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Original Article

Effectiveness of T-shaped toothbrush in children: A pilot study

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Abstract Dental caries and gingivitis are common oral health problems affecting schoolchildren worldwide. Effective tooth brushing in children is fundamental in preventing dental caries and gingivitis and maintaining good oral health. Children routinely present with unsatisfactory oral hygiene due to poor compliance and poor dexterity in tooth brushing. The purpose of the present study was to evaluate the effectiveness of a novel T-shaped toothbrush in plaque removal and gingival health among children and to obtain feedback regarding its use. Nineteen participants aged 8-10 years who fulfilled the criteria enrolled in this study. The children were taught the proper technique of using the new toothbrush and instructed to use it for a period of 2 weeks. The plaque scores and gingival scores were measured at baseline and after 2 weeks. They were asked to complete a questionnaire regarding the use of the toothbrush after 2 weeks. Statistical analysis was performed using *t*-test. There was a statistically significant (p <0.05) reduction in mean (SD) plaque scores from baseline 1.96 (0.85) to 1.51 (0.75), after 2 weeks. Similarly, mean (SD) gingival scores reduced significantly from 0.20 (0.11) to 0.13 (0.08) over the two-week period. Overall, majority of participants (68% to 89%) gave positive feedback in all aspects regarding the use of T-shaped toothbrush, although 63.2% of them reported having difficulties to handle the T-shaped toothbrush initially. The T-shaped toothbrush can effectively improve oral hygiene in children with acceptable plaque removal and adequate gingival health in children.

Keywords: Children; gingival health; oral hygiene; plaque removal; toothbrush.

Introduction

In many developed countries, dental caries levels have improved among children in recent decades, while lower income countries still have a high decay component (Frencken *et al*., 2017). An ecological shift in the dental biofilm or plaque is the primary aetiology in the development of dental caries and periodontal disease (Marsh, 2010). Good oral hygiene practices reduce the incidence of gingivitis as well as dental caries and it is considered one of the fundamental requirements for the maintenance of a functional dentition throughout life (Petersen, 2003). Thus, regular removal of the dental biofilm is crucial in the prevention and treatment of oral diseases.

Good oral hygiene can be achieved primarily by effective tooth brushing (Macpherson *et al*., 2013). Most children show poor compliance towards brushing because they consider it a tedious and repetitive procedure and tooth brushing practiced by most children is inadequate (Sandström *et al*., 2011). Effective tooth brushing in children depends on correct tooth brushing methods (Smutkeeree *et al*., 2011; Muller-Bolla and Courson, 2013; Patil *et al*., 2014) and habits such as the frequency (Stecksén-Blicks *et al*., 2004), duration (Sandström *et al*., 2011) and toothbrush design (Stroski *et al*., 2011; Ganesh *et al*., 2012). It is also influenced by patients' compliance and the dexterity of the individuals (Martens *et al*., 2000; Sandström *et al*., 2011).

Many studies were directed at developing new toothbrushes to improve effective plaque removal in children (Stroski *et al*., 2011; Ganesh *et al*., 2012; Telishevesky *et al*., 2012; Ghassemi *et al*., 2013). Recently, a new toothbrush with an innovative T-shaped brush head (Denson™,

Malaysia) was introduced with claims that it is designed to efficiently clean teeth surfaces and reduce gingival inflammation (Denson, 2015) [Fig. 1(a) and 1(b)]. The toothbrush was adapted from the shape of a razor used for trimming facial hair in men and used nylon bristles with round ending tips. It was designed to employ a vertical motion on all tooth surfaces which is consistent with the arrangement of the teeth and mimicked the natural up and down movement of the hand, which is more controlled and stable (Denson, 2015). Till date, no studies have evaluated the effectiveness of the T-shaped toothbrush in children. Prior to undertaking larger studies to compare this new toothbrush with currently available toothbrushes, it was important to establish if children were able to adapt to the new toothbrush. Thus, this pilot study aimed to assess the effectiveness of a T-shaped toothbrush in plaque removal and gingival health among children and to obtain feedback regarding its use.

(a) (b)

Fig. 1 (a) Anterior view and (b) Lateral view of brush head of T-shaped toothbrush (Denson™, Malaysia).

Materials and methods

Ethical approval and permission

Ethical approval was obtained from the Medical Ethics Committee of the institution [(Reference Number: DF CD1416/0093(P)]. In addition, necessary permissions to conduct the study among children attending a public school in the vicinity were obtained from the appropriate authorities.

