

Clinical evaluation of a light energy conversion toothbrush

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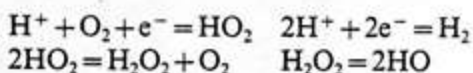
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Abstract. A blind, two-way crossover clinical trial was carried out to compare the effectiveness of plaque removal between a new, light energy conversion toothbrush incorporated with a semiconductor of TiO₂ (test) and a similar toothbrush without the semiconductor (control). The study was completed by 73 school children aged 13-15 years. Each toothbrush was used for a period of 3 weeks. The mean differences between baseline plaque scores and after subjects used the test and control brushes were analyzed by the paired *t*-test. The Soladey 2 toothbrush showed significantly more reduction of plaque on the buccal surfaces of all teeth than the control brush. There was no significant difference in the plaque removing ability of the two brushes on the lingual aspects of the mandible and on the lingual surfaces of the maxillary posterior sextant. As the buccal surfaces are more likely to allow light to reach the semiconductor during brushing than the lingual areas, it is possible that the reported photocatalytic property of the semiconductor may be involved in some way in the observed reduction of plaque.

Key words: evaluation; light energy; toothbrush.

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A new toothbrush called Soladey 2® has been recently introduced and is claimed to have better plaque removing potential than conventional toothbrushes due to a photo-electro-chemical effect it has on dental plaque (Weiger 1987). The basic difference between the Soladey 2 and the conventional brush is the incorporation of an N-type semiconductor of Titanium dioxide (TiO₂) at the neck of the brush. In the presence of light, saturated low energy electrons in the wet semiconductor are transformed into high energy electrons resulting in a reduction reaction as shown below.



This reaction results in the reduction of H⁺ ions from the organic acid in the plaque causing its decomposition. The reaction could also have an effect on plaque formation (Kusunoki et al. 1986, Niwa & Fukuda 1989). There is also evidence that the powdered TiO₂ semiconductor irradiated with visible light has a bactericidal effect against *Escherichia coli* and *Streptococcus mutans* (Morioka et al. 1988).

The aim of this study was to compare the plaque removing ability of the Soladey 2 toothbrush, with a similar brush, but *without* the semiconductor. 80 high school students, (males 43, females 37)

aged 13-16 years participated in the study. To be selected, subjects had to meet the following criteria: have at least 24 teeth excluding third molars; have relatively healthy oral tissues; not receiving local or systemic antimicrobials at the time of the study, no orthodontic or extensive restorative treatment at the start or during the study. The purpose of the study was explained to the subjects and an informed consent obtained.

The two brushes used were (i) Soladey 2 with the semiconductor (TiO₂) bar and (ii) the Soladey 2 with an imitation bar made of synthetic resin (control brush). Both brushes were made to appear alike. Plaque was assessed on the buccal and lingual surfaces of all teeth present (excluding third molars) according to the plaque index developed by Quigley & Hein (1962) and modified by Turesky et al. (1970).

The experiment was designed as a randomized two-way cross-over study with the examiner being blind. Prior to the start of the trial, the plaque scores were recorded to provide base line data. Plaque was assessed, after a thorough application of disclosing solution (Red Cote®) to all teeth. The subjects were divided into 2 groups of 40 each, age- and sex-matched.

The 1st group (A) was given the test brushes, and the 2nd group (B) was

given the control brushes. The examiner was not aware of this allocation. The same dentifrice was provided to all subjects who were requested to use only this dentifrice during the trial. Both groups were advised to use the brushes according to the manufacturer's instructions for a period of 3 weeks and were also provided with written instructions. The instructions were as follows: wet the bristles and the 'rod' before use; brush the teeth in the usual manner but always in a bright area; use only a small amount of the given toothpaste. No further instructions were provided and the subjects were free to carry out oral hygiene procedures as usual. This was done on purpose to mimic a real life situation as far as possible. At the end of the 3rd week, plaque scores were recorded. Group A was then provided with the control and group B the test brushes. At recall, 3 weeks later, plaque was again assessed. At the end of the experiment, the teeth of all subjects were scaled by a hygienist. To test the examiner variability, 10 children were randomly selected from among 13-15 year old children attending the pedodontic clinic, College of Dentistry. The subjects were examined 2 × for plaque using the selected index, with an interval of 20 min between examinations. The intra-examiner variability was calculated by

expressing the percent of exact duplication (Hunt 1986). This was found to be 85.1%.

The mean difference between baseline plaque scores and after subjects used the test and control toothbrushes were analyzed by the paired *t*-test. A total of 73 subjects completed the study. 7 students did not attend school at the time of the crossover and were excluded from the study. The relative effectiveness of the test brush was determined by comparing the difference between the mean plaque scores at the baseline and at the end of the trial, with the difference observed when the subject brushed with the control brush. Table 1 illustrates these differences for the test and control brushes for the anterior and posterior sextants of the mandible and maxilla. The test brush showed significant reductions of plaque except on the lingual surfaces of the mandibular teeth and the palatal aspects of the posterior sextants of the maxillary teeth. A similar comparison was carried out, combining the anterior and posterior sextants and the buccal and lingual surfaces. The test brush removed significant amount of plaque, when compared with the control, in the mandible, the maxilla and the whole mouth.

The results of this study indicate that the toothbrush incorporated with a N-type TiO₂ semiconductor had better plaque removing ability than the control brush without the semiconductor. The difference in the plaque scores on the lingual surfaces of the mandibular and maxillary posterior teeth did not show a statistical significance with either the test or the control brushes. This is not an unusual finding with

single-headed toothbrushes (Gibson et al. 1988).

