

# Smart Phone Application Reminder for Patients with Fixed Orthodontic Appliance to Improve Oral Hygiene

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## Abstract

**INTRODUCTION:** In light of the extensive use of mobile phones and their associated software applications (Apps), as well as the undisputed role of reminders and Apps in behavioral interventions, the goal of this study was to evaluate the usefulness of an application for smartphones (Brush DJ) to enhance oral hygiene compliance in individuals with fixed orthodontic therapy.

**MATERIALS AND METHODS:** In this prospective study, 82 patients between the ages of 18 and 22 were divided into four groups, two of which (the experimental group and the control group) had just begun fixed orthodontic treatment (called New) and the other two (the experimental group and the control group) were have passed fifth months from the beginning of the treatment (called Old). Patients in the intervention group were asked to use the Brush DJ smartphone App after getting traditional oral hygiene training, compared to patients in the control group who got conventional oral hygiene instruction. At baseline (T0), 4 weeks, 8 weeks, and 12 weeks following the start of the study, the plaque index (PI) and marginal bleeding index (MBI) were measured. Only patients with the software completed a questionnaire to determine how frequently and how long they brushed their teeth each day.

**RESULTS:** Both New and Old orthodontic cases in the intervention groups showed improvements in PI, whereas the parameter of bleeding showed no significant differences.

During the follow-up period, application usage was associated with a higher brushing frequency and duration.

**CONCLUSION:** Apps might significantly improve the oral hygiene compliance of orthodontic patients by acting as reminders and motivators.

**KEYWORDS:** Fixed orthodontic treatment; Oral hygiene; Smartphone Apps; Reminders

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## Introduction

The foundation of excellent oral health is good oral hygiene, particularly in patients with fixed orthodontic appliance where it might be difficult to maintain regular oral hygiene [1,2]. After the initial bonding, previous studies have

showed a quick fall in oral hygiene, followed by an improvement by the fifth month of therapy [3]. But other studies have also shown that oral hygiene issues are most severe at the conclusion of orthodontic therapy, highlighting the difficulty in maintaining sustained and acceptable

oral hygiene during orthodontic treatment course [4].

Lack of basic oral hygiene practices causes dental plaque to build up over time, which raises the risk of overgrowth of cariogenic bacteria such as *Streptococcus mutans* [5,6]. Despite having functional and

cosmetic advantages, fixed orthodontic therapy is linked to a higher risk of dental caries, particularly white-spot lesions, whose incidence is estimated to be between 50 and 90% [7,8]. After treatment, these lesions may become aesthetically problematic and progress to become more extensive [9,10].

These undesirable side effects may result in disappointing outcomes or premature termination of orthodontic treatment. According to the majority of orthodontists, 5 to 10% of patients discontinue orthodontic treatment early as a result of poor dental hygiene [11,12].

While fluoride administration (e.g. fluoride mouth rinses) and effective plaque removal from all tooth surfaces are crucial in preventing dental caries [13], individuals undergoing fixed orthodontic treatment encounter challenges in maintaining dental hygiene due to the impediment posed by the orthodontic brackets [14,15].

Inappropriate oral health and periodontal awareness and knowledge in the Iraqi population in particular is present. This emphasizes the need for intervention strategies to improve oral hygiene practice in young people with such appliances in Iraq [16].

Active reminders have been reported to improve dental and medical appointment attendance, adherence

to medication schedules and positive behavior changes [17]. Individuals who received motivational text messages reported an increase in tooth brushing habits after 3, 6 and 9 weeks [18]. Using a reminder system to establish the habit of brushing is applicable according to a study that showed that the habit is formed after 66 days [19].

The usage of smartphones nowadays opens up new possibilities for creating oral health interventions. This widespread use, particularly among young persons, may guarantee that adolescents wearing fixed orthodontic equipment have full access to care [20]. Smartphones have certain specific characteristics that make them appropriate for behavioral interventions, including: (1) their portability and high level of popularity among users, particularly teenagers and young adults. (2) Mobile apps (Apps) are a more practical and cost-effective form of intervention. (3) The distribution of health-related information and the delivery of behavioral therapies are made easier by cellphones' capacity to connect in a convenient manner [21].

