

RF BRUSH PILOT STUDY
FINAL REPORT

DO113781A

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1. INVESTIGATIONAL DEVCIE

1.1. General Device Description

The Silk'n Toothbrush emits RF energy that streams between two electrodes and over a silicon barrier. RF is an alternating electric current that oscillates at radio frequencies in the range of 3kHz-300GHz. The RF current tends to flow along the surfaces of electrical conductors, which is known as the skin effect; thus, the charges come in contact with the tooth surface, providing the efficacy of the brush. Silk'n Toothbrush provides Bipolar RF up-to 3W, 5 MHz.

1.2. Proposed mechanism of action

We have conducted laboratory research in order to understand the underlying mechanism of the toothbrush, and came to the understanding that the role of the alternating electrical current is to activate, speed up, or inhibit chemical reactions that could take place at the tooth surface, by changing the local charges (see proposed mechanism of action DO113767A). This process includes interactions with molecules that are attached to the tooth surface (such as dark stains and calculus), and the result is manifested by a thorough cleaning of the tooth surface, improving dental hygiene, whitening the tooth shade, removal of stains and decreasing calculus.

1.3. Intended Use

Silk'n Toothbrush is intended for teeth whitening, stain removal, reduction of calculus, gingivitis, and gum bleeding, and improvement of oral hygiene. It is for personal use at home and is not intended for use on multiple patients in a dental practice or institution.

2. SUMMARY OF THE CLINICAL INVESTIGATION PLAN

2.1. Investigation Design

This is an open label, prospective pilot study aimed to evaluate the safety and efficacy of the Silk'n toothbrush. The study included 14 subjects that performed 120 treatment sessions, over a period of 2 months.

Each subject served as his/her own control, while comparing results before treatment, and after 2 months of treatment. An interim analysis was conducted as well following one month of treatment.

Treatment was defined as 2 minutes brushing of the teeth in a regular manner, twice a day (morning and evening). Brushing was conducted using the Silk'n toothbrush and a regular marketed toothpaste (Colgate advanced clean).

2.2. Clinical investigation objectives

The objective of the study was to evaluate the safety and efficacy of the home-use device Silk'n toothbrush Model H7001/H7002 for self-treatment of stained teeth, teeth whitening, calculus reduction, and improvement of oral hygiene.

2.3. Ethical committee:

The study protocol and all study documents were approved by Bney Zion Hospital IRB on Sep 14, 2016, prior to study initiation (IRB ID#: 0073-16BNZ).

2.4. Study Endpoints

Efficacy assessment:

Primary (success criterion): An average whitening of at least 1 shade according to the VitaPan classical tooth shade guide (see figure 1), using the Vita EasyShade® device.

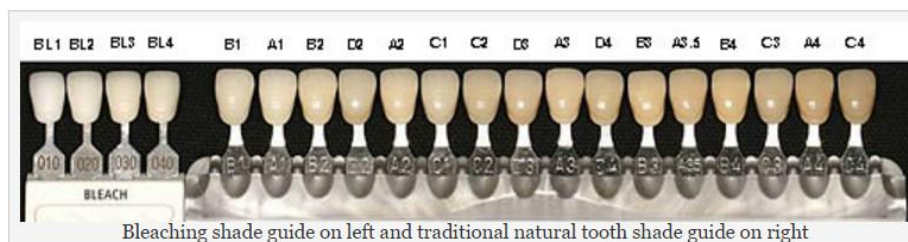


Figure 1: VitaPan classical tooth shade guide

Secondary:

1. An objective reduction of teeth stains and calculus as evaluated by before and after standardized digital photos.
2. A subjective impression of improvement in teeth appearance, gum sensitivity and bleeding, calculus, and oral hygiene following 2 months' treatment.

Safety assessment:

3. Dental examination.
4. Reported errors and near errors using the device
5. Device malfunctions which relate to device safety
6. Device related adverse events
7. Non device related adverse events (secondary endpoint)

2.5. Test MethodsEfficacy measures:

1. Assessment of teeth shade according to the VitaPan classical tooth shade guide, using the Vita EasyShade® device.
2. Subjective questionnaires
3. Standardized digital camera photographs for evaluation of calculus condition, and teeth stains.

Safety measures:

1. Radiological examination before inclusion in the study
2. A complete dental examination of the oral cavity

2.6. Subjects

Subjects were enrolled in the study after meeting all inclusion/exclusion criteria and providing signed Inform Consent Form.

