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Effect of an oral health education program based on the use of quantitative light-induced fluorescence technology in Uzbekistan adolescents

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ABSTRACT

Objectives: The aim of this study was to determine whether an oral health education program using a Qscan device based on quantitative light-induced fluorescence (QLF) technology could improve the oral hygiene status and oral health literacy of adolescents.

Materials and methods: One hundred adolescents aged 14–16 years attending a school in Tashkent city were included in this study. The participants were assigned to the following two groups using permuted block randomization technique: (i) control group (traditional learning) and (ii) experimental group (Qscan device-based learning). The participants included in the experimental group received additional education and training on dental plaque removal using the Qscan device. The accumulated levels of plaque were assessed in all participants, who also completed questionnaires about their oral health status, oral health knowledge, attitude, and behavior during an 8-week period.

Results: There were statistically significant improvements in the experimental group compared to the control group in the plaque index (0.46 vs 0.07, $p < .05$), oral health knowledge (19.4 vs 28.8, $p < .05$), attitude (16.7 vs 20.2, $p < .05$), and behavior (19.9 vs 30.5, $p < .05$).

Conclusions: This study has demonstrated that an oral health education program based on the use of QLF technology could be useful for improving the oral hygiene status and oral health literacy of adolescents in Uzbekistan.

1. Introduction

Dental disease is highly prevalent and a significant burden, especially in developing countries [1,2]. Excessive anxiety caused by the fear of treatment of dental disease in children can affect their learning capabilities as well as behavioral and social development [3,4], and so preventing dental disease is an issue that also has social and economic implications. However, more than 80% of the world's children live in developing countries with extremely limited oral health-care resources [5], and where the desired level of prevention of the dental disease has not yet been achieved. Dental caries affects people in Uzbekistan of all ages, and especially children and adolescents. Dental caries in Uzbekistan is the most common cause of hospital admissions for inpatient treatment among children and adolescents aged 5–15 years [6,7].

Oral health education has been considered a primary method via which dental health services can provide oral health information and improve the health literacy of patients, especially when the available resources are limited. The school setting is known as the most appropriate for applying health education programs in developing countries because it can be used to promote healthy lifestyles and self-care practices at a very low cost [8]. School-based oral health education programs have produced positive outcomes in oral cleanliness, oral health knowledge, and oral behavior among adolescents [9–13]. However, study results have been inconclusive concerning changes in the attitude of adolescents [14,15].

The Extended Parallel Process Model (EPPM) was developed with the aim of understanding how attitude both forms and changes, and it has provided a useful framework for understanding the attitudes of adolescents that are still forming [16]. The EPPM is based on two key variables: risk and efficacy. Improving the perceived risk and perceived efficacy requires a standard mode of delivery of health messages via the personal instruction approach in clinical settings on a one-on-one basis.

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Although this approach has been shown to be effective in improving dental health, it is time-consuming and may not be practical from a community perspective. Substituting such personal instruction with other forms of communication has been investigated, such as self-education using leaflets or videos, and classroom lectures, but these approaches have shown only limited success when compared with personal instruction [17]. It might be possible to improve the attitude and oral health status of adolescents if they could be made more aware of the risks from dental plaque and cariogenic diet which might lead to dental caries and gingival disease.

Various optical detection devices have recently been introduced in the field of dentistry. Quantitative light-induced fluorescence (QLF) technology is commonly used in clinical dentistry as an assessment tool for quantifying the degree of maturity and pathogenicity when attempting to control dental plaque [18,19]. It has also been confirmed that QLF technology can be used in the clinical setting for plaque assessment by detecting mature plaque as red fluorescence. A recently developed Qscan device (AIOBIO, Seoul, Korea) allows nonprofessionals to visualize and detect dental plaque easily, thereby enabling oral hygiene care to be managed in the home.

The aim of this study was to determine the effect of an oral health education program based on the use of QLF technology on the oral hygiene status and oral health literacy among adolescents in Tashkent city, Uzbekistan. We hypothesized that adolescents who receive oral health education using QLF technology are more likely to exhibit improved oral hygiene, oral health knowledge, attitude, and behavior.