Subjects

Twenty participants aged 8-10 years from one public primary school were invited to participate in this study using convenience sampling. Children were selected if having good systemic health, normal motor and cognitive development. They were excluded if they had an acute intraoral lesion, history of receiving antibiotic and/ or antiseptic therapy in the past one-month, proximal caries or restorations and had 3 or more missing teeth in one quadrant. Informed consent was obtained from the parents or legal guardians of all participants.

Study design

This was a pilot study to assess the effectiveness of the T-shaped toothbrush (Denson™, Malaysia) among 8-10-year-old children. All participants were provided with a T-shaped toothbrush and a tube of 1450 ppm fluoridated toothpaste (Fresh & White Refreshing Mint with Xylitol Toothpaste, Southern Lion) for their use during the 2-week period (2nd-16th April 2015). The subjects were clinically examined for plaque scores and gingival scores at baseline (Visit 1) and at the end of 2 weeks (Visit 2) by one examiner on the school premises in a mobile dental chair with a portable spotlight. The subjects were also instructed to refrain from using any other oral hygiene products or medication during the study period.

Toothbrush

The head of the toothbrush was perpendicular to the handle. The head measured 31 mm x 8 mm. There were 3 rows of tufts of bristles and each row having 8-9 tufts [Fig. 1(a) and 1(b)].

Indices

Gingival status was scored using the Loe and Silness (1963) Gingival Index (Table 1). The amount of plaque was scored using the modified Quigley and Hein Plaque Index

(TQHI) (Turesky *et al*., 1970) (Table 2). Both indices were recorded at 6 sites around all the teeth (mesiobuccal, midbuccal, distobuccal, mesiopalatal, midpalatal, distopalatal). All teeth were included except teeth with stainless steel crowns, space maintainers or cervical restorations.

Questionnaire to assess satisfaction after using T-shaped toothbrush

A simple structured feedback questionnaire was formulated to obtain the children's opinion after using the T-shaped toothbrush. The questionnaire was drafted in English and then translated to Malay, the local and national language of Malaysia. There was a total of 9 items to be rated on a scale ranging from 1-Poor, 2-Average, 3-Good, 4-Very good to 5-Excellent. The rating of 'Poor' was considered as a negative response. A rating of 'Average' was considered as satisfactory and rating of 'Good', 'Very good' and 'Excellent' were considered to be a positive response. The children were asked to complete the questionnaire after the second visit.

Data collection procedures

The examinations were carried out by a main examiner (NM) who was calibrated before the start of the study. The main examiner underwent training and calibration for the clinical recording of gingival score and plaque score using Loe and Silness (1963) Gingival Index and modified Quigley and Hein Plaque Index (TQHI) (Turesky *et al*., 1970) respectively, with one senior paediatric dentist (SAM) at the Faculty of Dentistry, University of Malaya (UM). The inter-examiner calibration procedure was done on three children aged 8-to-10-years who attended the Paediatric Dentistry clinic, Faculty of Dentistry, UM. Full mouth scoring for each child was done by the paediatric dentist and the main examiner on one visit for the gingival score and plaque score. For intra-examiner calibration, the main examiner scored the gingival and plaque score on the same patient twice on the same day after half an hour. The examiner reliability was tested using the intra-class correlation coefficient (ICC), software package SPSS 22.0 (SPSS Inc., Chicago, IL). The ICC values for inter-examiner variability was 0.96 and 0.88 for the gingival score and plaque score respectively. Intra-examiner variability for the main examiner was 0.96 for gingival score and 0.89 for plaque score.

At Visit 1, clinical examination was performed to record plaque and gingival scores. Gingivitis was assessed first by observation of gingival tissues followed by gentle probing along the wall of the gingival sulcus using a William's periodontal probe to detect gingival bleeding. Subsequently, a disclosing solution (Mira-2-ton, Hager Werken, Germany) was applied with a cotton pellet on the teeth to identify biofilm formation to record plaque score. No professional cleaning was performed prior to the start of the study.

After completing the clinical examination, the technique for using the T-shaped toothbrush was demonstrated to the children via a recorded video of a child using the T-shaped toothbrush. Additionally, a hands-on demonstration using an enlarged teaching model of the mouth and a sample T-shaped toothbrush was done. Each child was instructed to brush twice a day (morning and before sleeping) for 2 minutes using the prescribed toothbrush and toothpaste (pea-sized amount).

Follow-up assessment was done after two weeks. At Visit 2, all children were examined again for plaque and gingival scores in a similar fashion as in Visit 1. Then, the participants were asked to answer a feedback questionnaire to assess the satisfaction after using T-shaped toothbrush.

