciduous molar tooth around two years of age. The parents/caregivers should continue to brush children's teeth up to the age of six years [1]. This is due to the fact that young children are not cognitively developed to be able to follow the tooth brushing instructions nor do they have the manual dexterity required to brush their teeth effectively. At school age up to the age of nine years, children are to brush their teeth under parental supervision to ensure effective tooth brushing and proper use of toothpaste. After the age of nine, children can brush on their own [1,2].

Supervised tooth brushing in children is an act of observing and directing a child on how to perform tooth brushing [3]. It is done in order to ensure effective and appropriate tooth brushing practices in children whilst imparting proper brushing skills. Supervision of tooth brushing may be aided by plaque disclosing agents, which facilitates visibility and appreciation of plaque retentive areas and thus its removal [4]. If tooth brushing is done properly and routinely, it results in children's good oral hygiene status; that is good level of cleanliness of the mouth and teeth [5] which is pivotal in the prevention of the common oral diseases; dental caries and periodontal diseases.

Most studies investigating the effect of supervised tooth brushing intended to examine its effect on dental caries increment [6,7]. However, few studies have investigated its effect on plaque reduction, gingival health and tooth brushing skills [8-11]. These studies were mainly done among adolescents.A study done in India among 12 to 15 years old adolescents with a follow up period of three months reported a mean plaque score reduction from 2.91 to 0.82 among boys and 2.78 to 0.95 among girls as well as reduction in gingival bleeding index from 0.31 to 0.29 for boys and from 0.23 to 0.21 for girls [8]. Likewise, a study among 8-12 years schoolchildren in Java Indonesia by Hartono., *et al.* 2002 [10] showed a 21% reduction in plaque score. However, Rosema., *et al.* 2012 [11] in their study among 8 - 11 years Burmanese schoolchidren did not find statistical significant reduction in mean plaque nor mean bleeding score. Brushing skills were reported to improve up to 55% among first grade Israel children after provision of dental health education by a dentist through demonstration [9].

Effectiveness in tooth brushing have also been evaluated through the use of plaque disclosing agent [4,12] which facilitates visibility and appreciation of plaque retentive areas and thus its removal [4]. The effect of using plaque disclosing agent was demonstrated in plaque reduction [12] and improvement in tooth brushing skills [4]. No study reporting the effect of plaque disclosing agent on gingival health was retrieved.

In a study conducted among Brazilian adolescents, a clear reduction was seen in mean plaque values between the group that used a disclosing agent as compared to the group that did not use the agent [12]. Likewise, a marked improvement in children's self-performed tooth brushing ability was reported by Chounchaisithi., *et al.* 2014 [4] in terms of mean reduction of patient hygiene performance (PHP) of 1.24 as compared to 0.92 among those who used disclosing plaque visualization and those who did not, respectively.

Scarce information is available regarding supervised tooth brushing in Tanzania. The only study which was done among lower primary school children involved tooth brushing supervision by school teachers [13]. The findings of the study revealed a reduction in mean plaque score from 20.5 to 15.9 and mean gingival bleeding score from 4.9 to 3.5 at three months following supervised tooth brushing intervention. On the other hand, there is no universal norm for tooth brushing in children nor is there recommendation for parental/guardian supervision which is adhered to in routine family practices. Generally, children brush their own teeth at the ages when they should be brushed or supervised. Consequently, often most children have gingivitis. It was thought that supervised tooth brushing at school by dental professionals may help children to attain the required level of oral hygiene. Therefore, the purpose of this study was to

determine and compare the effect of using plaque disclosing agent while brushing teeth and that of supervised tooth brushing on oral hygiene status, gingival health and tooth brushing skills among 7-8 years old primary school pupils in Dar es Salaam.

Materials and Methods

Trial design

This was a parallel cluster randomized controlled field trial with three groups; supervised tooth brushing, use of plaque disclosing agent and a control group in a ratio of 3:3:4 clusters (primary schools) as trial allocation.

Participants

The participants of this study were class two primary school children aged 7 - 8 years old studying in public schools of Kinondoni district in Dar es Salaam, Tanzania. The children were expected to have just started to brush their teeth on their own but doing so under parental supervision, have established school socialization life, sense of learning new simple skills and accepting new roles. Therefore being able to understand, follow simple instructions and hopefully retain the gained knowledge and skills to adulthood making them suitable for this study. Data collection and institution of trial interventions were carried out within school premises.