Considering the widespread use of smartphones and Apps in diverse fields by the younger generation, as well as the undeniable role of reminders and Apps in behavioral interventions, use of smartphone Apps for this purpose is understandable. Hence, in this study, we tested a mobile health

technology, the Brush DJ App (<https://www.nhs.uk/apps-library/brush-dj/>), to see if it improved oral hygiene measures of orthodontic patients.

## Material and Methods

### Subjects and settings

The study was conducted in the Orthodontic Clinic at Al-Shamyia Specialized Center in Thi-qar. Participants for this study included patients with fixed appliance orthodontic treatment according to the following criteria.

### Inclusion criteria:

- I. Patients with ages between 18 and 22 years who received their orthodontic appliances with the starting of the study and patients that passed their fifth month of orthodontic treatment.
- II. Patients who had smartphones with enough storage to download the software program.
- III. All anterior teeth were present without missing any tooth and cases with lateral incisor agenesis were avoided.
- IV. Subjects should talk and read Arabic language.

### Exclusion Criteria:

- I. Patients with mental and physical disabilities, as well as craniofacial problems.
- II. Patients with dysplasia of the enamel or dentin.
- III. Patients who are receiving antiplaque drugs, such as antibiotics or antibacterial mouth rinses.
- IV. Patients suffering from periodontal disease.
- V. Patients needing first premolar extractions.

### **Intervention Period**

The sample was divided into four groups, two groups were experimental and control starting orthodontic treatment with the starting of the study (called New), and the other two, also experimental and control, had passed their fifth month from the starting of the orthodontic treatment (called Old). Only the New groups were recalled after one week after insertion of the appliances for recording the scores to give time for plaque formation and gingival irritation. All groups received oral hygiene instructions, toothpaste (Sensodyne), oral hygiene kit at the baseline (T0) and only the experimental group participants were instructed to download the application (Brush DJ).

The oral hygiene habits were recorded in the experimental groups (New and Old) only, using a questionnaire before and after the end of the study.

The study outcomes were the amount of plaque and the total number of gingival bleeding sites in the incisors, canines and first premolars of the maxilla and mandible. Al-Anezi and Harradine plaque was used to measure the amount of plaque on the buccal surfaces [22]. Gingival bleeding was assessed using the Marginal Bleeding Index.

### **Statistical analysis**

The statistical package for social sciences software (SPSS Inc., version 26, Chicago, Illinois, USA) was used to carry out the statistical procedures.

Data were analyzed through parametric tests including:

#### **1. Descriptive statistics:**

- Mean
- Standard deviation (SD)
- Tables and figures

#### **2. Inferential statistics:**

- Paired sample t-test.

In the statistical evaluation, the following levels of significance were used according to probability value (p-value):

$P > 0.05$  Non-significant (NS)

$0.05 \geq p > 0.01$  \* Significant

$0.01 \geq p > 0.001$  \*\* Highly significant

### **Results**

Eighty-two fixed orthodontic patients were enrolled in this study with ages

ranging from 18 to 22 years. Forty-seven patients were females and 35 males. Forty patients (20:20) were in the New groups (experimental and control) and 42 patients (21:21) in the Old groups (experimental and control).

### **Follow up of plaque index**

#### ***New experimental group***

The plaque index was assessed after 4 weeks, 8 weeks, and 12 weeks, and compared to that at baseline. The mean plaque index of the New experimental group was significantly reduced from 0.39 at baseline to 0.30 ( $P = 0.037$ ) after 4 weeks, then to 0.27 ( $P = 0.018$ ) after 8 weeks, and to 0.24 ( $P = 0.022$ ) after 12 weeks of orthodontic treatment.

#### ***New control group***

The comparison of the mean plaque index of the New control group at baseline, after 4 weeks, 8 weeks, and 12 weeks of treatment showed no significant differences in the mean plaque index ( $P \geq 0.05$ ) throughout the study period.

#### ***Comparison between New experimental and control groups***

The comparison between the New experimental and control groups according to the percentage of change in plaque index revealed that the percentage reduction in the plaque index of the New experimental group was significantly higher after 8 weeks and 12 weeks of

treatment compared with the New control group (-47 vs -5.9, P= 0.014 after 8 weeks, and -50.5 vs -6.08, P= 0.008 after 12 weeks) (Figure 1 and Table 1).