2.7. Treatments procedure

Subjects signed informed consent prior to any study related activities, and were given information about the device and its operation. Dental examination was conducted, including dental

radiography (unless the subject provided a recent radiograph that was taken within the past 6 months).

Baseline data such as demographic characteristics and relevant medical history was collected, and visits schedule was set. Teeth shade was evaluated and scaled according to the VitaPan classic shading scale using the Vita EasyShade® device. The shading was evaluated and documented for 6 upper and 6 lower front teeth. Front teeth were photographed using a digital standardised camera for comparison of teeth stains and calculus condition before and after treatment.

Following visit 1 subjects performed at-home brushing sessions twice a day, over a period of 2 months, each brushing was performed for 2 minutes. The subjects received a designated form for documentation of treatments including any unusual incident during home treatments (i.e., device malfunctions).

Each subject served as his/her own control, while comparing the shade score before and after treatment. A total of 6 clinic visits were conducted during the study, once a week during the first month, and the final 6th visit at the end of the study. A safety assessment was conducted at each visit via dental examination. In addition, compliance with study protocol was evaluated.

During visits 5 and 6, an evaluation of teeth shade and calculus condition took place, and front teeth were photographed using a digital standardised camera as was conducted during visit 1.

2.8. Statistical analysis

The reliability of the Vita EasyShade measurements within scales was evaluated using Cronbach's alpha. The average colour of 12 front teeth was calculated within each visit per subject. The changes in colours were evaluated between visit1 & visit 5 as well as between visit 1 & visit 6, using the unstructured mixed model. This model enabled to analyse the contribution of every tooth (out of 144 teeth in total) to the overall change in teeth shade, while taking into account the variability of shades in different subjects. Results were presented in tabular format including count, Mean, SD, and graphical representation of individual change. Significance level was defined as $\alpha=0.05$. Statistical analyses were carried out using SPSS 24.0.1.

3. RESULTS

3.1. Subjects

Fifteen subjects were recruited to the study; two subject decided independently to drop out due to lack of time and interest. The demographic data of 13 subjects, which completed the study, is shown in Table 1 below. Out of the 13 completers, one subject was excluded from the study due to very low compliance with the treatment protocol. Table 1 presents the compliance details of all 13 completers. Table 2 details the demographic characteristics of 12 subjects that completed the study and were included in the final analysis.

Table 1: demographic data

Subject ID	Subject initials	age	gender	Country of origin	Compliance (#brushings)	Compliance (% out of 120)
2	O-G	45	Female	Russia	64	53.33
4	M-C	68	Male	North Africa	100	83.33
5	R-V	62	Female	North Africa	91	75.83
6	K-K	39	Male	Russia	101	84.16
7	Y-S	35	Male	Asian	125	104.16
8	S-E	48	Male	North Africa	56	46.67
9	S-A	65	Male	North Africa	80	66.67
10*	N-A	42	Male	Russia	20	16.67
11	Y-B	54	Male	Israeli	63	52.5
12	A-K	25	Male	Asian	100	83.33
13	N-J	40	Male	European	110	91.67
14	R-W	45	Male	European	114	95
15	E-S	30	Female	Israeli	87	72.5

*Subject 10 was excluded from the analysis due to extremely low compliance.

Table 2: demographic characteristics

N	12
Age	
Mean±SD	46.63± 13.73
Min-Max	25 - 68
Gender	
Male	9 (75.0%)
Female	3 (25.0%)
Country of origin	
North Africa	4 (33.33%)
Russia	2 (16.67%)
Asian	2 (16.67%)
European	2 (16.67%)
Israeli	2(16.67%)

3.2. Safety Assessment

Safety analysis was conducted using all 13 subjects. No unexpected adverse events were detected or reported during the study. Subjects reported that the brushing was conducted in a similar manner to a regular toothbrush, and no unusual feeling was indicated. Two subjects, reported on teeth sensitivity and pain, which were caused by untreated infected tooth nerves and cavities and were found not related to the treatment by the study physician.

