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# EFFECTIVENESS OF SMARTPHONE APPLICATION IN IMPROVING ORAL HYGIENE COMPARED TO ORAL INSTRUCTIONS IN PATIENTS WITH PLAQUE-INDUCED GINGIVITIS: A RANDOMIZED CONTROLLED TRIAL

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## *ABSTRACT*

Attaining ideal oral health through preventive measures is the primary concern of dental health practitioners. Dentists and dental hygienists encourage patients to practice proper oral care by themselves; therefore, patients are advised to follow a benchmark or regimen of oral care. Inflammation is caused when the dental plaque accumulates around and under the gingiva, which eventually destroys the gingival tissue and leads to periodontitis if the accumulation of dental plaque persists. However, patients oftentimes fail to maintain the oral hygiene regimen which was instructed to them during the chair side time due to their hectic lifestyles in the current fast-paced time.

Smartphones are extensively used in every aspect of life in the current era, including in health sciences. Medical practices from teaching, research, and patient care to diagnosis of diseases can be performed easily nowadays using a handheld smartphone via different applications. In recent years, smartphone applications are often used in dentistry as an adjunct apparatus for motivation and oral health education. Using different applications and text messaging services makes it simpler to motivate patients to maintain their oral care. In addition, along with smartphone applications, different social media platforms are also motivating patients to improve their oral health. Different smartphone applications are available that send notifications to patients to remind them to take care of their teeth. Hence, the current study aimed to assess the effectiveness of smartphone application compared to the old traditional method in terms of oral hygiene instruction

**KEYWORDS:** Oral hygiene instructions, Smartphone application

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## INTRODUCTION

With the introduction of smartphones, a new era of integrated communication and entertainment has begun (Bhanderi et al., 2021). Smartphone ownership is common among teens with varying ages, economic backgrounds, races and ethnicities. According to the results of a Pew Research Center survey of U.S. teens in 2023, most teens possess or have the access to a smartphone (95%). Older teens ages 15 to 17 are more likely to be near-constant internet users compared to younger teens (50% vs. 40%) (Pew Research Center, December 2023). Although smartphones are beneficial for a variety of uses, such as rapid sharing of information, convenient electronic commerce, contact with other cultures, entertainment and emotional support, the adverse effects of smartphone use cannot be denied (Qureshi et al., 2022). Easy availability of smartphones led to its addiction in adolescents including those from lower socioeconomic level globally (Davey et al., 2014). In 2022, the results of a cross-sectional study revealed increasing dependency on smartphones among adolescents, who constitute an age group with elevated risk for smartphone addiction. People having this problem encounter psychological, social, and health problems (Qureshi et al., 2022). Nonetheless, there is scarcity of research regarding the consequences of smartphone use in adolescents residing in developing countries (Bhanderi et al., 2021).

The effects of poor oral health on individuals' general health have been extensively studied. For example, periodontitis is regarded as one of the risk factors involved in the pathogenesis of cardiovascular disease, diabetes mellitus, recurrent pneumonia, and kidney disease (Dörfer et al., 2017). A fundamental factor for preservation of periodontal health is oral hygiene because it decreases the accumulation of microbial plaque on the teeth and gingiva (Stewart et al., 1997). The effect of self-care procedures including brushing and flossing on the periodontal disease prevention has been strongly evident (Claydon, 2008). With changes witnessed in the concepts of oral disease management marking a shift towards the prevention at the individual level, light is shed on possible benefits of smartphones in health promotion being a key component in disease prevention. Approaches for health promotion including thorough explanations of disease risk information and self-monitoring of individual's own health, have been fruitful in modifying the behavior of individuals towards their health. Owing to the high use of smartphones by individuals, they are now regarded as devices suitable for promoting health and accessing health information (Hincapié et al., 2020) In dentistry, around 1075 oral hygiene apps were found on the Apple App Store and Google Play Store platforms as of 2018 (Marchetti et al., 2018). Most of the available apps primarily focused on brushing timers and techniques and are mostly helpful in teaching tooth brushing techniques. Therefore, mobile apps could serve as an aid in motivating oral hygiene maintenance(Nayak et al., 2019). The aim of our study is to examine the extent to which using a smartphone application as an educational tool and reminder of the oral hygiene instructions will affect patients' oral health. To the best of our knowledge, there is no study comparing the use of smartphone applications in improving oral hygiene compared to oral instructions in adolescent patients having plaque-induced gingivitis in a developing country.