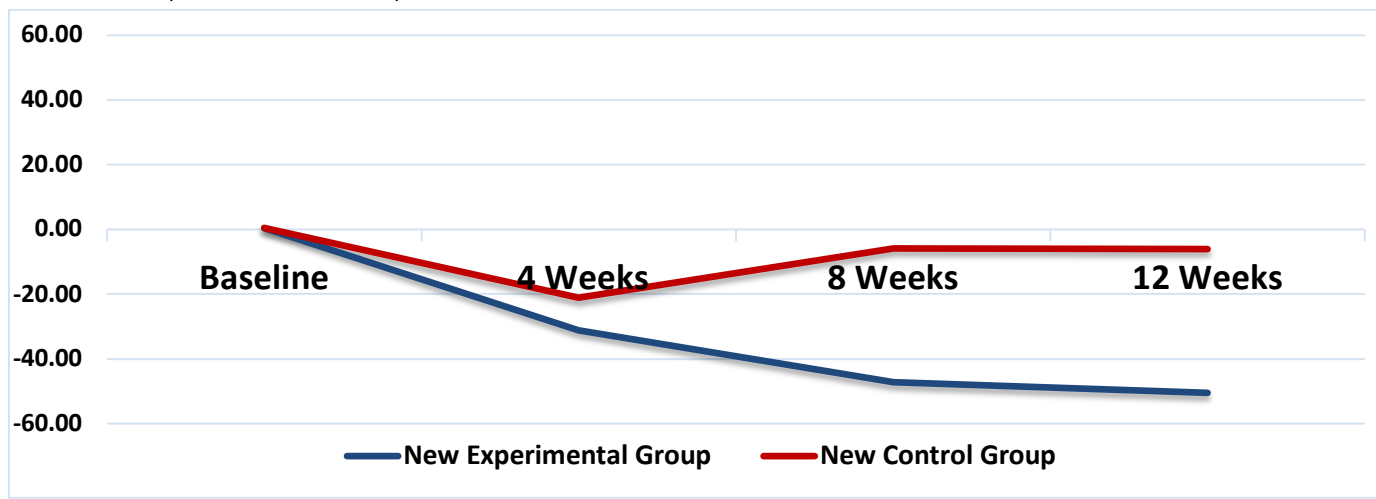


Figure 1. Percentage of change in plaque index of the New experimental and control groups throughout the study period.

Table 1: Comparison between New experimental and control groups by percentage change in the plaque index throughout the study period (red colour indicates statistical significant differences).

% Plaque Index Change	Study Groups		t-test	P- Value*
	New Experimental Mean ± SD	New Control Mean ± SD		
After 4 Weeks	- 31.2 ± 18.4	- 21.1 ± 6.62	- 0.584	0.563
After 8 Weeks	- 47.3 ± 22.2	- 5.9 ± 2.35	- 2.606	0.014
After 12 Weeks	- 50.5 ± 23.6	- 6.08 ± 3.62	- 2.817	0.008

**Old experimental group**

In this group, the mean plaque index significantly reduced from 1.01 at baseline to 0.81 (P= 0.005) after 4 weeks, and to 0.78 (P= 0.001) after 8

weeks, then to 0.67 (P= 0.001) after 12 weeks of orthodontic treatment.

**Old control group**

In this group, the mean plaque index after 4 weeks, 8 weeks, and 12 weeks

of orthodontic treatment was not significantly different (P ≥ 0.05) than that at baseline.

**Comparison between Old experimental and control groups**

In comparison between the Old experimental and control groups according to percentage of change in plaque index, after 8 weeks and 12

weeks the Old experimental group had a significant higher percentage reduction in the plaque index than the Old control group (-29 vs -3.89, P=

0.047 and -37.3 vs -13.42, P= 0.0039, respectively) (Figure 2 and Table 2).

