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Effects of electronic toothbrush with lithium battery on plaque control
For patients with multibracket appliances in use

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Introduction

It is of a great significance to eliminate dental plaque as a cause of dental diseases and to thoroughly execute plaque control for the reattachment in terms of preventing dental caries and periodontal disease during orthodontic treatment. As a mean for plaque control, mechanical cleaning with various toothbrushes and dental fross is first pointed out. Plaque control is not easy for general patients. Furthermore, whether or not the plaque control is appropriate is one of determinants for desirable outcome of orthodontic treatment in patients with multibracket appliances in use for years.

As an effective approach to plaque control, an electronic toothbrush has recently been developed. The toothbrush was designed by Pratt [1] in 1889 to attract plaque on the brush by forming electric circuit and providing the brush end with electron. Since then, effects of electronic toothbrush with battery, including those to release fluoride into the tooth in 1950's, have been reported. Furthermore, semiconductor developed as an electronic supply and the effects on the elimination of plaque have been investigated [4-17]. However, most studies were conducted for targeting general patients but not orthodontic patients during treatment.

This study was thus designed to elucidate the effects of an electronic toothbrush with a lithium battery on plaque control for patients during orthodontic treatment with multibracket appliances and to explore the clinical application.

Materials and method

1. Subject

Fourteen patients in Orthodontic Clinic, Hiroshima University Dental Hospital, ranging in age from 18 to 30-year-old with the mean of 23-year 5-month-old, were selected as subjects. Each patient was subjected to the measurement of plaque around the teeth for a period of 15 weeks.

Immediately before the measurement, the initial-phase treatment or leveling of the teeth had been completed for all the subjects and thus severe tooth malposition was corrected. Brushing instruction with scrubbing method was given to each subject before initiating a series of treatment.

2. Electronic tooth brush

In this study, an electronic toothbrush of Fukuba HyG provided by Fukuba Co. (Chiba, Japan) was used. A lithium battery of 3.0 volts was placed inside the holder, producing positive and negative electric potentials on the holder and brush end, respectively. During brushing, the brush was coated with saliva and an electric circuit was developed by the contacts with the teeth and gingiva. Two control toothbrushes were designed as follows; one is the same toothbrush without the battery and the other includes the battery with opposite electric polarity. The size of the brush was 18.5 mm in length and 8.7 mm in width. The diameter and length of each brush unit were 0.23 mm and 9.5

mm, respectively, and the stiffness was medium (Fig. 1).

3. Experimental design

Before the experiment, each subject was requested conventional brushing and then plaque score was recorded by use of plaque staining solution after the removal of archwires. This score before experiment served as the control. As a next, mechanical cleaning was thoroughly performed by the doctor in charge , confirming no deposition of plaque by means of the staining agent. Finally, the archwires were placed again and three-week experiment was initiated in all the subjects.

During the experimental period, one of three brushes was given to each subject without notifying the type to both the subject and the examiner to design double blind examination. After three-week brushing at home, the amount of plaque reattachment was recorded by use of plaque detecting solution. During the recording, the archwires were removed and then were placed again immediately after the measurement. All these procedures were repeated for the remaining two toothbrushes.

4. Data processing and the statistical treatment

The status of plaque reattachment was assessed according to a modified method of patient hygiene performance (PHP) designed by Podshadley and Haley[13]. Each of facial and lingual surfaces on the tooth crown was equally divided into three mesiodistal areas, i.e. mesial, middle and distal parts. The middle area was further divided occlusogingivally into the incisal, middle and cervical regions. Finally, for each of the five areas, positive and negative staining with the detective solution of red color were scored as one and zero, respectively. Then, the decrease rate in the plaque score was calculated for each individual as a difference between the values before experiment and after using each toothbrush. The statistical significance was examine by a Student's t-test with a special reference to the value of zero for three types of toothbrushes.

Results

For all toothbrushes, no pathologic changes were observed on the hard and soft tissues such as the teeth, oral mucous membrane and gingiva, indicating the safety of these toothbrushes in use in the mouth.