Interventions

There were two trial interventions which were educational in nature. In the first intervention (use of plaque disclosing agent) pupils were provided with plaque disclosing agent tablets to chew until the tablet resolved, then rinse and spit. After spiting they were instructed to visualize via a face mirror, colored stains on the teeth and gums indicating areas covered by plaque. They were then instructed to brush their teeth in their own ways but ensuring that all stained areas were cleared off. Pupils in the second intervention (supervised tooth brushing) were instructed, demonstrated and coached on: sequential tooth brushing, surfaces to be brushed and type of movements. Sequential tooth brushing entailed to start on the upper jaw; right, anterior then left side, followed by brushing the lower jaw left side, anterior part/segment and finally right side. Regarding teeth surfaces; children were instructed to brush the outer surfaces of the teeth, inner surfaces and then the chewing surfaces. The movements instructed were short horizontal strokes with overlapping steps to cover two to three teeth at a time. The controls received no any further instructions other than the basic oral health information which was given to all children participating in the study before embarking to their respective trials. They maintained their standard of dental care.

Outcomes

The primary outcome of the study was improvement in tooth brushing skills and the secondary outcomes were improvement in oral hygiene status and gingival health. Tooth brushing skills were assessed by observing the children as they brushed their teeth in respect of surfaces they brushed, sequence they followed and type of movements used. At least one correct skill item was scored as 1, not having a skill was scored 0. Improvement in oral hygiene status and gingival health were assessed by reduction in plaque and gingival bleeding scores. Plaque and gingival bleeding were scored on six index teeth as recommended by Silness and Loe modified and customized for children namely 16, 11, 64, 36, 32 and 84 [14].

Sample size

A two stage cluster sampling technique was used with schools as a sampling unit. Ten schools were conveniently selected in stage one and individual pupils were selected using systematic sampling design in stage two. Ultimately, the estimated sample size of 270 participants was attained by selecting 27 pupils from each school. The sample was estimated on assumption that at baseline the proportion of children with tooth brushing skills was 20% which was expected to increase following intervention by 25%, power of the study being 85% and 95% confidence.

Randomization

A simple randomization of clusters was used to allocate participating schools into respective study groups. An independent person generated the random allocation sequence. Ten identical pieces of paper bearing individual names of the schools were placed in a container and mixed. One piece of paper was picked at a time from the container then allocated the schools to three groups, one at a time and in turns. Ultimately, four schools were allocated to the control group and three schools in each of the intervention groups; pupils in

those schools automatically belonged to the assigned interventions.

Blinding

The study was single blinded, that is; only the assessor was not aware of the group assignment and the intervention given. The nature of the intervention trial which was educational necessitated interaction between participants and the investigator; hence their blinding could not be feasible. Basic oral health information that was provided to all participants regardless of the group assignment acted as a pseudo placebo.

Data management

Data management (entry, coding and analysis) was done using computer program software SPSS version 20.

Coding and transformation

Intervention groups were coded as 0 = Control, 1 = Supervised tooth brushing and 2 = Plaque disclosing agent. Plaque and gingival bleeding were assessed on six index teeth. Plaque was assessed on Mesial, Buccal and Lingual surfaces, scored as; 0, 1, 2 and 3 as per modification for children use by Silness and Loe [14]. To aid analysis plaque score values were re-coded as 0 = no plaque and 1 = those who had plaque. Mean plaque score was obtained from total number of plaque score on teeth surfaces examined and scored for plaque. Gingival bleeding was assessed according to Silness and Loe [14] as; 0, 1, 2 and 3. These scores were re-coded for analysis as; 0 = healthy gum and 1 = gingival bleeding. Mean gingival bleeding score was obtained from total number of gingival bleeding score on teeth examined for gingival bleeding. Tooth brushing skills were assessed as follows; 0 = no any skill and 1 = a correct skill. The skills were then categorized as; have no skills, have at least one skill, have two skills and have all skills (score 0 - 3). Mean tooth brushing skills score was obtained from total number of skills examined.

Statistical Analysis

The dependent variables were mean scores for tooth brushing skills, plaque and gingival bleeding. Paired t-test was used to compare intervention outcomes from baseline to follow up while one way analysis of variance (ANOVA) examined the influence of individual intervention on the primary and secondary outcomes.

Ethical consideration

Ethical clearance was provided by MUHAS IRB. Pupils whose parents/guardians agreed with the study and signed a letter of informed consent were invited for enrollment. Only pupils who asserted to participate were enrolled into the study.