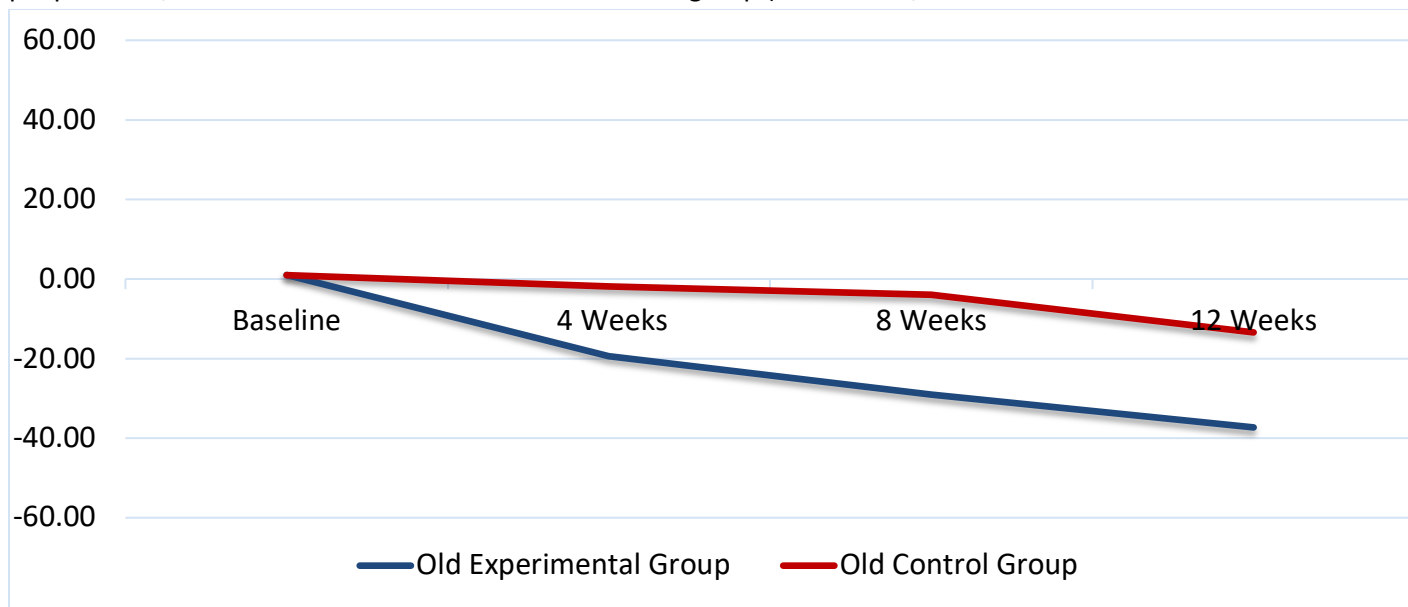


Figure 2. Percentage of change in plaque index of the Old experimental and control groups throughout the study period.

Table 2: Comparison between Old experimental and control groups by percentage change in the plaque index throughout the study period (red colour indicates statistical significant differences).

% Plaque Index Change	Study Groups		t-test	P- Value*
	Old Experimental Mean ± SD	Old Control Mean ± SD		
After 4 Weeks	- 19.3 ± 5.71	- 1.80 ± 0.88	- 1.296	0.203
After 8 Weeks	-29.0 ± 9.15	- 3.89 ± 1.63	- 2.040	0.047
After 12 Weeks	- 37.3 ± 18.7	- 13.42 ± 4.05	- 2.063	0.039

### Follow up of gingival bleeding index

#### New experimental group

Regarding the comparison in the mean gingival bleeding index of the New experimental group, no significant difference ( $P \geq 0.05$ ) was obtained in the mean gingival bleeding over the course of this study.

#### New control group

In this group, the mean bleeding index significantly increased after 4 weeks compared to that at baseline (0.035 vs 0.018,  $P = 0.01$ ). No significant difference ( $P \geq 0.05$ ) was detected after 8 weeks and after 12 weeks of treatment.

#### Comparison between New experimental and control groups

The comparison between the New experimental and control groups according to the percentage of change in bleeding revealed that there was no significant difference ( $P \geq 0.05$ ) in the degree of bleeding reduction between the two groups (Figure 3 and Table 3).