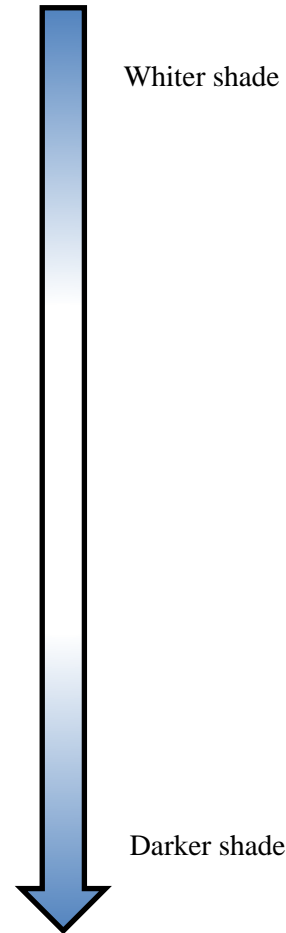
3.3. Efficacy Assessment

3.3.1. Evaluation of teeth shade

Teeth shade measurements were performed using the Vita EasyShade® device and the evaluation was conducted using the Vita classical shade guide (see figure 1). The average shade of each tooth was calculated automatically by the device according to 5 singular measurements per tooth. Teeth whitening was evaluated according to a designated index, as instructed by the Vita EasyShade manual. According to this index, whiter teeth shades are correlated with lower index number, as indicated in Table 3 below.

Table 3: Vita classical shade guide and whitening index.

Vita classical shade guide	Whitening index
B1	1
A1	2
B2	3
D2	4
A2	5
C1	6
C2	7
D4	8
A3	9
D3	10
B3	11
A3.5	12
B4	13
C3	14
A4	15
C4	16



Analysis of Cronbach’s alpha was performed in order to evaluate the validity of the results. The resulting values of Cronbach’s alpha confirm that the study measurements are correlated and reliable (see Table 4).

Table 4: Reliability of teeth shade measurements

	Cronbach's alpha
Baseline	0.883
Visit 5	0.877
Visit 6	0.887

Figure 2 illustrates the average scores of teeth whitening index per subject at each visit (calculated by averaging the scores of 12 front teeth), indicating on a notable trend of shade reduction

(increased whitening). Figure 3 illustrates the average scores of whitening index, calculated for 144 teeth of 12 subjects at baseline, visit 5 and visit 6. Statistical analysis conducted by the unstructured mixed model confirms a significant reduction in the average score of whitening index between baseline and visit 5 ($p < 0.001$) as well as between baseline and visit 6 ($p < 0.001$). In addition, no significant difference was found between the average teeth shade in visit 5 as compared to visit 6 ($p = 0.918$). Table 5 presents the gap estimates of teeth shade averages, with a gap of 1.25 ± 0.93 and 1.27 ± 0.96 scores from baseline to visit 5 and visit 6 respectively, and a 0.02 gap between visit 5 and visit 6 that is not statistically significant.