2. Materials and methods

2.1. Participants

The study period was from September 2015 to November 2015, and it included 100 adolescents aged 14–16 years attending school #123 in the M. Ulugbek district of Tashkent city. Written informed consent was obtained from the parents or caregivers of all participants before the trial. The study was performed according to the protocols and procedures approved by the Institutional Review Board at Tashkent State Dental Institute (2017-0001). The sample size was calculated for α error fixed at 5% and β error fixed at 20%, expected mean difference of plaque index (primary outcome) 0.38 and standard deviation 0.41 based on the formulations required in each group. Considering the dropout rate (10%), a minimum of 50 participants would be required. The participants were assigned to two groups using a permuted block randomization technique: (i) the Qscan device-based learning group and (ii) the traditional learning group (Fig. 1). Initially there were more than 100 adolescents, but we selected 100 adolescents according to the selection criteria given in Fig. 1. During the evaluation periods, some of the students were sick and some were absent for unknown reasons, and for others we could not evaluate certain characteristics such as their level of education or oral hygiene status. These various reasons meant that we had to exclude them from the analysis, and so of the initial 135 subjects at baseline, 100 of them were randomly selected and divided into 2 groups. Fifty subjects were assigned to the control group, which received a traditional learning program about oral hygiene, while the other 50 subjects were assigned to the experimental group, which received an oral health education program based on the use of the Qscan device. The final numbers of subjects were 42 in the experimental group and 44 in the control group (Fig. 1).

2.2. Educational intervention

Lessons on oral hygiene were provided to the control group of adolescents in a traditional lecture format lasting 10 min and involving demonstrational models. The key educational messages were the importance of oral health, the role of microbial plaque, the appropriate frequency and methods of toothbrushing and flossing, the importance of regular dental attendances, what constitutes a healthy diet, and the appropriate use of fluoride.

Lessons were provided to the experimental group with a traditional method combined with a demonstration of how to measure the individual plaque level using the Qscan device. This device is usually used by consumers to check their own plaque in the home setting (Fig. 2), and it can also be used effectively in the school oral health care setting because it reduces the inconvenience and time required to measure dental plaque compared to traditional disclosing methods [20,21]. The educator used the Qscan device to help students to see plaque in their mouth in a red color, and explained the concept of dental plaque and the importance of its daily removal (Fig. 3).

On the first day of education, fluoride-containing toothpaste and toothbrushes (Dentafill Plyus, Uzbekistan) were distributed to all participants. Leaflets containing the same oral health information were also distributed during the first lesson. The education was provided three times: at baseline and during the second and fourth weeks of the intervention period.

2.3. Clinical examination and questionnaire-based measurement

The oral health status of all participants was examined in the classroom during school hours while they were seated in comfortable chairs. Three blinded and calibrated dentists examined all participants using headlamps, dental mirrors, and World Health Organization (WHO) probes. At baseline, the dental caries status was recorded using the decayed, missing, and filled teeth (DMFT) index according to the WHO diagnostic criteria [21]. The Silness-Löe plaque index was used to evaluate oral hygiene, with the scores recorded for six index teeth: #16, #12, #24, #36, #32, and #44 [22]. Six dental plaque measurements were made at baseline, weekly during the intervention period of 4 weeks, and at a final examination after a follow-up period of 4 weeks (Fig. 4). A gold-standard examiner (one of the authors: B.K.) trained the three dentists who participated in this study (D.K., J.A., and K.T.). During the survey we conducted duplicate examinations on 5% of the participants each day. The interexaminer and intraexaminer reliabilities were maintained during all periods of the trial, as indicated by Cohen's kappa values of ≥ 0.70.

All of the participants completed a questionnaire survey at baseline about oral health knowledge, attitude, behavior, and demographic information. The oral health knowledge, behavior, and attitude were assessed using a modified version of the questionnaire developed by Angelopoulou et al. [23]. The researchers administered the questionnaire with assistance from class teachers. The respondents were asked questions on their basic knowledge of oral heath, attitude, and dental health practices. The questions on oral health knowledge comprised the causes of gingivitis and gum bleeding, reasons for using dental floss, the importance of a healthy diet, what fluoride is, the fluoride content of toothpaste, the use of fluoride, the effects of fluoride on dentition, and the importance of teeth. Questions were included on brushing habit, aids used for brushing, brushing frequency, and rinsing habit in order to assess the practices related to oral health. The respondents also completed questionnaires on background characteristics including sex and age.