For the facial and lingual surfaces, the electronic brush produced significantly higher rate of decrease in plaque reattachment, excluding the upper and lower lingual surfaces (Fig. 2). The electronic toothbrush with the opposite electric polarity also exhibited similar findings, although the upper lingual surface experienced a significantly greater decrease in the plaque score with this type of toothbrush in use. For the lower lingual area, no significant decreases were found for all types of toothbrushes (Fig. 2).

The decrease rates are shown for each of the five areas on the upper and lower teeth in

Figs. 3 and 4, respectively. On the facial and lingual surfaces of the upper teeth, significant decrease rates were found when the two types of toothbrushes were used (Fig. 3). For the lower teeth, however, no significant decreases were found in the incisal area with the toothbrushes in use, although mesial, middle and distal areas presented similar findings to those for the upper dentition. Furthermore, only an electronic toothbrush with normal polarity produced a significant rate of decrease in the lower cervical area (Fig.. 4).

Discussion

Orthodontic treatment, in general, requires a year-unit period and such a complicated appliance as multibracket system. Therefore, plaque control ability of each patient has a potential to vary the objectives of treatment and to determine the outcomes. Plaque control has currently been achieved by mechanical cleaning with various kinds of toothbrushes. In addition, electronic toothbrush has been designed as the aid based op the effects of micro electric current on plaque reattachment.

It is well known that micro electric current influences bacterial growth and reattachment. Given such a consideration, electronic toothbrush has been developed to prevent the apposition of bacteria. In order to generate the electric current, direct current was first used, and then semi-conductor was applied. The semi-conductor generates a micro current of 10 mA by converting light energy to electric one[13]. Various conditions, however, remain to be solved to exert fully the capacity; i.e. it is desirable to use the toothbrush under a condition with enough amount of light energy[7].

The electric current inside the brush is approximately 0.15 mA with the tissue resistance of about 20K ohm. Since the amount is greater in the lithium battery than in the semi-conductor, it is assumed that the effect of bacteria absorption is more substantial in this toothbrush[15]. The effects of bacteria absorption with electronic toothbrush have already been examined in various studies[4-17] in terms of the prevention of marginal periodontitis and the treatment outcomes, however, most of these studies targeted general patients in dental practice not orthodontic patients. Furthermore, unclean area around the tooth in general patients is different from that in orthodontic patients with multibracket appliances, i.e. the unclean areas for these patients are, in general, the cervical region of the tooth and the periphery of the appliance.

With these considerations, the present study was designed to examine the effects of toothbrush on plaque control for such orthodontic patients during treatment. To this end, the whole and five areas on the tooth crown were subjected to the evaluation without notifying, in advance, the type of brush, the purpose of examination and the method in detail. For the evaluation of plaque attachment, there are various techniques with plaque index and plaque attachment area on the standardized photographs. In this study, a modified PHP method was employed, because this

technique is simple and exhibits high reproducibility with plural examiners.

There have been various reports on the effects of electronic toothbrush in terms of changes in plaque attachment[5], bleeding index and pocket depth[12], the number of oral bacteria and the degree of gingival inflammation. Some of the studies elucidated more substantial effects of electronic tooth brush on plaque elimination and bacteria absorption[16,17] than those of general brushes, the effects only for the group with high accumulation of the bacteria[4], the effects on gingival inflammation index and the amount of gingival fluid[4], no detectable effects[10] varied with probability[13], if any. In this study, an overall effect of the electronic tooth brush on plaque elimination was demonstrated, whereas the effect was not found in the placebo control brush without battery. For each area on the surface of tooth crown, different findings were derived. The lingual surface of the lower incisors experienced no significant differences in the effects among three types of toothbrushes. This may be due to the fact that the size of electronic brush is larger than that of conventional ones used in orthodontic practice, producing less handling efficiency of the electronic brush. In the facial regions including all the five areas, meanwhile, electronic brush produced substantial decrease in plaque reattachment than the controls, demonstrating a prominent effect for the areas around orthodontic brackets and archwires in particular.

