# Effectiveness of an Ionic Toothbrush with a Lithium Battery in the Removal of Dental Plaque

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**Abstract**

The effectiveness of removing dental plaque using an ionic toothbrush with a 3-V lithium battery was investigated. It was found to be significantly more effective than the control ionic toothbrush which had the battery removed. Moreover, another ionic toothbrush, which was powered by a reversed current circuit, did not demonstrate any significant plaque-removing efficacy. On the basis of these findings, we concluded that the plaque-removing effect of an ionic toothbrush may be enhanced using negative ionic power.

**Key words**: Dental plaque / Oral hygiene / Ionic toothbrush

## Introduction

Plaque control is most important for the prevention of periodontal disease and dental caries. The ionic toothbrush (IT) tested in the present study was primarily designed to effectively control dental plaque by producing a minute current that is conducted between the toothbrush and the human body in order to exert an effect on the electric coupling that exists to hold oral bacteria to teeth. It has been reported that this ionic toothbrush had a therapeutic effect against gingivitis[1-3] as well as a plaque removing ability[2,3]. In contrast, one report has suggested that this IT was not effective against gingivitis nor for removing dental plaque[4].

In the present study, we performed a 6-week clinical examination for the purpose of evaluating the plaque removing effect of the IT as well as that of a newly-developed ionic toothbrush (RT) which is powered by a reversed current circuit.

## Materials and Methods

1. Subjects

The subjects were 27 volunteer students (15 males and 12 females), ranging in age from 18 to 27 years. None had ever received any special oral hygiene instruction. Before starting the experiment, the purpose of the study was orally explained and each gave informed consent.

2. Toothbrush

The IT used in the present study (Hukuba Dental Co., Chiba) had a lithium battery, DC 3.0V, installed in its grip. The grip was designed to be positively charged and the brush negatively, while cleaning the oral cavity. Two other kinds of toothbrushes, which could not be distinguished from the IT in appearance, were used as controls. One kind (RT) forms a reverse current circuit and the other was an IT which had the built-in battery removed (CT).

3. Methods

The experimental period was 6 weeks, which was divided into three 2-week sections, called stages Ⅰ, Ⅱ, and Ⅲ. The subjects were randomly classified into three groups A, B, and C. Each of the three kinds of toothbrushes was used for 2 weeks by each group. Group A used the IT, RT, and CT during the stages Ⅰ, Ⅱ, and Ⅲ, respectively while group B used the RT, CT, and IT, respectively, during the three stages, and group C started with the CT, and then used the IT and RT, respectively during each of the three stages.

Before starting the experiment, the subjects were interviewed to determine the number of times they normally brushed per day and their smoking habits. As a result, a total of 26 subjects, 9 in group A, 8 in group B, and 9 in group C, were studied, as one from group B dropped out during the experiment. The results were analyzed using the Student's *t*-test.

No instruction was given for the number of times to brush, brushing method, or use of dentifrice. The experimental and control toothbrushes were allocated without the examiner's or subject's knowledge as a double blind test. The oral examination was performed by a dentist.

4. Assessment of dental plaque

Dental plaque on the labial side of 6 anterior teeth in the maxilla was observed, and then evaluated according to the PHP index[5]. The total score was calculated for each individual subject.

## Results

The pre-experiment interview mean results revealed that the subjects brushed twice a day. Each group included 2 smokers.

The changes in the PHP index for each group after each stage are shown in Table 1. In group A, the index scores after stage Ⅰ, during which the IT was used, were significantly reduced ($p<0.05$). However, the scores at the end of stage Ⅲ, when the CT was used, were significantly higher than at the end of stage Ⅰ ($p<0.05$). In group B, no significant difference was observed regardless of the stage. In group C, a significant difference ($p<0.05$) was observed between the baseline scores and at the completion of stage Ⅱ.

The scores for each toothbrush as compared with the PHP index are shown in Fig. 1. The IT and RT both had significantly reduced scores when compared to the baseline ($p<0.05$). The CT showed a decreasing tendency, but it was not significant. As compared to the CT, the IT PHP index scores were significant lower ($p<0.05$). Furthermore, some subjects complained of a metallic taste when using the RT.