The 23-item structured questionnaire was originally constructed in English, and it was translated into the Uzbek language for local use. The lessons were provided once over a 2-week period, and oral health knowledge, oral health behavior, and attitude were evaluated with the aid of the questionnaire. The total study duration was 8 weeks (Fig. 3).

2.4. Statistical analysis

All statistical procedures were performed using SPSS (version 23.0, IBM Corporation, Armonk, NY, USA). Descriptive statistics were reported using frequency (%) or mean ± SD values, as appropriate. The chi-square test and independent-samples *t*-test were conducted to

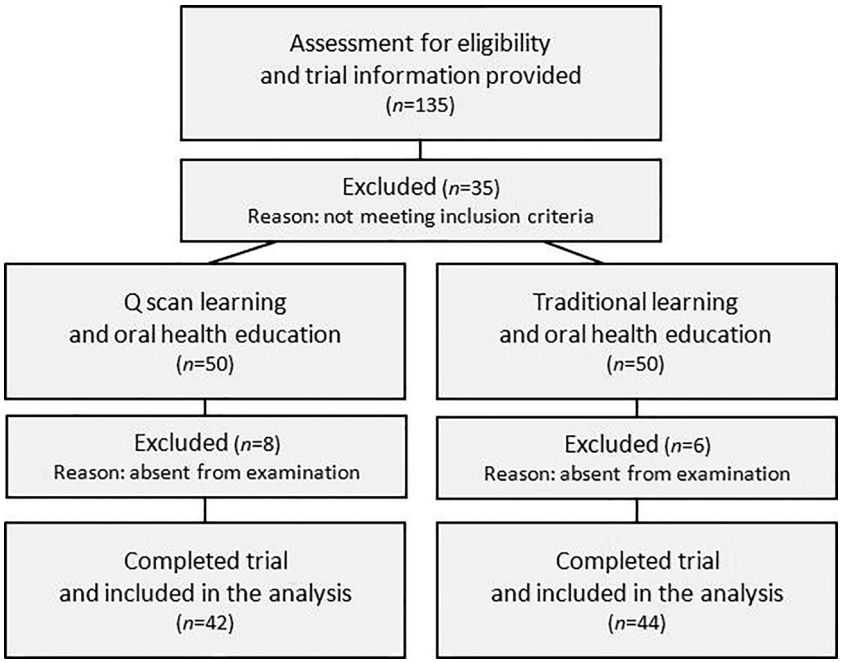

Fig. 1. Flow diagram for enrolment in this study.

Fig. 2. Qscan device used in this study (left) and the photograph showing how to use this device in the oral health education program (right).

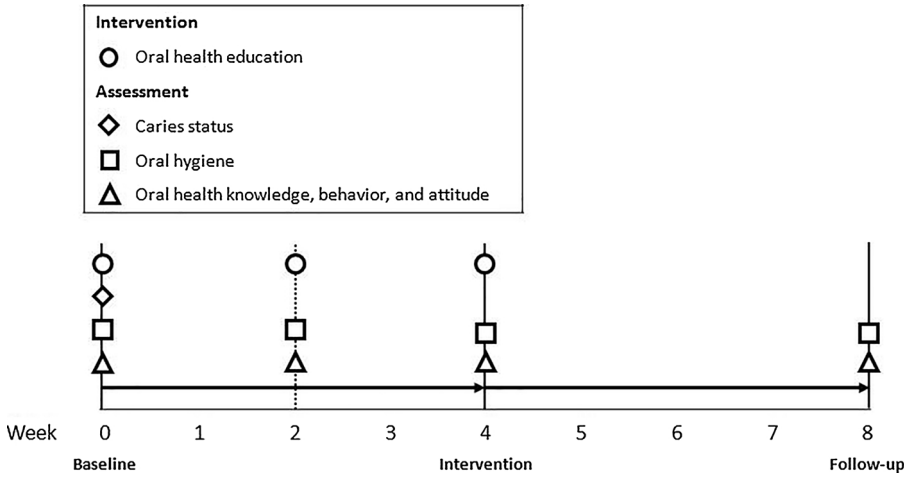

Fig. 3. Schedule of interventions and assessments in this study.

compare the Qscan experimental group and the control group. Linear mixed models were used with a first-order autoregressive correlation matrix to make comparisons between the learning groups and the different time periods. These techniques are an extension of linear regression, and allow for the clustering of repeated measured variables within subjects.