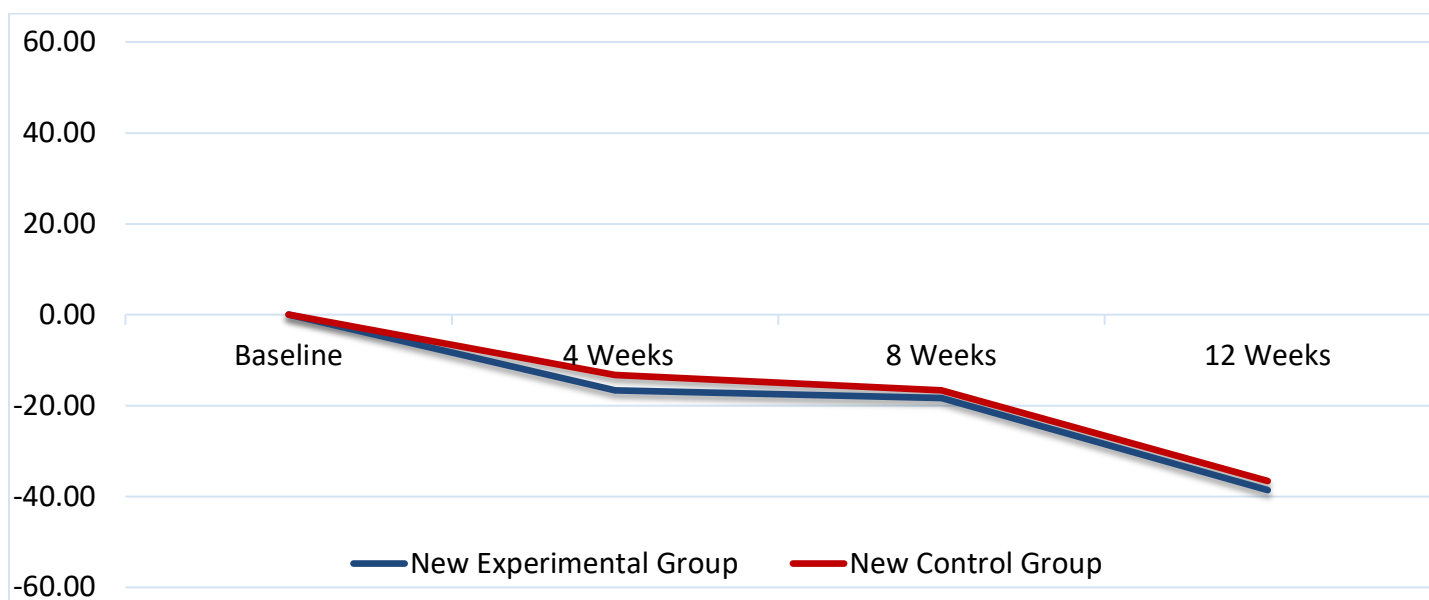


Figure 3. Percentage of change in bleeding index of the New experimental and control groups throughout the study period.

Table 3: Comparison between New experimental and control groups by percentage change in the bleeding index throughout the study period.

% Bleeding Index Change	Study Groups		t-test	P- Value*
	New Experimental Mean $\pm$ SD	New Control Mean $\pm$ SD		

After 4 Weeks	- 26.6 ± 9.81	- 23.33 ± 9.144	- 1.242	0.309
After 8 Weeks	- 18.3 ± 8.62	- 16.66 ± 5.27	- 1.361	0.207
After 12 Weeks	- 38.6 ± 19.81	- 36.6 ± 17.12	- 1.423	0.189

**Old experimental group**

The mean bleeding index of this group significantly decreased within time from 0.063 at baseline to 0.041 (P= 0.011) after 4 weeks, and to 0.031 (P= 0.001) after 8 weeks, then to 0.029 (P= 0.001) after 12 weeks of orthodontic treatment.

**Old control group**

In this group, the mean bleeding index was not significantly different (P ≥ 0.05) after 4 weeks, 8 weeks, and 12 weeks than that at baseline.

**Comparison between Old experimental and control groups**

In comparison between the Old experimental and control groups according to the percentage of change in bleeding index, no significant difference was seen in the degree of bleeding reduction between the two groups (Figure 4 and Table 4).