It is considered that accumulation of dental plaque on the teeth is initiated by the deposition or attachment of oral bacteria[20,21]. It is also understood that the surface of oral bacteria is charged positive and exhibits an electric connection with the enamel surface by binding calcium ion in the saliva. Since the brush end is charged negative by means of the lithium battery used inside the brush, the surface attracts hydrogen ion and generates OH radicals on the surface of tooth, which are assumed to exert plaque elimination effects by the oxidization response to prevent the connection of bacteria with the enamel surface[24,25]. No substantial influences of bracket materials on the OH radicals were found in this examination, although it is considered that production of OH radicals may be influenced by the differences in orthodontic materials such as metals and ceramics. The effects of electronic toothbrush were similarly detected when the electric polarity was normal or opposite. This may be explained by the fact that positive electricity on the brush end directly attracts oral bacteria with negative electricity produced by the phosphate on the cell wall of gram positive bacteria and finally eliminates the attachment of bacteria.

Conclusions

The effects of an electronic toothbrush with lithium battery on plaque elimination were examined for orthodontic patients with multibracket appliances for 15 weeks. As a result, the following findings were obtained.

1. No substantial influences were observed for the teeth and the supporting tissues such as the gingiva and alveolar bone, indicating a safety use of the brush in the oral cavity.

2. The electronic toothbrushes with the battery, either with normal or opposite polarity, produced substantial decreases in the plaque scores, whereas the control one without the battery exhibited no influences.
3. The effects for plaque elimination were induced in the areas around orthodontic brackets and archwires in particular.

Legends for figures

Figure 1: Electronic toothbrush used in this study

Figure 2: Decrease rate in the plaque reattachment score on the facial and lingual surfaces for both the upper and lower teeth

*: significant at the 5% level of confidence

**: significant at the 1% level of confidence

Figure 3: Decrease rate in the plaque reattachment score in the mesial, incisal, middle, cervical and distal areas on the facial surfaces of the upper teeth

*: significant at the 5% level of confidence

**: significant at the 1% level of confidence

Figure 4: Decrease rate in the plaque reattachment score in the mesial, incisal, middle, cervical and distal areas on the facial surfaces of the lower teeth

*: significant at the 5% level of confidence

**: significant at the 1% level of confidence

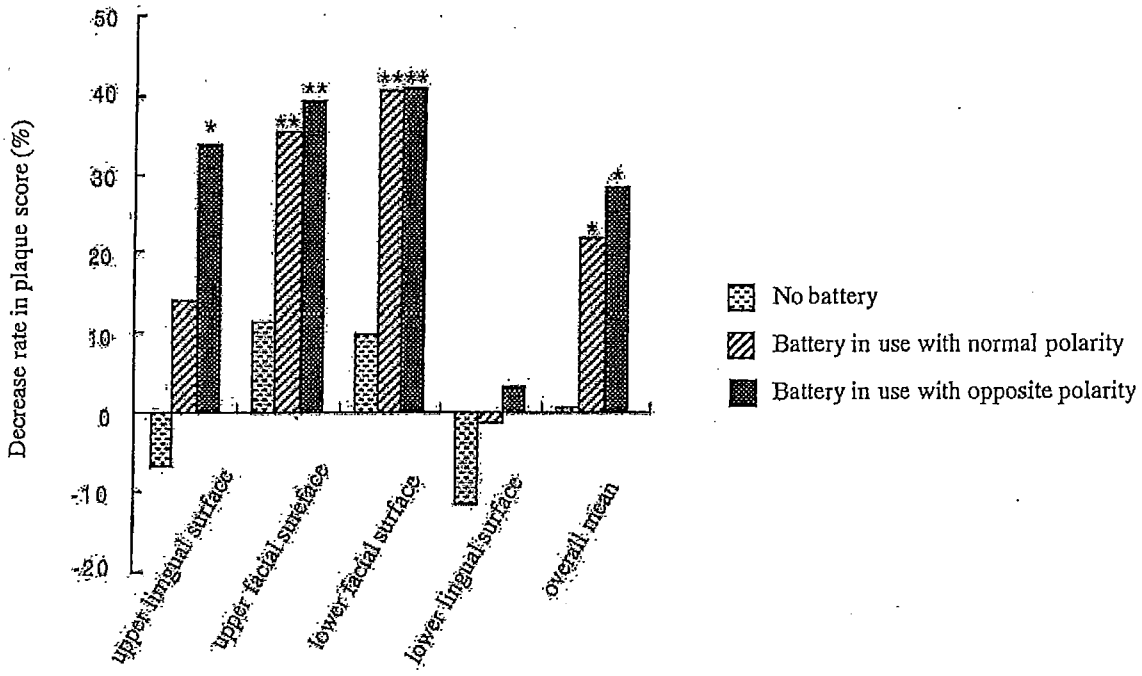
Decrease rate in plaque score (%)
50
40
30
20
10
0
-10
-20
upper lingual surface
upper facial surface
lower facial surface
lower lingual surface
overall mean
No battery
Battery in use with normal polarity
Battery in use with opposite polarity