It is not clear whether the improved plaque scores after using the test brush in the present study was due to the effect of the photocatalytic reaction on the adhesion of plaque microorganisms, or to a possible increase in the brushing frequency/time or to both. It is probable that an adolescent, when provided with a 'new' type of toothbrush, may become conscious of his/her role as a participant in a study and may brush his/her teeth more frequently or for a longer period of time than normal. In order to minimize this effect, both the test and control brushes were manufactured to look alike and all subjects used the same dentifrice.

The test toothbrush incorporating the TiO₂ semiconductor appears to be more efficient in removing plaque than the conventional toothbrush, especially on the buccal surfaces of teeth. The use of the toothbrush at these surfaces are more likely to allow light to reach the TiO₂ semiconductor at the neck of the brush than when the brush is used on lingual surfaces. Hence, it is possible that the reported photocatalytic property of the semiconductor may be involved in some way in the observed reduction of plaque (Niwa & Fukuda 1989). However, the exact nature of the mechanism involved is as yet to be elucidated and warrants further *in vitro* and clinical investigations.

Zusammenfassung

Klinische Beurteilung einer Zahnbürste mit Lichtenergiekonversion
Mit einem gekreuzten klinischen Zweiwege-

test wurde versucht, den Einfluß einer neuen, mit Lichtenergiekonversion und TiO₂ als Halbleiter versehenen Zahnbürste (Testobjekt) auf die Entfernung dentaler Plaque, mit der Wirksamkeit einer ähnlichen Zahnbürste ohne Halbleiter (Kontrolle) zu vergleichen. Die Studie wurde mit 73 Schülern im Alter von 13–15 Jahren durchgeführt. Anwendungszeit für jede Zahnbürste war 3 Wochen. Die mittleren Unterschiede zwischen den Beurteilungseinheiten der, bei der Eingangsuntersuchung registrierten Beurteilungseinheiten für Plaque (plaque scores), und den gleichen scores nach Anwendung der Test- und Kontrollbürsten, wurden mit dem gepaarten *t*-Test analysiert. Die Soladex 2 Zahnbürste reduzierte die Plaque an allen bukkalen Zahnoberflächen signifikant besser als die Kontrollbürste. Hinsichtlich der Fähigkeit beider Bürstenformen, die Plaque an den lingualen Zahnflächen des Unterkiefers und an den lingualen Flächen der 6 posterioren Oberkieferzähne zu entfernen, wurde kein abgesicherter Unterschied festgestellt. Da es wahrscheinlich ist, daß das Licht den Halbleiter bei der Reinigung bukkaler Oberflächen besser erreicht als beim Putzen linguale Regionen, ist es möglich, daß die bereits bekannte photokatalytische Eigenschaft des Halbleiters mit der hier beobachteten Plaque-reduktion zusammenhängt.

Résumé

Évaluation d'une brosse à dents à conversion de l'énergie lumineuse

Un essai clinique en aveugle par méthode doublement croisée a été pratiqué pour comparer l'efficacité de 2 brosses à dents lors de l'élimination de la plaque: une nouvelle brosse à dents à conversion de l'énergie lumineuse dans laquelle un semi-conducteur de TiO₂ était incorporé (test) et une brosse à dents semblable mais sans semi-conducteur (control=témoin). 73 écoliers de 13–15 ans ont participé à toute l'étude. Ils utilisaient chacune des brosses pendant une période de 3 semaines. Les différences moyennes entre les scores de la plaque au début et après utilisation des brosses test et témoin ont été analysées par test-*t* pour valeurs appariées. On a constaté que la brosse Soladex 2 donnait sur les faces vestibulaires de toutes les dents une réduction de la plaque significativement plus importante que la brosse témoin. Du côté lingual à la mâchoire inférieure et sur les faces linguales des sextants postérieurs à la mâchoire supérieure, il n'y avait pas de différence significative entre l'élimination de la plaque obtenue par les 2 brosses. Étant donné que l'accès de la lumière au semi-conducteur est plus probable pendant le brossage des faces vestibulaires que pendant le brossage des zones linguales, il est possible que des propriétés photocatalytiques du semi-conducteur, décrites antérieurement, aient une certaine influence sur la réduction de plaque observée.

Table 1. Reduction from baseline in the mean plaque scores: anterior versus posterior sextants

	Test	Control	Difference ± S.D.	<i>t</i>	<i>P</i>
<i>Anterior sextant</i>					
both jaws	0.92	0.26	0.66 ± 2.30	2.45	<0.05
buccal maxilla	0.97	0.24	0.73 ± 2.45	2.52	<0.05
mandible	0.87	0.27	0.60 ± 1.45	2.09	<0.05
lingual both jaws	0.53	0.09	0.44 ± 1.55	2.43	<0.05
maxilla	0.29	-0.12	0.41 ± 1.53	2.25	<0.05
mandible	0.78	0.30	0.48 ± 2.19	1.86	N.S.*
<i>Poster sextant</i>					
both jaws	0.95	0.17	0.78 ± 1.85	3.59	<0.001
buccal maxilla	1.04	0.18	0.86 ± 2.17	3.40	<0.01
mandible	0.86	0.17	0.69 ± 1.40	3.01	<0.01
lingual both jaws	0.43	0.21	0.22 ± 1.09	1.79	N.S.*
maxilla	0.30	0.05	0.25 ± 1.37	1.57	N.S.*
mandible	0.57	0.36	0.21 ± 1.17	1.52	N.S.*

* N.S.: not significant.

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