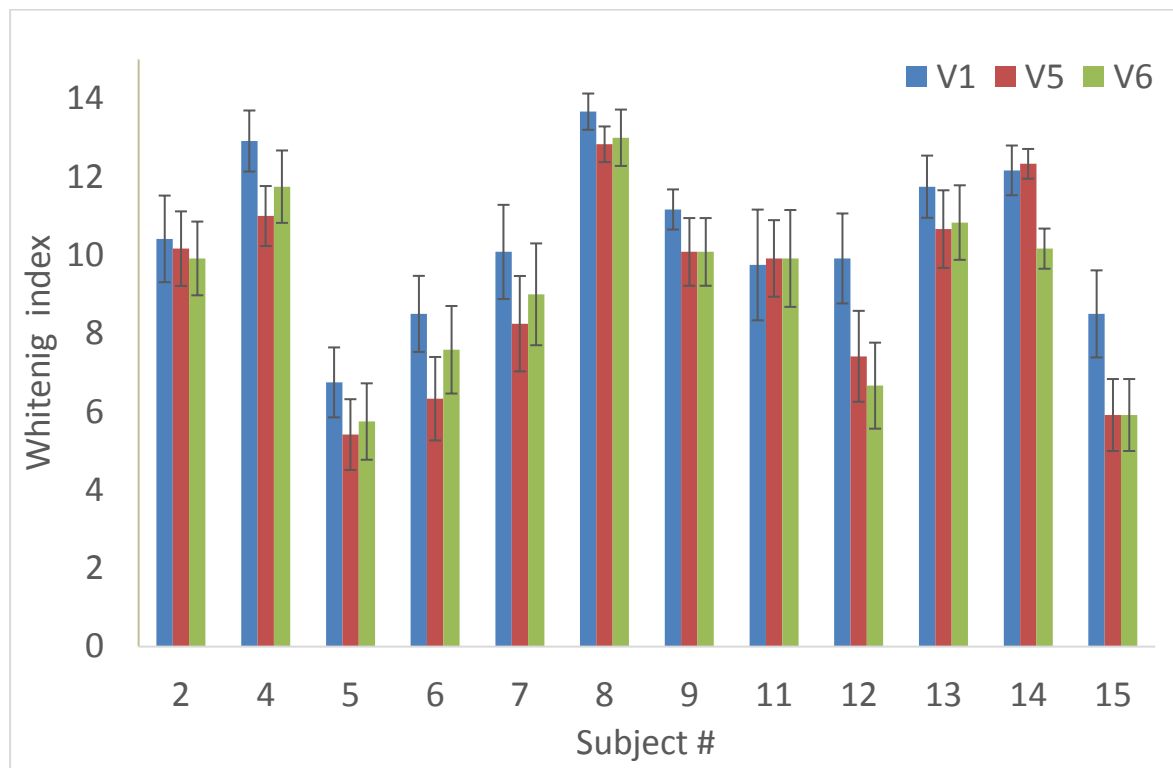


Figure 2: Teeth whitening index per subject, as measured by the Vita EasyShade device. Measurements were averaged over 12 (6 upper and 6 lower) front teeth.

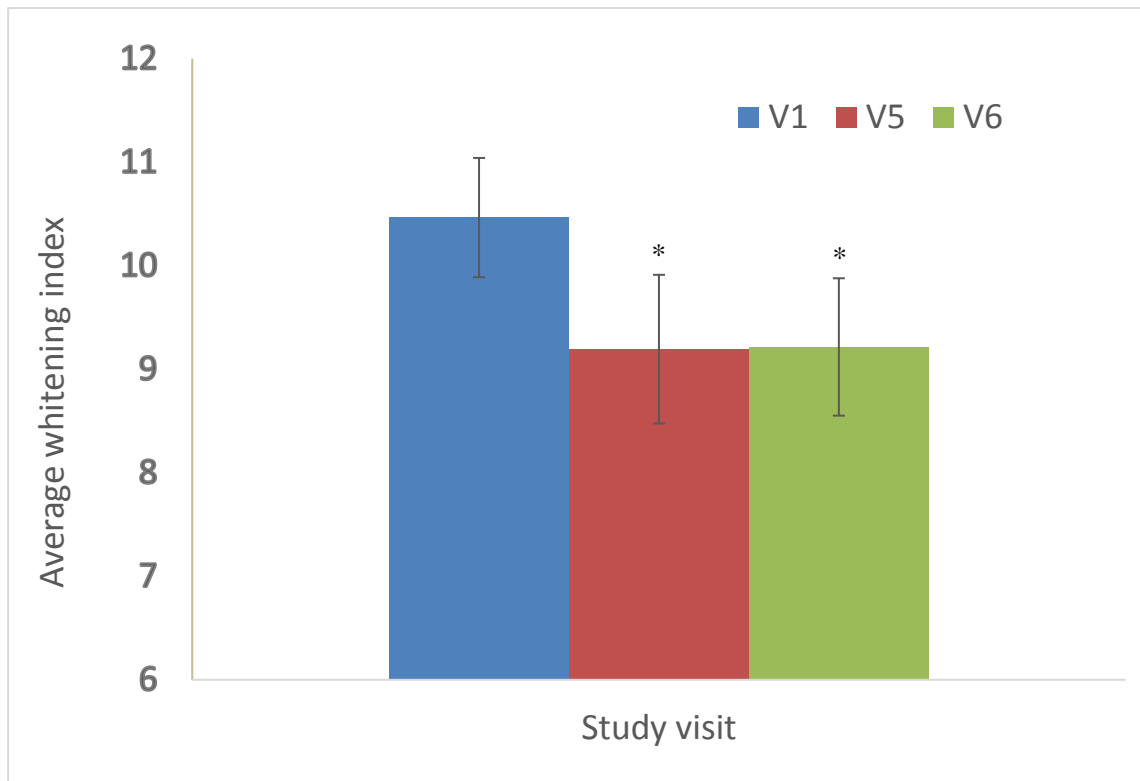


Figure 3: Teeth shade evaluation, as averaged for all 12 subjects before, after one month and after two months of brushing. *p<0.001, unstructured mixed model.

In addition to the pairwise comparison of teeth shade in Visit 5 and 6 with baseline, the effects of age and gender on teeth shade were analyzed as well (see table 5). Results indicate that there is no significant difference in teeth shade between females and males; however, the age factor significantly influence teeth shade (p<0.001). According to our analysis, the average whitening index increases in 0.21 points per year, indicating that the teeth shade darkens with age.