Results

At the time of the study, Kinondoni district had 140 public primary schools with a population of 10,382 pupils who were aged 7 to 8 years old. Through convenient sampling, 10 schools were selected and at schools 27 pupils were systematically selected. A total of 17 pupils had incomplete clinical information and 8 had no parental consent, therefore they did not participate. Ultimately, 245 participants were recruited at baseline; this gave a participation rate of 90.7%. The participants were randomized into 95 (38.8%) controls, 76 (30.2%) use of plaque disclosing agent group and 74 (31%) a supervised tooth brushing group. Intervention was instituted, following which 231 participants maintained participation to the end making a follow-up rate of 85.6%, of whom; 87 belonged to controls, 71 to supervised tooth brushing group and 73 to plaque disclosing agent group (Figure 1). The analysis was done per protocol where the proportion of controls was 87/231, supervised tooth brushing 71/231 and plaque disclosing agent 73/231.

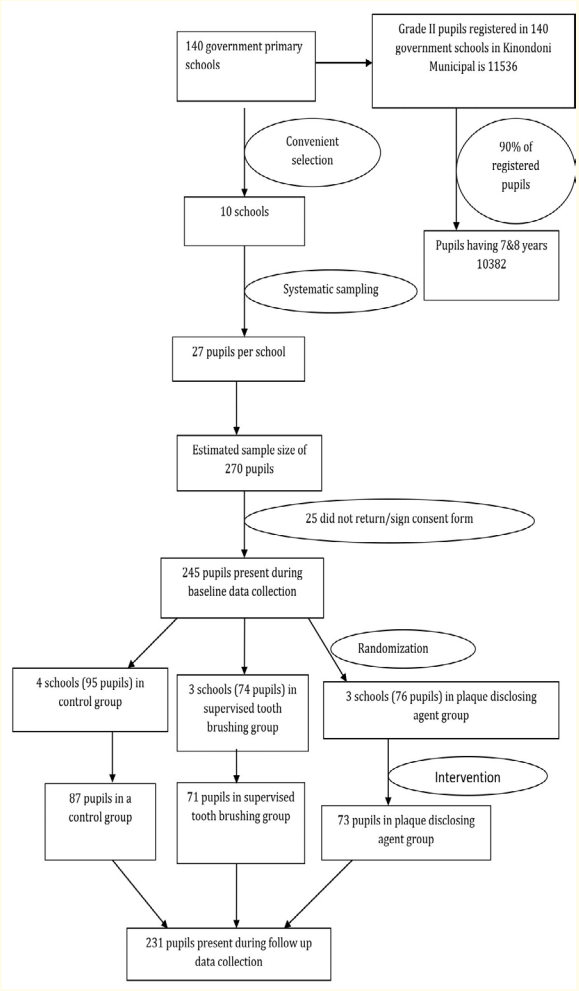

Figure 1: *Flow of clusters and individual participants.*

Recruitment of participants was done from 21st to 27th January 2017 through site visiting (schools), sampling and baseline data collection. This was followed by execution of intervention between 30th January and 3rd February 2017. Both, controls and intervened groups were monitored from 7th to 15th February 2017. The trial ended with post intervention data collected from 6th to 10th March 2017.

At baseline participants' socio-demographics were evenly distributed in the three intervention groups; that is, there were no statistically significant differences in the distribution of the participants' socio-demographics between the three groups (Table 1). Likewise, mean scores of two outcome variables (plaque score and tooth brushing skills) were uniformly distributed whereas mean gingival bleeding score was statistically significantly higher among controls (Table 2).

Variable	Categories	Supervised tooth brushing group % (n)	Plaque disclosing agent group % (n)	Control group % (n)	P-value
Age	7 years	34.4 (42)	27 (33)	38.5 (47)	0.263
	8 years	26 (32)	35 (43)	39 (48)	
Sex	Female	32.5 (40)	27.6 (34)	39.8 (49)	0.492
	Male	27.9 (34)	34.4 (42)	37.7 (46)	
Mother's education	Primary and less than primary school	28.8 (34)	28.8 (34)	42.4 (50)	0.715
	Secondary education and beyond	31.5 (30)	31.6 (30)	36.8 (35)	
Father's education	Primary and less than primary school	26.3 (26)	31.3 (31)	42.4 (42)	0.584
	Secondary education and beyond	32.7 (37)	29.2 (33)	38.1 (43)	
Mother's occupation	Have no income generating activities outside home	26.8 (19)	32.4 (23)	40.8 (29)	0.740
	Have income generating activities outside home	31.7 (64)	29.9 (41)	39.4 (56)	
Father's occupation	Self-employed or small scale business	30.5 (29)	29.5 (28)	40.0 (38)	0.968
	Employed and business men	28.9 (33)	29.8 (34)	41.2 (47)	