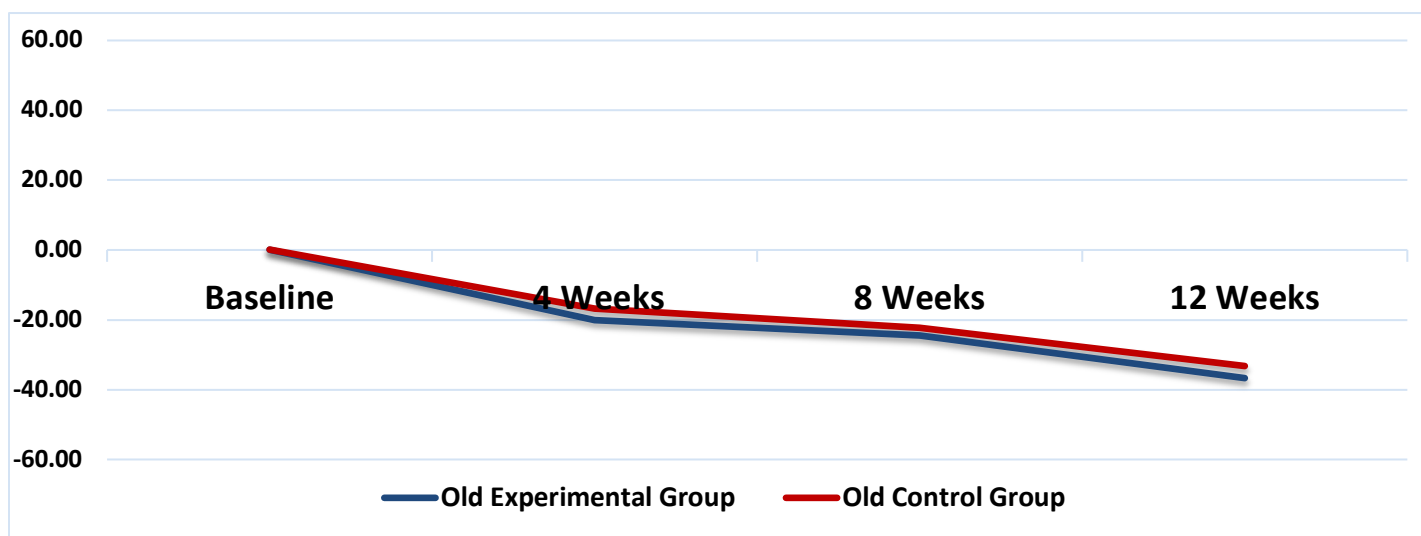


Figure 4. Percentage of change in bleeding index of the Old experimental and control groups throughout the study period.

**Table 4:** Comparison between New experimental and control groups by percentage change in the plaque index throughout the study period.

% Bleeding Index Change	Study Groups		t-test	P- Value*
	Old Experimental Mean $\pm$ SD	Old Control Mean $\pm$ SD		
After 4 Weeks	- 21.1 $\pm$ 11.03	- 16.88 $\pm$ 7.43	- 1.437	0.187
After 8 Weeks	-24.4 $\pm$ 10.55	- 22.2 $\pm$ 11.67	- 1.074	0.379
After 12 Weeks	- 36.70 $\pm$ 17.84	- 33.24 $\pm$ 15.04	- 1.256	0.201

**Questionnaire*****New experimental groups***

The results of the questionnaire before and after the intervention were summarized in Table 5.

The mean score of the oral hygiene questionnaire of patients in New experimental group significantly increased after using the smartphone application ( $P = 0.003$ ) (Table 6).

**Table 5:** Questionnaire data for New experimental group.

Questions	Before intervention	After intervention
Do you brush your teeth? 1) Yes 2) Occasionally or never	75% (15) 25% (5)	75% (15) 25% (5)
How many times do you brush your teeth every day? 1) Brush not every day 2) Brush once a day 3) Brush twice a day or more	25% (5) 35% (7) 40% (8)	5% (1) 15% (3) 80% (16)
Do you use toothpaste when brushing your teeth? 1) Yes 2) No 3) I don't know	95% (19) 5% (1) 0%	100% (20) 0% 0%
Do you use fluoride toothpaste when brushing your teeth? 1) Yes 2) No 3) I don't know	5% (1) 20% (4) 75% (15)	10% (2) 35% (7) 55% (11)
Do you use floss? 1) No 2) Occasionally 3) Once a week 4) Daily use	60% (12) 20% (4) 10% (2) 10% (2)	30% (6) 35% (7) 25% (5) 10% (2)
How often do you change your toothbrush?		



