

### 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<sub>2</sub> (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.

### 1. INTRODUCTION

It is well established that dental plaque is the primary factor in the etiology of caries and periodontal disease and that the common and most efficient means of controlling plaque is toothbrushing. Recently, a new toothbrush (Soladey 2) has been introduced and is claimed by the manufacturers to have better plaque removing potential than conventional toothbrushes due to a photo-electro-chemical effect it has on dental plaque. (fig. 1).

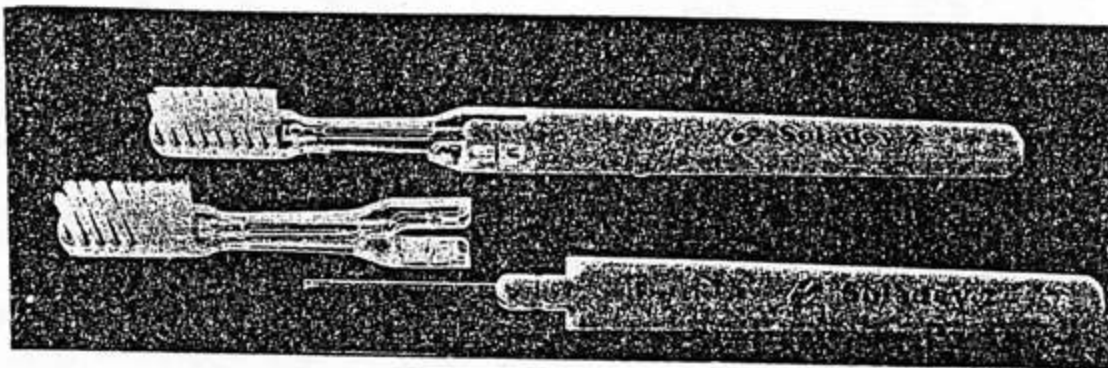
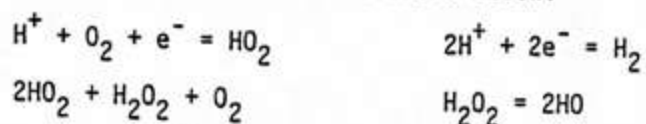


FIGURE 1. Light energy conversion toothbrush (soladey-2)

The basic difference between the Soladey 2 and the conventional brush is the incorporation of an N-type semiconductor (titanium dioxide) at the neck of the brush.

#### 1.1 Mode of action

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<sup>+</sup> ions from the organic acid in the plaque causing its decomposition. The reaction could also have an effect on plaque formation<sup>3,4</sup>. There is also evidence that the powdered TiO<sub>2</sub> semiconductor irradiated with visible light has a bactericidal effect against E. Coli and S. Mutans<sup>5</sup>.

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.

## 2. MATERIAL AND METHODS

### 2.1 Subject selection

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 was obtained from the students and their parents according to University guidelines for protection of human subjects. The two brushes used in this study were (i) Soladey 2 with the semiconductor (TiO<sub>2</sub>) 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 and Hein<sup>8</sup> and modified by Turesky.

### 2.4. Trial design

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<sup>TM</sup>) to all teeth. The subjects were divided into two groups of 40 each, matched by sex and age. The first group (A) was given the test brushes, and the second group (B) were given the control brushes. The examiner was not aware of this allocation. The same toothbrush was provided to all subjects and the subjects requested to use only this toothpaste 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 verbal and 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. At the end of the third week, plaque scores were recorded. Group A were 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. The mean differences between baseline plaque scores and after subjects used the test and control toothbrushes were analyzed by the paired t-test.

## 3. RESULTS AND DISCUSSION

A total of 73 subjects completed the study. Seven 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 the control brushes in the maxilla and the mandible, Table 2, the buccal and lingual surfaces, and Table 3, the anterior and posterior surfaces.

TABLE 1

Reduction from baseline in the mean plaque scores:  
Maxilla vs Mandible

Buccal and Lingual Surfaces	Test	Control	Difference ± S.D.	t	P
Both Jaws	0.74	0.22	0.52±1.42	3.16	<0.01
Maxilla	0.65	0.09	0.56±1.50	3.18	<0.01
Mandible	0.83	0.34	0.49±1.45	2.87	<0.01

N = 73

TABLE 2

Reduction from baseline in the mean plaque scores:  
Buccal vs Lingual surfaces

		Test	Control	Difference ± S.D.	t	P
Buccal Surface	Both Jaws	0.94	0/21	0.73 ± 1.98	3.13	<0.01
	Maxilla	1.01	0.21	0.80 ± 2.18	3.14	<0.01
	Mandible	0.86	0.21	0.65 ± 1.94	2.87	<0.01
Lingual Surface	Both Jaws	0.48	0.16	0.32 ± 1.18	2.33	0.05
	Maxilla	0.29	0/02	0.31 ± 1.30	2.08	0.05
	Mandible	0.66	0.33	0.33 ± 1.38	2.0	N.S*

\*N.S: Not Significant

TABLE 3

Reduction from baseline in the mean plaque scores:  
Anterior vs Posterior Sextants

	Anterior Sextant	Test	Control	Difference ± S.D.	t	P
Buccal	Both Jaws	0.92	0.26	0.66 ± 2.30	2.45	0.05
	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 Jaw	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*
Buccal	Both Jaws	0.68	0.13	0.55 ± 1.68	2.82	0.01
Lingual	Maxilla	0.54	0.03	0.57 ± 1.70	2.87	0.01
Combined	Mandible	0.82	0.28	0.54 ± 1.93	2.39	0.05
Poster Sextant						
Buccal	Both Jaws	0.95	0.17	0.78 ± 1.85	3.59	0.001
	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.*
Buccal	Both Jaws	0.69	0.19	0.50 ± 1.33	3.23	0.01
Lingual	Maxilla	0.67	0.11	0.56 ± 1.53	3.12	0.01
Combined	Mandible	0.71	0.27	0.44 ± 1.30	2.94	0.01

\*N.S: Not Significant

The test brush showed significant reductions of plaque when compared with the control except on the lingual surfaces of the mandible, and the palatal aspects of the maxillary posterior teeth.

The test toothbrush incorporating the TiO<sub>2</sub> semi conductor 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<sub>2</sub> 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<sup>3</sup> of the semiconductor may be involved in some way in the observed reduction of plaque. However, the exact nature of the mechanism involved is as yet to be elucidated and warrants further in vitro and clinical investigations.

#### 4. ACKNOWLEDGMENTS

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