Table 1: *Distribution of study participants' socio-demographics by intervention groups at baseline (n = 245).*

Variable	Supervised tooth brushing % (n)	Plaque disclosing agent % (n)	Control % (n)	P-value
Mean plaque score	25.9	25.9	27.2	0.485
Mean gingival bleeding score	5.0	5.7	6.8	0.001
Mean tooth brushing skills score	0.2	0.1	0.1	0.167

Table 2: *Distribution of mean outcome variables by intervention groups at baseline (n = 245).*

All primary and secondary outcomes changed positively in favour of the intervention provided regardless of their assigned intervention groups namely; controls, supervised tooth brushing and plaque disclosing agent. Particularly, the mean score for plaque and gingival bleeding dropped and that of tooth brushing skills rose from baseline to follow up (p = 0.001) (Table 3).

	Control	Supervised tooth brushing	Plaque disclosing agent
Mean plaque score			
At baseline	26.6	25.7	25.5
At follow up	21.8	19.6	19.0
p-value	0.001	0.025	0.001
Mean gingival bleeding score			
At baseline	6.6	4.9	5.6
At follow up	4.0	3.3	2.8
p-value	0.001	0.001	0.001
Mean tooth brushing skills score			
At baseline	0.1	0.2	0.1
At follow up	0.4	1.4	0.4
p-value	0.001	0.001	0.001

Table 3: *Participants' mean scores for plaque, gingival bleeding and tooth brushing skills in the three groups at baseline and follow up.*

The effect size for the use of plaque disclosing agent as an intervention resulted into mean difference (95% CI) of plaque score 2.8 (0.8, 4.8) and gingival bleeding 1.2 (0.4, 2.0) at follow up compared to non-statistically significant different effects at baseline (Table 4).

	Mean difference (95% CI)	P-value
Plaque score		
At baseline	1.1 (-2.0, 4.1)	1.000
At follow up	2.8 (0.8, 4.8)	0.003
Gingival bleeding score		
At baseline	1.0 (-0.05, 2.0)	0.067
At follow up	1.2 (0.4, 2.0)	0.002
Tooth brushing skills score		
At baseline	0.03 (-0.1, 0.7)	1.000
At follow up	0.005 (-0.3, 0.3)	1.000

Table 4: *Participants' mean difference (95% CI) scores in plaque, gingival bleeding and tooth brushing skills for use of plaque disclosing agent.*

When supervised tooth brushing group was compared with the controls, the mean difference (95% CI) at baseline was not statistically significant for plaque score and tooth brushing skills. At follow up supervised tooth brushing revealed a statistically significant different effect size for plaque score 2.2 (0.1, 4.1) and tooth brushing skills -1.0 (-1.2, -0.6) (Table 5).

	Mean difference (95% CI)	P-value
Plaque score		
At baseline	0.9 (-2.2, 4.0)	1.000
At follow up	2.2 (0.1, 4.1)	0.034
Gingival bleeding score		
At baseline	1.7 (0.7, 2.8)	0.001
At follow up	0.7 (-0.1, 1.6)	0.104
Tooth brushing skills score		
At baseline	-0.7 (-0.2, 0.06)	0.606
At follow up	-1.0 (-1.2, -0.6)	0.001

Table 5: *Participants' mean difference (95% CI) scores in plaque, gingival bleeding and tooth brushing skills for supervised tooth brushing.*

There were no statistically significant differences in effect size for the three outcome variables at baseline between supervised tooth brushing and use of plaque disclosing agent. The only statistical significant different in mean change; 1 (0.7, 1.3) was observed at follow up for mean tooth brushing skills score (Table 6).

	Mean difference (95% CI)	P-value
Plaque score		
At baseline	0.2 (-3.1, 3.4)	1.000
At follow up	0.6 (-1.5, 2.8)	1.000
Gingival bleeding score		
At baseline	-0.7 (-1.8, 0.3)	0.307
At follow up	0.5 (-0.4, 1.3)	0.576
Tooth brushing skills score		
At baseline	0.1 (-0.04, 0.2)	0.271
At follow up	1.0 (0.7, 1.3)	0.001

Table 6: *Participants' mean difference (95% CI) scores in plaque, gingival bleeding and tooth brushing skills for the two interventions (Supervised tooth brushing as compared to plaque disclosing agent).*

Discussion

This study was a cluster randomized controlled field trial which was done among 7 - 8 years grade two public primary school pupils in Dar es Salaam. The findings can be generalized and applied to primary school children of similar socio-economic background and locale.