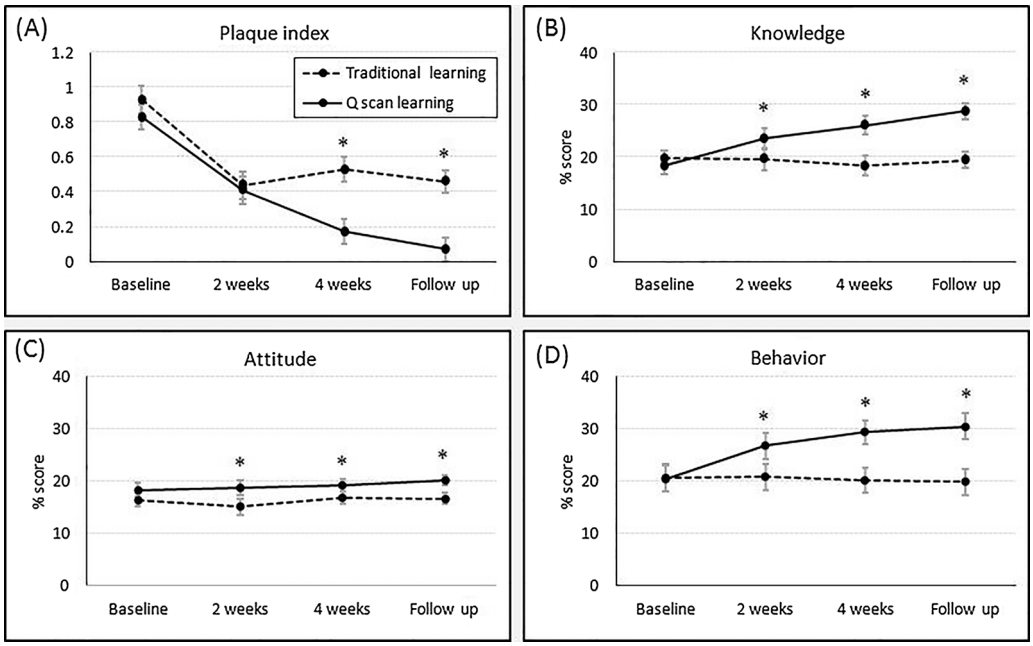

Fig. 4. Oral hygiene status (plaque index) and oral health behavior variables in the two study groups.
Data are median and confidence-interval values.
Significant difference ($p < .05$) are indicated by an asterisk.

3. Results

The oral hygiene status did not differ significantly between the control and experimental groups at baseline (Table 1). Carious lesions were present 95.5% and 100% of the teeth in the control and experimental groups, respectively; the corresponding DMFT scores were 4.20 ± 0.39 and 5.14 ± 0.45. After 2 weeks of intervention, both groups showed improvement in oral hygiene status, oral health knowledge, attitude, and behavior (Table 2).

The plaque index did not differ significantly between the two groups until the second week, but it was 68% lower in the experimental group compared to the control group (0.17 vs 0.53, $p < .001$) on the fourth week. This significant difference increased to 85% on the eighth week (0.07 vs 0.46, $p < .001$). Comparing changes in plaque index according to time between the two groups revealed that the control group showed a sharp decline from baseline to 2 weeks, but then stagnated. In contrast, in the experimental group there was a significant decrease from baseline to the final (eighth) week.

The changes in oral health behaviors after 2 weeks differed between the two groups. In the experimental group, the knowledge and behavioral variables were improved by 28.3% and 30.7%, respectively, after 2 weeks compared to the baseline at the eight week (Fig. 4), while there was no significant changes in any of the behavioral variables in the control group. The difference between these two groups increased gradually, and the knowledge and behavioral variables of the experimental group improved by 56.5% and 48.8% compared to the baseline on the eighth week (Fig. 4).