## MATERIALS AND METHODS

This is a randomized, controlled, single-blinded clinical trial conducted in Cairo, Egypt. Research Ethics Committee of the Faculty of Dentistry, Cairo University approved the study protocol (Approval number: 38-4-24). The trial was prepared in accordance with the CONSORT guidelines for reporting of randomized controlled trials (Moher et al., 2010). Patients were recruited from the 'paid treatment unit' belonging to the outpatient clinic at

the Faculty of Dentistry, Cairo University. The study protocol was explained to eligible patients then an assent was obtained from patients who agreed to participate in this study. An informed consent was signed by the guardian of the patients.

The sample size was calculated using PS - Power and Sample Size Calculation*. After accounting for the patient loss to follow-up around 25%, a sample size of 60 patients divided into two groups would guarantee power equal to 0.82.

**Eligibility criteria:**

Patients were enrolled as follow: (a) age range between 12-19 (b) presence of at least 20 permanent teeth (c) had plaque-induced gingivitis with 10 or more teeth showing plaque or bleeding (d) Absence of crowding in the incisor region.

Exclusion criteria included: (a) Systemic disease that might affect periodontal healing as Diabetes Mellitus (b) Physical disorders affecting manual dexterity or mental disorders affecting mental cognition (c) Patients with cleft palate where oral hygiene regimen could be compromised (d) Predisposing local factors to plaque accumulation such as orthodontic treatment, carious and non-carious cervical lesions, faulty restorations, and unusual tooth crown morphology (e) Patients treated with therapeutic drugs producing gingival enlargement as a side effect (phenytoin, cyclosporine) (f) Patients who are using other operating systems than Android and iOS phones.

Simple randomization was performed by a computer-generated list from a "random.org" website by a colleague (G.N) not participating in the study. Numbers were kept in opaque envelopes and concealed from the principal investigator. Patients were asked to choose one envelope then they were accordingly assigned to one of the two groups in 1:1 ratio. The principal investigator and the patients could not be blinded due to the nature of the intervention, while the outcome assessor was blinded. Allocation concealment was performed through the use of opaque well sealed envelopes.

At baseline visit, the test group consisting of thirty participants was instructed on how to download a free smartphone application for oral hygiene instruction. "Healthy Teeth–Tooth Brushing Reminder with timer"** is an application that acts as a reminder twice a day for tooth brushing. Daily notifications from the application were sent to patients to remind them to brush. The application also possessed a menu with graphics interchange format (GIF) to show how to brush properly. Furthermore, notifications were sent for the timing to change the toothbrush. The control group consisting of thirty participants was informed of the oral hygiene instructions verbally by the principal investigator. Patients were asked to demonstrate the oral hygiene instructions to the principal investigator to ensure that they are fully comprehended. The outcome assessor recorded scores for all patients at two different timepoints: at baseline (T0) and after two months of the instructions (T1) using the gingival index (GI) (Davies et al., 2004) and Quigley–Hein Turesky modification index (QHTMI) (Creeth et al., 2009) (Table 1) for scoring plaque accumulation. "Garnet"***, a disclosing solution, was used to stain the dental plaque and assign scores to patients.

Then supragingival scaling and polishing was performed to all patients. At the follow-up two months after the baseline visit, the same outcome assessor assigned scores to all patients.