The participants were equally distributed by socio-demographics and intervention outcomes at baseline in all the three intervention groups, implying that randomization was achieved. This ensures that the evaluation results symbolize true effects of the intervention.

The interventions produced substantial improvement in children's oral hygiene status, gingival health and tooth brushing skills in the two intervention groups as well as the controls. These findings demonstrate that supervision of tooth brushing and use of plaque disclosing agent was capable of causing expected trial effect. On the other hand, the studied children may have not received any oral health education from professionals earlier, in such a way that just oral hygiene instructions that were given to all (pseudo placebo) could bring positive changes in controls. Our findings are comparable to those of other studies that reported improvement in plaque score [8,13,15-18], gingival health [13,16] and tooth brushing skills [9,10,19] for intervention groups.

Marked mean difference in plaque and gingival bleeding scores observed at follow up among the plaque disclosing agent group imply that, the change was attributed by the use of plaque disclosing agent to aid tooth brushing. Furthermore, the mean difference for plaque score was large while that of gingival health was small according to Cohen values [20]. This indicates the strength of plaque disclosing agent in achieving cleanliness. However, it requires an individual to achieve cleanliness routinely for sufficient positive effect on gingival health. Similar findings have been reported in Thailand and Brazil [4,12,21]. On the other hand, there was slight gain in tooth brushing skills which in a way, was expected since the use of plaque disclosing agent to aid tooth brushing emphasized on clearing of the plaque dyed sections and not the tooth brushing skills. Our findings are comparable to those of Chounchaisithi., *et al* [4].

Apparent improvement in tooth brushing skills and oral hygiene status was observed among children in supervised tooth brushing group while unexpectedly no improvement was seen on gingival health. The improvements in children's tooth brushing skills signify that the intervention had positive impact on pupil's ability to brush their teeth. These findings are in line with those of other studies which reported reduction of plaque and improved tooth brushing skills in supervised tooth brushing group [8,9,13,15,17-19,22]. The finding on gingival health is contrary to those of van Palenstein Helderman., *et al.* 1997, Bezerra, and de Toledo 2002, Damle., *et al.* 2014 and Aída., *et al.* 2017 who reported reduction of bleeding gum in supervised tooth brushing groups [8,13,15,21,22].

When viewed independently, plaque disclosing agent had a positive impact on oral hygiene and gingival health while supervised tooth brushing had on oral hygiene and tooth brushing skills. Comparing the two interventions by looking at the effect size; a statistical significant difference was seen on tooth brushing skills while no differences were observed on oral hygiene nor gingival health. Both interventions proved to be effective in improving oral hygiene, plaque disclosing agent on gingival health and supervised tooth brushing on tooth brushing skills. The effect observed on tooth brushing skills following supervised tooth brushing was anticipated since the intervention coached the children on the know-how of the systematic and coverage of tooth brushing that were later on utilized to assess the skills. Studies that have compared the two interventions could not be retrieved but those that have combined supervised tooth brushing with plaque disclosing agent reported reduction in plaque score and gingivitis [21,22].

Limitations

Despite the observed positive changes of the two trial interventions, interpretation of these findings should take into consideration a few limitations. First, the fact that the mean gingival bleeding score of controls was significantly higher than that of the two intervention groups, may have caused underestimation of the effect of the study interventions on the gingival health. Secondly, possibility of selection bias due to use of convenient sampling of the study area and participating schools.

Conclusion and Recommendation

Supervised tooth brushing showed positive effect on pupil's tooth brushing skills and oral hygiene status while use of plaque disclosing agent positively influenced pupils' oral hygiene status and gingival healthy. Further studies to investigate the effect of supervised tooth brushing and use of plaque disclosing agent that will involve the parents and assess their effect on dental caries are recommended.

Other Information

The study was not given a trial registration number because the National ethical review board categorized it as an educational intervention with no anticipated harm to the participants. It was partially funded by Muhimbili University of Health and Allied Sciences and Colgate Pamolive Tanzania for providing study materials (toothpastes and tooth brushes). The full trial protocol has not been made public.

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