Table 1
Demographic characteristics, oral health status and oral health behavior scores in the experimental group (Qscan device-based learning) and the control group (traditional learning) before intervention.

	Experimental group (n = 42)	Control group (n = 44)	p[a]
Sex			
Male	18 (42.9)	16 (36.4)	0.538
Female	24 (57.1)	28 (63.6)	
Age, years			
14	10 (23.8)	12 (27.3)	0.667
15	11 (26.2)	8 (18.2)	
16	21 (50.0)	24 (54.6)	
Caries status			
DT index	4.17 ± 2.84	3.14 ± 2.42	0.073
FT index	0.79 ± 1.49	0.89 ± 1.43	0.750
MT index	0.19 ± 0.71	0.18 ± 0.39	0.944
Oral hygiene status			
Plaque index	0.83 ± 0.31	0.93 ± 0.18	0.067
Oral health behavior score, %			
Knowledge	18.4 ± 5.6	19.7 ± 5.1	0.253
Behavior	20.5 ± 6.0	20.7 ± 10.6	0.932
Attitude	18.4 ± 4.0	16.5 ± 5.1	0.060

Data are n (%) or mean ± SD values.
DT index, number of decayed teeth; FT index, number of filled teeth; MT index, number of missing teeth; plaque index, Silness-Löe plaque index.
[a] By independent-samples t-test for caries status, oral hygiene, and oral health behavior scores; by chi-square test for sex and age.

4. Discussion

This study has shown that oral health education including the use of QLF technology is effective in improving the oral health knowledge and oral hygiene status of adolescents. The oral health knowledge improved in both intervention groups over an 8-week intervention, while the oral health attitude and behavior improved only in the test group, with no significant difference in the control group. This is consistent with a previous study finding that education produced only a short-term improvement of knowledge (i.e., over 6 weeks), and that alone did not change the cognition of the severity of the risk (i.e., the perceived threat) [24].

This study is the first to confirm the efficacy of including the utilization of QLF technology in oral health education provided to adolescents in the school environment. This is an innovative educational method that is increasingly used for oral hygiene assessments and caries detection. A six-step method for evaluating significant changes in oral health behavior has been reported [25]: (i) identifying the problem, (ii) creating confidence and commitment, (iii) enhancing awareness of behavior, (iv) developing and implementing an action plan, (iv) evaluating the plan, and (vi) maintaining the change and preventing; in this method, QLF technology can be applied before and after the fourth step.

Table 2
Differences in oral hygiene status and oral health behavior scores between the two groups and their changes among the different time periods.

	Group	Baseline	During intervention 2 weeks	4 weeks	8 weeks	$p^{\dagger}$
Oral hygiene status						
Plaque index	Control	0.93 (0.86–1.01)[a]	0.44 (0.36–0.52)[b]	0.53 (0.45–0.60)[b]	0.46 (0.40–0.53)[b]	< 0.001
	Experimental	0.83 (0.75–0.91)[a]	0.41 (0.33–0.49)[b]	0.17 (0.10–0.25)[c]*	0.07 (0.00–0.14)[c]*	< 0.001
Oral health behavior score, %						
Knowledge	Control	19.7 (18.1–21.3)	19.6 (17.5–21.6)	18.4 (16.6–20.2)	19.4 (17.9–21.0)	0.713
	Experimental	18.4 (16.8–20.0)[a]	23.6 (21.5–25.7)[b]*	26.1 (24.2–27.9)[b]*	28.8 (27.2–30.4)[bc]*	< 0.001
Attitude	Control	16.5 (15.1–17.8)	15.1 (13.6–16.7)	16.8 (15.6–18.1)	16.7 (15.6–17.7)	0.447
	Experimental	18.4 (16.9–19.8)[a]	18.8 (17.2–20.3)[b]*	19.2 (18.0–20.5)[b]*	20.2 (19.2–21.3)[b]*	0.002
Behavior	Control	20.7 (18.1–23.3)	20.8 (18.3–23.3)	20.2 (17.9–22.5)	19.9 (17.4–22.4)	0.336
	Experimental	20.5(17.9–23.2)[a]	26.8 (24.3–29.4)[b]*	29.4 (27.1–31.8)[b]*	30.5 (27.9–33.1)[b]*	< 0.001

Data are mean (confidence-interval) values.
Plaque index, Silness-Löe plaque index.
Comparisons were performed within the same period of time using a linear mixed model.
Asterisks indicate significant differences between control group and experimental group ($p < .05$).
† *p*-values were calculated within the same group using a linear mixed model with Bonferroni correction. Different letters indicate significant differences among the different time periods ($p < .05$).