Table 1 Changes in PHP Index between groups for 6 weeks

| Group (N) | Baseline | Stage I (2 weeks) | Stage II (2 weeks) | Stage III (2 weeks) |
|---|---|---|---|---|
| A (9) | 18.00±6.12 | IT 11.67±7.94 | RT 15.44±7.59 | CT 16.89±6.01 |
| | | * | * | |
| B (8) | 15.13±6.45 | RT 10.00±8.00 | CT 13.75±6.89 | IT 13.75±7.48 |
| C (9) | 19.22±3.93 | CT 16.56±6.98 | IT 13.22±6.22 | RT 16.00±6.98 |
| | | * | | |

*: $p<0.05$, Mean±SD

IT : Ionic toothbrush
RT : Ionic toothbrush which is powered by a reversed current circuitry
CT : Control ionic toothbrush which had the battery removed

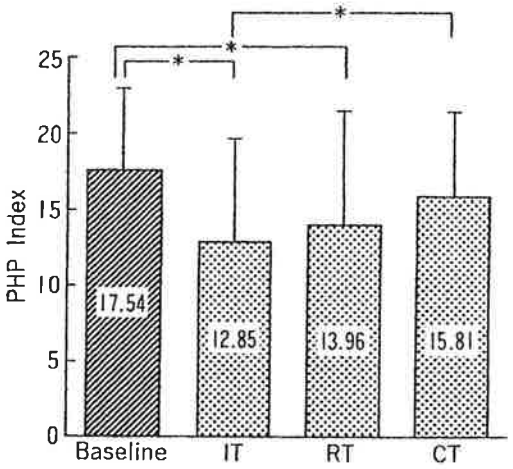


Fig 1. Changes in PHP Index with use of three kinds of toothbrush.
*: $p<0.05$

## Discussion

In the present study, the PHP scores after stage I were lower than the baseline in all groups. This was likely due to the 'novelty-effect', as reported by Hoover *et al.* (1992)[6]. Expecting this effect, we designed the experiment with two styles of toothbrushes, which were indistinguishable in appearance, as a double blind control.

The plaque removing effect of the IT has been previously reported[2,3]. Maki *et al.* (1993)[2] reported that the IT was effective in removing dental plaque in a high-risk group, which was evaluated by a caries activity test. In the present study, we used three types of toothbrushes. The IT showed a significantly higher plaque-removing effect than the CT, which was the same, but had no battery inside. It was speculated that the anions might be activated that inhibit coupling between the pellicle and bacteria, mediated by calcium bridges. This may result in its effectiveness in removing plaque[7].

The RT, which forms a reversed current, was used as a control in the present study. Galgut (1996)[8] reported the effect of an electronic toothbrush, whose grip was negatively

electrified while the brush was positively charged. When this toothbrush is used, the bacteria in the plaque supposedly becomes negatively charged, which should inhibit plaque adherence to the teeth as they are also negatively charged. However, in the present study, no plaque inhibiting effect was observed with the RT. Moreover, it is possible that the RT caused the metal fillings to electrically liquify, as some of our subjects experienced a metallic taste with its use.

There are many other types of toothbrushes with designs based on a variety of principles. For example, Niwa *et al.* (1989)[9], Hoover *et al.* (1992)[6], and Morioka *et al.* (1988)[10] reported the plaque removing effect of a light energy conversion toothbrush that incorporates a semi-conductor, which caused electrons to be produced at the tip of the brush when a light is focused on it. They explained that dental plaque easily decomposed with its use, as the electron deprived $H^+$ ion escaped from the organic acid in the plaque[9]. Niwa *et al.* (1989)[9] found in a 3-week experiment that no significant difference in plaque removal was observed between the IT and a control toothbrush, but that the IT was significantly effective against gingivitis. Hoover *et al.* (1992)[6] reported that the IT was highly effective for the removal of dental plaque from the buccal surfaces of teeth. Morioka *et al.* (1988)[10] reported in their *in vitro* experiment that cations had an inhibiting effect on the adherence mechanism of *Streptococcus mutans*. Furthermore, Hotta *et al.* (1992)[11] studied the plaque removing effect of a piezo-electronic toothbrush using a type of IT different from the one used in the present experiment and found no significant difference.

As a result of the present clinical study, we found that the IT had a significantly greater plaque-removing effect than the CT; however, the RT had no such effect.

## Conclusion

The effectiveness of an ionic toothbrush for the removal of dental plaque was investigated. It was found to be significantly more effective than a control ionic toothbrush. The results obtained in this study demonstrate the effectiveness of an ionic toothbrush. The removal of dental plaque can be enhanced by use of an ionic toothbrush.

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# リチウム電池内蔵電子歯ブラシのプラーク除去効果

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リチウム電池内蔵電子歯ブラシ，逆の電流回路を形成する電子歯ブラシ，電子歯ブラシから電池を除去した歯ブラシのプラーク除去効果を評価することを目的として，27名を対象に6週間の臨床試験を行った．その結果，リチウム電池内蔵電子歯ブラシは，対照とした電池のない歯ブラシに対して有意にプラーク除去効果が認められた．逆の電流回路を形成する電子歯ブラシには有意なプラーク除去効果は認められなかった．これらの結果は，リチウム電池内蔵電子歯ブラシの植毛部がマイナスに帯電することによりプラーク除去効果が得られることを示している．