1) Every 3 months	45% (9)	50% (10)
2) Every 6 months	35% (7)	50% (10)
3) Every year	20% (4)	0%
4) More than year	0%	0%
How long do you take for oral hygiene?		
1) About one minute	65% (13)	5% (1)
2) About two minutes	0%	55% (11)
3) More than two minutes	15% (3)	20% (4)
4) I don't know	20% (4)	20% (4)
Are you interesting in orthodontic treatment?		
1) Yes	100% (20)	100% (20)
2) No	0%	0%
Are you interesting to be compliant in oral hygiene control during and after orthodontic treatment?		
1) Yes	65% (13)	80% (16)
2) No	0%	0%
3) I don't know	35% (7)	20% (4)

**Table 6:** Comparison in oral hygiene scores of the New experimental group before and after using the smartphone application (red colour indicates statistical significant difference).

New Experimental Group	Questionnaire Score	Paired t-test	P- Value*
	Mean ± SD		
Before Application	4.50 ± 1.39	- 3.470	0.003
After Application	5.25 ± 1.29		

**Old experimental**

The results of the questionnaire before and after the intervention were summarized in Table 7.

The mean score of the oral hygiene questionnaire of patients in the Old experimental group significantly increased after using the smartphone

application (P = 0.001) as shown in Table 8.

**Table 7:** Questionnaire data for Old experimental group.

Questions	Before intervention	After intervention
Do you brush your teeth?		
1) Yes	90.5% (19)	100% (21)
2) Occasionally or never	9.5% (2)	0%
How many times do you brush your teeth every day?		
1) Brush not every day	0%	0%
2) Brush once a day	23.8% (5)	9.5% (2)
3) Brush twice a day or more	76.2% (16)	90.5% (19)
Do you use toothpaste when brushing your teeth?		

1) Yes	100% (21)	100% (21)
2) No	0%	0%
3) I don't know	0%	0%
Do you use fluoride toothpaste when brushing your teeth?		
1) Yes	19% (4)	33.3% (7)
2) No	14.3% (3)	14.3% (3)
3) I don't know	66.7% (14)	52.4% (11)
Do you use floss?		
1) No	42.9% (9)	52.4% (11)
2) Occasionally	42.9% (9)	33.3% (7)
3) Once a week	9.5% (2)	4.8% (1)
4) Daily use	4.8% (1)	9.5% (2)
How often do you change your toothbrush?		
1) Every 3 months	38.1% (8)	71.4% (15)
2) Every 6 months	52.4% (11)	28.2% (16)
3) Every year	9.5% (2)	0%
4) More than year	0%	0%
How long do you take for oral hygiene?		
1) About one minute	57.1% (12)	33.3 (7)
2) About two minutes	33.3% (7)	47.6% (10)
3) More than two minutes	9.5% (2)	19% (4)
4) I don't know	0%	0%
Are you interesting in orthodontic treatment?		
1) Yes	100% (21)	90.5% (19)
2) No	0%	9.5% (2)
Are you interesting to be compliant in oral hygiene control during and after orthodontic treatment?		
1) Yes	52.4% (11)	76.2% (16)
2) No	0%	0%
3) I don't know	47.6% (10)	23.8% (5)

**Table 8:** Comparison in the scores of oral hygiene questionnaire of the Old experimental groups before and after using the smartphone application (red colour indicates statistical significant difference).

Old Experimental Group	Questionnaire Score	Paired t-test	P- Value*
	Mean $\pm$ SD		
Before Application	4.95 $\pm$ 1.39	- 4.483	0.001
After Application	5.90 $\pm$ 1.29		

## Discussion

### Plaque index

### New groups

In this study, the New experimental group showed a significant reduction

in plaque index (PI) from baseline to 12 weeks after orthodontic treatment, aligning with similar

studies using smartphone apps as instructional tools [23]. Notably, significant differences in percentage of change of PI between the two new groups (experimental and control) emerged after 8 and 12 weeks, but not at the 4-week follow-up. This initial one-month period after braces installation is challenging for patients, and it is crucial to establish good oral habits during this time [24,25].