Fig. 2


No battery
Battery in use with normal polarity
Battery in use with opposite polarity
Decrease rate in plaque score (%)
60
40
20
0
-20
-40
incisal area
mesial area
middle area
cervial area
distal area

Fig.3

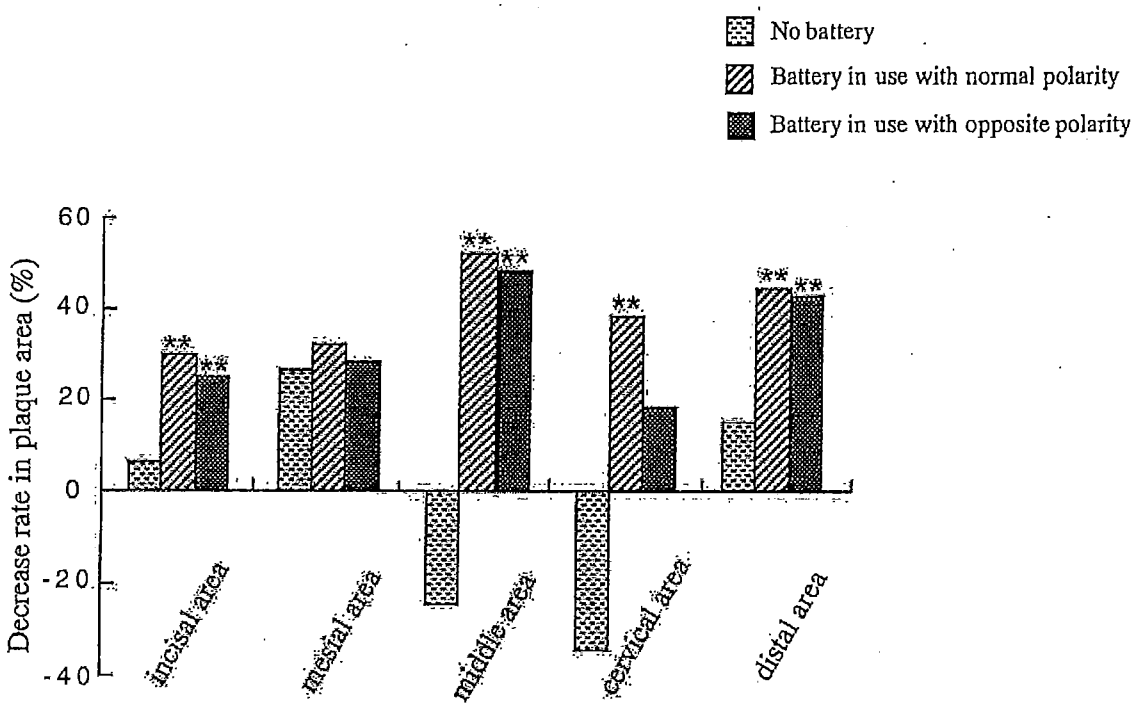
No battery
Battery in use with normal polarity
Battery in use with opposite polarity
Decrease rate in plaque area (%)
60
40
20
0
-20
-40
**
incisal area
mesial area
middle area
cervical area
distal area

Fig.4