Statistical analysis

The data was entered and analysed using software package SPSS 22.0 (SPSS Inc., Chicago, IL). Numerical variables were age, gingival score and plaque score. These are expressed in frequencies, percentages, means, and standard deviation using descriptive statistics. Categorical variables included gender. The differences of total mean for gingival and plaque score between Visit 1 and Visit 2 were compared using paired *t*-test since the data was normally distributed. Questionnaires were analysed using descriptive statistics for frequencies and percentages of the response rates. The level of statistical significance was set at 5% ($p<0.05$) with 95% confidence interval.

Table 1 Gingival Index (Loe and Silness, 1963)

Gingival Index	
0	Absence of inflammation
1	Mild inflammation: Slight change in color and texture. There is no bleeding on probing
2	Moderate inflammation: Moderate glazing, redness, edema and hypertrophy. There is bleeding upon probing
3	Severe inflammation: Marked redness and hypertrophy, a tendency to spontaneous bleeding and ulceration

Table 2 Plaque Index (Turesky *et al*., 1970)

Plaque Index	
0	No plaque present
1	Separate flecks of plaque at the cervical margin
2	A thin, continuous band of plaque (up to 1mm) at the cervical margin
3	A band of plaque wider than 1mm but covering less than one-third of the surface
4	Plaque covering at least one-third but less than two-thirds of the surface
5	Plaque covering more than two-thirds of the surface

Results

Out of the 20 children who fulfilled the inclusion and exclusion criteria and were invited to participate in the study, only 19 parents consented to their children participating in the study. A total of 11 (57.9%) boys and 8 (42.1%) girls completed the study. The study population comprised of 6 (31.6%) 8-year-old, 8 (42.1%) 9-year-old and 5 (26.3%) 10-year-old children.

Paired *t*-test was used to analyse the mean gingival score and plaque score between both visits. The mean (SD) gingival score at Visit 1 was 0.20 (0.11) and this decreased to 0.13 (0.08) at Visit 2. For the plaque score, the mean (SD) at Visit 1 was 1.96 (0.85) and decreased to 1.51 (0.75) at Visit 2. There was a significant reduction ($p<0.05$) in gingival and plaque scores at the end of 2 weeks (Table 3).

Table 4 shows the satisfaction level of children after the use of T-shaped toothbrush for a period of 2 weeks. From the questionnaire, 12 (63.2%) children reported having difficulties in manipulating the T-shaped toothbrush initially, especially when brushing at the posterior region. Overall, majority of participants (68% to 89%) gave a positive feedback regarding the T-shaped toothbrush in all aspects. Almost two-third of the children (63.2%) gave an excellent score regarding ability of T-shaped brush head to reach all areas of the mouth, which was the highest response rates. In general, about 5.3% to 31.6% of the participants rated the T-shaped toothbrush negatively.

Table 3 Comparison of mean gingival score and plaque score at Visit 1 and Visit 2

Indices	**Baseline (Visit 1) Mean (SD)**	**2 weeks (Visit 2) Mean (SD)**	**Mean reduction (SD)**	***p* value**
Gingival score	0.20 (0.11)	0.13 (0.08)	0.06 (0.08)	*0.004
Plaque score	1.96 (0.85)	1.51 (0.75)	0.45 (0.67)	*0.010

*Significant difference from baseline, paired *t*-test, $p<0.05$

Table 4 Satisfaction level of children regarding the use of T-shaped toothbrush in preliminary study

Question	Rating scales n (%)				
	Negative	Satisfactory		Positive	
	Poor	Average	Good	Very good	Excellent
1. Clean feeling with tongue	6 (31.6%)	0 (0%)	1 (5.3%)	3 (15.8%)	9 (47.4%)
2. Clean feeling between teeth	2 (10.5%)	0 (0%)	6 (31.6%)	6 (31.6%)	5 (26.3%)
3. Clean feeling on back teeth	3 (15.8%)	5 (26.3%)	4 (21.1%)	4 (21.1%)	3 (15.8%)
4. Comfort during brushing	3 (15.8%)	1 (5.3%)	3 (15.8%)	4 (21.1%)	8 (42.1%)
5. Comfort after brushing	3 (15.8%)	0 (0.0%)	5 (26.3%)	5 (26.3%)	6 (31.6%)
6. Easy to use	2 (10.5%)	4 (21.1%)	5 (26.3%)	3 (15.8%)	5 (26.3%)
7. Shape of brush head	1 (5.3%)	3 (15.8%)	6 (31.6%)	6 (31.6%)	3 (15.8%)
8. Size of brush head	1 (5.3%)	2 (10.5%)	3 (15.8%)	4 (21.1%)	9 (47.7%)
9. Brush head enables reaching all areas	1 (5.3%)	3 (15.3%)	0 (0.0%)	3 (15.8%)	12 (63.2%)

Discussion

When a new toothbrush is developed and introduced in the market, it is important to evaluate its efficacy in terms of plaque removal and ability to improve gingival health. This information provides dental professionals the necessary evidence to recommend its usage. Since there were no scientific studies or reports available regarding the T-shaped toothbrush (Denson™, Malaysia), the following information was obtained from webpages and related testimonials (Denson, 2015). As described by the manufacturer, the T-shaped toothbrush (Denson™, Malaysia) requires a vertical motion or up-and-down movement which simulates the natural up and down movement of the hand, suggesting that this is the correct way of tooth brushing, making the brushing process to be more controlled and stable.