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TABLE (1) GI and QHTMI scoring system.

| GI Score | QHTMI Score |
|---|---|
| Score 0 = No inflammation | Score 0 = No plaque |
| Score 1 = Mild inflammation. Gingiva slightly changes in color and little change in texture | Score 1 = Separate fleck of plaque on the tooth |
| Score 2 = Moderate inflammation. Gingiva moderately glazing, redness, edema, and hypertrophy. Tendency to bleed upon probing | Score 2 = A thin continuous band of plaque |
| Score 3 = Severe inflammation. Marked redness and hypertrophy of gingiva. Tendency to spontaneous bleeding | Score 3 = A band of plaque up to one-third of the tooth |
| | Score 4 = Plaque covering up to two-thirds of the tooth |
| | Score 5 = Plaque covering two-thirds of the crown of the tooth. |

**Statistical Analysis**

The statistical analyses were performed using R Statistical Software (v4.1.2; R Core Team 2021)*. Visual inspection of density plots and Shapiro Wilk test for Normality were performed to determine the appropriate comparative tests. Results showed that the data was not normally distributed. Nonparametric Mann-Whitney U test was performed to assess between-group comparisons while Wilcoxon Signed Rank test was used to assess within-group comparisons. Statistical significance was verified at p value ≤ 0.05.

**RESULTS**

Sixty participants were enrolled in two groups consisting of thirty-five females and twenty-five males with age range from 12 to 19 years old. Two participants withdrew (one from each group) after randomization due to traveling. At baseline, there was no statistically significant difference between the mean score of GI ($p$= 0.6273) and QHTMI ($p$=0.5357) of smartphone application group and oral instructions group. At the follow-up, our results showed a statistically significant difference in the mean GI score and the mean QHTMI score of the test and control groups ($p$= 0.0002, 0.0053) respectively. (Table 2)

While there was no statistically significant difference in the mean GI score of the oral instructions group at T0 (2.33 ±0.66) and T1 (2.07±0.69), the mean GI score of the smartphone group at T0 (2.23±0.73) and T1(1.17±0.74) showed a statistically significant difference. The mean score of QHTMI of the smartphone group (1.97±1.03) had the most significant improvement compared to baseline (3.27±1.26). (Table 3)

* https://www.R-project.org/

TABLE (2) Descriptive analysis of Periodontal Status of study groups according to time of follow up and between-group comparisons :

| Follow up | Periodontal Status | Group | Mean | SD | Median | Range | | Mann-Whitney U test | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Min | Max | p-value* | Interp-retation |
| $T_0$ | GI | Control | 2.33 | 0.66 | 2 | 1 | 3 | 0.6273 | No difference |
| | | Test | 2.23 | 0.73 | 2 | 1 | 3 | | |
| | QHTMI | Control | 3.5 | 1.01 | 3 | 2 | 5 | 0.5357 | |
| | | Test | 3.27 | 1.26 | 3 | 1 | 5 | | |
| $T_1$ | GI | Control | 2.07 | 0.69 | 2 | 1 | 3 | 0.0002 | Statistical significant difference |
| | | Test | 1.17 | 0.74 | 1 | 0 | 3 | | |
| | QHTMI | Control | 2.8 | 1.16 | 2.5 | 1 | 5 | 0.0053 | |
| | | Test | 1.97 | 1.03 | 2 | 0 | 4 | | |

**Significance level at p-value ≤0.05*.

TABLE (3) Descriptive analysis of Periodontal Status of study groups and Within-group comparisons:

| Group | Periodontal Status | Follow up | Mean | SD | Median | Range | | Wilcoxon Signed Rank test | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Min | Max | p-value* | Interp-retation |
| Control | GI | $T_0$ | 2.33 | 0.66 | 2 | 1 | 3 | 0.2048 | No difference |
| | | $T_1$ | 2.07 | 0.69 | 2 | 1 | 3 | | |
| | QHTMI | $T_0$ | 3.5 | 1.01 | 3 | 2 | 5 | 0.0146 | Statistical significant difference |
| | | $T_1$ | 2.8 | 1.16 | 2.5 | 1 | 5 | | |
| Test | GI | $T_0$ | 2.23 | 0.73 | 2 | 1 | 3 | 0.0002 | Statistical significant difference |
| | | $T_1$ | 1.17 | 0.74 | 1 | 0 | 3 | | |
| | QHTMI | $T_0$ | 3.27 | 1.26 | 3 | 1 | 5 | <0.0001 | |
| | | $T_1$ | 1.97 | 1.03 | 2 | 0 | 4 | | |