### **Old groups**

Both groups (experimental and control) that had orthodontic devices for five months experienced reduced plaque values after 12 weeks, consistent with other studies that observed an initial decline in oral hygiene followed by improvement by the fifth month of treatment [3]. The lack of significant differences at the 4-week follow-up between the two old groups could be due to the difficulty of changing oral habits within the first month, as forming New habits can take varying durations [26,27].

### **Bleeding index**

#### **New groups**

Regarding bleeding scores, the experimental and control New groups generally showed no significant differences throughout the study, except for the control group, which saw a significant increase after 4 weeks. This aligns with a suggestion that patients with fixed orthodontic appliances may experience slight increases in oral parameters early on [28,29]. A study by Hadzic *et al.*

(2022) noted that the bleeding index increased but could be mitigated by intensive oral hygiene practices [30].

### **Old groups**

In the groups with 5 months of orthodontic bonding, the experimental group showed a significant reduction in bleeding scores throughout the study, while the control group did not exhibit statistical differences. These results are similar to a study by Eppright *et al.* (2014), which used text messages as reminders to improve oral conditions and found improvements in bleeding and plaque indices over time in the reminder group [31]. However, in contrast to their findings, there were no significant differences between the two Old groups regarding the percentage of change in plaque values in this study.

### **Questionnaire**

#### **Brushing frequency**

Most of the respondents brush their teeth before intervention in experimental groups both New group and the group that have passed 5 months of bonding the orthodontic device with only 40% of the New group and 76.2% of the other group brush twice or more a day. In a comparison with other studies, it was found that most of the participants brush twice a day and others brush thrice [32,33]. In contrast to Pandey *et al.* (2016) study who found that 63% of the sample brushed once daily

while 26% brushed twice daily, and 11% brushed thrice a day [34].

After the intervention by using the Brush DJ reminder it was found an increase in the time of brushing a day (80% for the New group and 90.5% for other group) twice or more daily. These results are strongly consistent with results of other research by Farhadifard, *et al.* (2020) who found that brushing frequency and duration were correlated positively with App usage during the follow-up period [35].

As the majority of the patients practice the brushing twice daily which is what is recommended during patient education, it is an indication that they took the instruction and the App seriously and practice them in a good manner [33].

### **Dental floss**

The majority of the respondents doesn't floss their teeth before and after the intervention this may attributed to the difficulty for flossing the teeth. These results are in agreement with Pinto *et al.* (2017) who found fewer patients reporting daily use as the duration of orthodontic treatment increased [36]. Evidence suggests that the compliance rate for daily flossing is low, particularly among subjects wearing orthodontic appliances since the appliances make flossing more challenging [36,37].

### **Fluoridated toothpaste**

In this questionnaire the participants were asked for using toothpastes with fluoride, the majority of the percent respond for "I don't know". While after intervention for both experimental groups, the percentage decreased and slightly increased for whom used fluoridated paste. This change it may be attributed to the patient's education about reading the component of the toothpaste.

### **Toothbrush replacement**

Before the intervention, less than half of the sample in both groups changed their toothbrush every 3 months as recommended by the American Dental Association. After the intervention, only one person in the New group followed this recommendation, making it 50%. In the group that had passed 5 months of treatment, there was a notable increase in patients (71.4%) choosing to change their toothbrushes every 3 months. This shift may be attributed to the complexity of orthodontic treatment as it progresses, making plaque removal more challenging, leading to increased brushing frequency and earlier damage to toothbrush bristles [38].

### **Brushing duration**

In accordance with most of the respondents, the app encouraged them to wash their teeth for longer time. According to a US survey, individuals wash their teeth for an average of 46 seconds [39]. However, studies have shown that brushing for

two minutes eliminates 26% more plaque than brushing for 45 seconds [40]. The increased brushing time reported by app users is encouraging, and it seems that the usage of music encourages this longer brushing period. This results are in agreement with Underwood *et al* (2015) as they reported for 88% of respondents that the app motivated them to brush their teeth for longer duration [40].

### **Conclusion**

The utilization of a smartphone application as an adjunctive tool for enhancing oral hygiene among orthodontic patients has yielded highly promising results. These findings suggest that smartphone applications can serve as valuable resources for orthodontic patients in maintaining their oral health during the course of treatment.

### **Data Availability**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### **Conflict of interest**

All the authors declare no commercial or financial conflict of interest.

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