They also claimed that the utilisation of T-shaped toothbrush has a likely advantage for children with reduced manual dexterity since gripping the handle is more comfortable (Denson, 2015). Earlier studies using the conventional toothbrush found more children using the distal oblique grip rather than the power grip (Mentes and Atukeren, 2002; Das and Singhal, 2009; Sharma *et al*., 2012; Pujar and Subbareddy, 2013). Further studies should be conducted on the grip used for the T-shaped toothbrush. The authors speculated that the T-shaped toothbrush would probably use the power grip rather than any other grip, suggesting that tooth brushing with this design is likely to be more stable and comfortable.

The findings of this pilot study demonstrated that the children had good compliance and were able to accept the T-shaped toothbrush. However, more than half of children reported difficulties in manipulating the T-shaped toothbrush initially, especially in the posterior region. Initial difficulties with the brush were inevitable, since the children were not accustomed to the design, vertical brush strokes and position of the brush handle while brushing. However, they were able to adapt to the T-shaped toothbrush when they used it consistently within a span of two weeks.

Within the 2-week duration of the present study, the T-shaped toothbrush significantly decreased the plaque and gingival scores. This proved that the toothbrush was effective in plaque removal for 8 to10-year-old children. However, the initial enthusiasm of getting a new type of toothbrush may also have encouraged the children to brush more fervently and regularly. Secondly, there was a likelihood of the 'Hawthorne effect'. The Hawthorne effect is a type of reactivity in which subjects modify or improve an aspect of their behaviour being experimentally measured in response to the

fact that they are being studied or observed (McCarney *et al*., 2007). To overcome the factors listed above, further studies should be conducted over a longer period and compared with the more conventionally used children manual toothbrush.

The plaque score was assessed using modified Quigley and Hein plaque index (Turesky *et al*., 1970) which was the most commonly used index in assessing the efficacy of toothbrushes (Yaacob *et al*., 2014) and fulfilled the criteria for an ideal index in clinical studies (Hazen, 1974). The measurements were recorded on all teeth rather than on index teeth to obtain a more accurate result (Yaacob *et al*., 2014). However, this index did not measure the plaque accumulation on occlusal surfaces which is the site of predilection for caries especially in children. Thus, an additional plaque index for occlusal surfaces may have been useful to assess the effectiveness of T-shaped toothbrush in plaque removal.

A duration of two weeks was chosen for this study period. This timeframe was significant since lack of oral hygiene for a period of 10-21 days would have been sufficient to develop clinical signs of gingivitis (Loe *et al*., 1965). Since no child showed any gross accumulation of plaque or signs of severe gingivitis, it was understood that all children were able to adapt to the toothbrushes allotted to them.

Results from the feedback questionnaire regarding the use of T-shaped toothbrush showed the potential for the toothbrush to increase motivation and improve compliance of the children towards regular habit of tooth brushing. The present study demonstrated acceptability of the T-shaped toothbrush. It was rated positively by majority of participants in all aspects related to cleaning, comfort and size or shape of the brush head.

Limitations of this pilot study include the limited duration of the study, which may not reflect the actual effectiveness and adaptation of the children towards the new shape of toothbrush. The sample size of 19 participants is too small and was not representative of the general population. Further studies should be conducted using a larger sample size over a longer duration.

Conclusions

The results of this study indicated that the T-shaped toothbrush has the potential to improve the oral hygiene in children because it significantly reduced plaque accumulation and improved gingival health. Feedback results found that the T-shaped toothbrush was well received by 8-10-year-old children within 2 weeks, which was rated positively by majority of participants regarding its overall use.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest. Sources of funding: This study was funded by Postgraduate Coursework Research Grant, Faculty of Dentistry, University of Malaya, Malaysia; PPPC/C1-2015/DGK/10. Research involving Human Participants: All procedures performed were in accordance with the ethical standards of the institutional committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethical approval to conduct the study was obtained from the Medical Ethics Committee of the institution [(Reference Number: DF CD1416/0093(P)]. Informed consent was obtained from all parents of the individual participants included in the study.

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