Short communication

Clinical evaluation of a light energy conversion toothbrush

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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 TiO_2 (test) and a similar tooth brush 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; tooth brush.

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A new toothbrush called Soladey 2·K has been recently introduced and is claimed to have better plaque removing poten tial 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 incor poration of an N-type semiconductor of Titanium dioxide (TiO,) at the neck of the brush. In the presence of light, satu rated low energy electrons in the wet semiconductor are transformed into high energy electrons resulting in a re duction reaction as shown below.

$$H^+ + O_2 + e^- = HO_2 \quad 2H^+ + 2e^- = H_2$$
$$2HO_2 = H_2O_2 + O_2 \quad H_2O_2 = 2HO$$

This reaction results in the reduction of II+ 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 TiO, sem iconductor irradiated with visible light has a bactericidal effect against Escher ichia coli and Streptococcus mutans (Morioka et al. 1988).

The aim of this study was to compare the plaque removing ability of the Sola dey 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 re ceiving 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 sub jects and an informed consent obtained. The two brushes used were (i) Sola dey 2 with the semiconductor (TiO,) bar and (ii) the Soladey 2 with an imitation bar made of synthetic resin (control brush). Both brushes were made to ap pear alike. Plaque was assessed on the buccal and lingual surfaces of all teeth present (excluding third molars) accord ing 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 sub jects who were requested to use only this dentifrice during the trial. Both groups were advised to use the brushes accord ing 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 exam iner variability, 10 children were ran domly selected from among 13-15 year old children attending the pedodontic clinic, College of Dentistry. The subjects were examined 2 x 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 TiO_2 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 TiO_2 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 TiO_2 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.

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

		Test	Control	Difference ± S.D.	*t*	*P*
	Anterior sextant					
	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
	both jaws	0.53	0.09	0.44+1.55	2.43	< 0.05
lingual	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.*
	Poster sextant					
	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
	both jaws	0.43	0.21	0.22± 1.09	1.79	N.S.*
lingual	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.

Zusammenfassung

Klinische Beurteilung einer Zahnbiirste mit Lichtenergiekonversion

Mit einem gekreurten klinischen Zweiwege-test wurde versucht, den EinfluB einer neuen, mit Lichtenergiekonversion und TiO_2 als Halbleiter versehenen Zahnbinte (Testobjekt) auf die Entfernung dentaler Plaque, mit der Wirksamkeit einer ahnlichen Zahnbiirste ohne Halbleiter (Kontrolle) zu vergleichen. Die Studie wurde mit 73 Schillem im Alter von 13-15 Jahren durchgefiihrt. Anwendungszeit fur jede Zahnbiirste war 3 Wochen. Die mittleren Unterschiede zwischen den Beurteilungseinheiten der, bei der Eingangsuntersuchung registrierten Beurteilungseinheiten fiir Plaque (plaque scores), und den gleichen scores nach Anwendung der Test- und Kontrollbarsten, wurden mit dem gepaarten t-Test analysiert. Die Soladey 2 Zahnbiirste reduzierte die Plaque an allen bukkalen Zahnoberflachen signifikant besser als die Kontrollbiirste. Hinsichtlich der Fahigkeit beider Biirstenformen, die Plaque an den lingualen Zahnflachen des Unterkiefers und an den lingualen Fliichen der 6 posterioren Oberkieferzahne zu entfernen, wurde kein abgesicherter Unterschied festgestellt. Da es wahrscheinlich ist, daB das Licht den Halbleiter bei der Reinigung bukkaler Oberflachen besser erreicht als beim Putzen lingualer Regionen, ist es moglich, daB die bereits bekannte photokatalytische Eigenschaft des Halbleiters mit der hier beobachteten Plaquereduktion zusammenhangt.

Résumé

Evaluation d'une brosse a dents a conversion de l'inergie lumineuse

Un essai clinique en aveugle par methode doublement croisee a ete pratique pour comparer l'efficacite de 2 brosses a dents lors de l'elimination de la plaque: une nouvelle brosse a dents a conversion de l'energie lumineuse dans laquelle un semi-conducteur de TiO_2 etait incorpore (test) et une brosse à dents semblable mais sans semi-conducteur (control = temoin). 73 ecoliers de 13-15 ans ont participe a toute l'etude. Its utilisaient chacune des brosses pendant une periode de 3 semaines. Les differences moyennes entre les scores de la plaque au debut et apres utilisation des brosses test et temoin ont ite analysees par test-t pour valeurs appariees. On a constate que la brosse Soladay 2 donnait sur les faces vestibulaires de toutes les dents une reduction de la plaque significativement plus importante que la brosse temoin. Du cote lingual a la machoire inferieure et sur les faces linguales des sextants posterieurs a la machoire superieure, il n'y avait pas de difference significative entre l'elimination de la plaque obtenue par les 2 brosses. Etant donne que l'acces de la lumiere au semi conducteur est plus probable pendant le brossage des faces vestibulaires que pendant le brossage des zones linguales, il est possible que des proprietes photocatalytiques du semi-conducteur, &rites anterieurement, aient une certain influence sur la reduction de plaque observie.