This protocol seems to be effective in changing the health behavior and maintaining this for relatively long periods.

Education utilizing QLF technology seems to be effective in changing the attitude of adolescents. Oral health knowledge improved through the education phase regarding the risk of threat, but no long-term change in behavior was seen. However, this is consistent with a report that applying the EPPM is effective in changing the attitude by providing a solution (e.g., the Qscan device) that can be surely managed in a situation where only the knowledge of the threat will not change the behavior [26].

The oral health of adolescents still needs constant improvement, despite the experience of dental caries in children and adolescents declining in most developed countries over the past 40 years, the level remains unacceptably high [27–29]. This phenomenon is often attributed to an increased intake of sugar in the diet. Previous studies have shown that adolescents in developing countries such as Uzbekistan are more likely to be affected by periodontal disease and therefore need more management [30]. The results of the present study showed that the Qscan device using QLF technology can be a useful tool for adolescents to improve their oral health and oral hygiene.

School-based oral health experience learning is known to be effective in improving oral hygiene. Angelopoulou et al. reported that a school-based oral health experiential learning program for improving the oral hygiene and gingival health of 13-year-olds was effective in improving both oral health attitude and behavior in a 6-month intervention [23]. Moreover, applying the motivational interviewing method through counseling produced a significant improvement in the gingivitis morbidity, as compared with the traditional education method alone [31]. School-based oral health education provided in a peer-to-peer environment is especially effective in developing countries, and is both relatively inexpensive and effective in improving oral health knowledge and behavior [30].

Education that utilizes new technologies and their associated devices can also be expected to be more effective. This study has shown that the use of additional equipment such as the Qscan device in oral health education can yield better educational effects than traditional education methods. It was reported previously that education using newly introduced Web-based graphic images provided greater improvements than education based on an existing method [32]. Training using other types of equipment (e.g., simulation equipment) has been reported to have a greater educational effect than traditional training-only groups [33–35]. These results suggest that benefits are obtainable by actively utilizing assistive devices such as the Qscan device in oral health education courses for the general public as well as adolescents.

More efforts are needed to improve the effectiveness of oral health education. The results of this study are consistent with previous findings of only well-organized programs leading to significant improvements in the oral health attitude of students [36]. It is also noteworthy that the adoption of a so-called adherence triangle concept, which includes interdisciplinary training and education among dentists, teachers, and peers, resulted in 68% of educational participation and behavior changes that lasted for up to 9 months [37]. Well-structured research is essential for inducing appropriate changes in health behaviors, including theoretical investigations of the design of interventions and how to deliver them [38,39].

This study was subject to some limitations. The included sample was collected in the same area so as to ensure similarity between research groups in terms of socioeconomic level, and so it is not representative of the entire Uzbek population. Dental caries were assessed in accordance with WHO recommendations using dental mirrors and explorers in the dental office of a school. However, the oral health education program using the Qscan device included subjective factors, such as each dentist selecting the most severe area of the particular mouth when educating the students. Further research is needed that includes consideration of self-efficacy, intention, social influences, coping planning, and action planning, since all of these factors are reportedly determinants of oral health behavior [40].

5. Conclusion

The application of the Qscan device in oral health education provided to Uzbekistan adolescents has allowed several conclusions to be drawn. Significant improvement amongst adolescents in the Qscan group compared to the control group after 8 weeks were determined in oral hygiene status, oral health knowledge, attitude, and behavior. This study has demonstrated that including QLF technology in a school-based learning program is useful for improving the oral hygiene status and oral health literacy of Uzbekistan adolescents.

Competing interests

The authors declare that they have no competing interests.

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