***Significance level at p-value ≤0.05*.**

## DISCUSSION

The literature has previous reports on the advantages of applying technologies in various disciplines of dental sciences (Toniazzo et al., 2019). As it is now widely accepted that adolescents use smartphones in their daily lives, it represents an opportunity for smartphones to be recognized as a tool for dental health education (Klasnja & Pratt, 2012). Nowadays, educational applications could teach health information and have wide reach because of the popularity of smartphones (Al-ak'hali et al., 2020). Although these applications do not necessarily increase dental knowledge; however, they could be motivational to practice better oral hygiene regimens (Underwood et al., 2015). In the current study, the effectiveness of a smartphone application for oral hygiene instructions compared to verbal oral hygiene instructions was assessed.

In the current era, we face new challenges to make the process of learning more engaging and attractive for young people, forcing teaching methods to adjust to the frequent psychosocial changes of adolescents. For this reason, a smartphone application was chosen for the oral hygiene education of the test group, with the application considered as an interesting tool (Marchetti et al., 2018). Adolescents usually exhibit a higher amount of supragingival plaque with a higher incidence of gingivitis compared to adults (Acharya et al., 2011). Therefore, the sample age selected in this study was 12–19 years. Evaluation of gingival inflammation and plaque accumulation are reliable methods for assessment of gingival health (Al-ak'hali et al., 2020). GI reflects gingival inflammation (Davies et al., 2004) and QHTMI reflects plaque accumulation (Creeth et., 2009).Throughout the years, they have been used in different studies. Hence, the current study used GI and QHTMI scoring systems for the assessment of gingival health.

While our study shared the same aim with the study of (Alasmari et al., 2022) testing the effect of the transmission of more attractive oral hygiene information, there was a major difference between both studies. The design of the study of (Alasmari et al., 2022) was a prospective cohort lacking a lower risk of bias granted by randomization and allocation concealment of randomized controlled trials as our own study. Furthermore, the study of (Alasmari et al., 2022) included Periodontitis patients and an older age group, while our study was limited to the young age group because of their highest engagement and attachment to smartphone applications among all age groups and, therefore, our study was limited to plaque-induced gingivitis.

In both of our study groups, gingival health was improved after two months showing reduced accumulation of dental plaque and gingival inflammation resolution. Nonetheless, this improvement was statistically not significant in the mean GI score of the control group ($p=0.2048$). On the other hand, the difference in the GI mean score of the test group between T0 ($2.23\pm0.73$) and T1($1.17\pm0.74$) was statistically significant as well as the difference in the QHTMI mean score of the test and control groups. Our results are in accordance with the results of (Moshkelgosha et al., 2017). In their study, computerized oral hygiene instructions were proposed as more effective in oral health provision compared to the oral instructions.

Our findings contrast with the results of (Marchetti et al., 2018). In their study, different methods of oral health education were investigated in adolescents. Their results showed a significant reduction in oral indices for all methods. The difference between the results of both studies could be attributed to the nature of their study as it consisted of four phases where oral hygiene instructions were more frequently repeated. In addition, their study was conducted in a developed economy, which may have influenced the extent to which oral health knowledge is reinforced. Furthermore, the difference between our results and

that of (Al-ak'hali et al., 2020) is due to their small sample size as they planned a preliminary study without sample size calculation.

Using Smartphone application in oral health education revealed superiority to the traditional method of verbal delivery of oral hygiene instructions to the age group 12-19 years. This may be explained by the amount of time adolescents spend using their smartphone along with their attachment to technology and virtual reality being evident in the rise in numbers of smartphone addicts (Bhanderi et al., 2021). Furthermore, the reminders inherent to the smartphone application improved compliance of patients to oral hygiene instructions. A limitation worth mentioning in our study is the short follow-up period. Further studies with longer follow-up are needed.

Within the limits of our study, we conclude that using Smartphone application in oral health education for adolescents could be beneficial in improving their oral hygiene compared to verbal delivery of oral hygiene instructions.

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