Table 5: Gap estimates of teeth shade

Influencing factor	Unstructured (N=12)	
	Shade gap estimate	P value
Visit 6 vs BL	-1.25	<0.001
Visit 5 vs BL	-1.27	<0.001
Visit 5 vs Visit 6	-0.02	0.918
Female vs Male	-0.13	0.830
Age	0.21*	<0.001

*Per age difference of 1 year.

3.3.2. Evaluation of dark stains and calculus

In addition to the whitening effect as measured by the Vita EasyShade device, a positive effect on dark stains and calculus was observed using digital photographs taken before and after 1 and 2 months of brushing.

Figure 5 exemplifies the effect of the Silk'n Toothbrush on teeth stains. This subject had visible dark stains on his lower teeth, as indicated by photograph A taken during visit 1 (before brushing). A comparison to visit 5 (photograph B, following one month of brushing) as well as visit 6 (photograph C, following two months of brushing) indicates on a gradual but significant improvement of teeth stains, which were cleared almost entirely after two months of brushing.

Figure 6 demonstrates the effect of Silk'n Toothbrush on calculus, showing visibly clear reduction of calculus on the tooth enamel and between the teeth after 2 months of brushing.

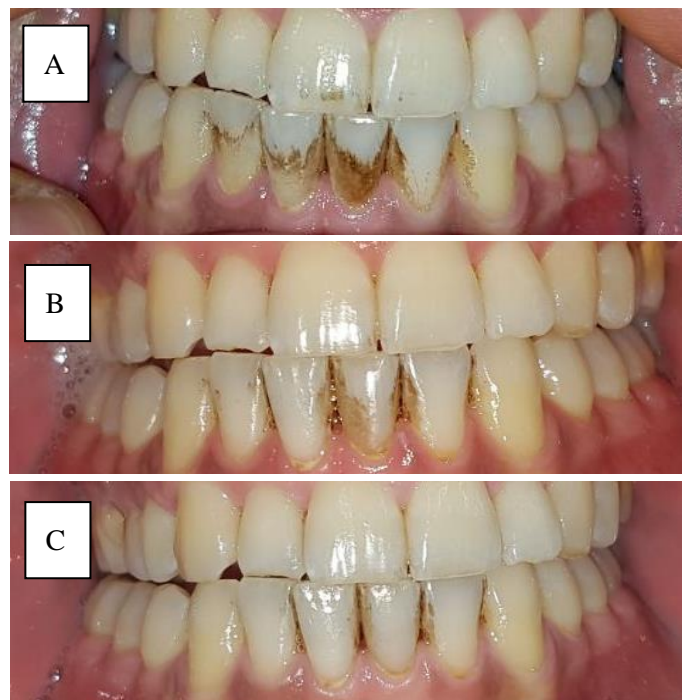


Figure 5: Effect on teeth stains as indicated by digital photographs taken before (A), after one month (B), and after 2 months (C) of brushing with the Silk'n Toothbrush.

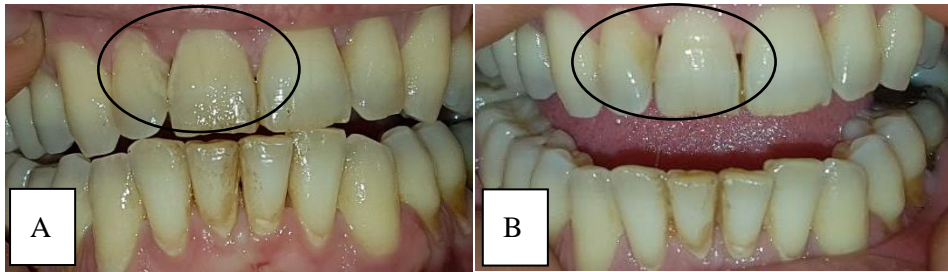


Figure 6: Effect of Silk'n toothbrush on the calculus level as indicated by digital photographs taken before (A), and after two months (B) of brushing.

3.3.3. Evaluation of Subjects' satisfaction

During visit 6, the subjects filled satisfactory questionnaires in order to evaluate their impression on the device operation, safety, and treatment outcomes. The results are shown in Table 6. Questionnaire items number 1 and 3-8 were scored on a scale of 5, where 1 is very high satisfaction, and 5 is very low satisfaction. Items number 2, and 9-11 were open questions. The results indicate that most subjects were satisfied or very satisfied with the device operation, device safety and with the overall effect of the Silk'n toothbrush. Subjects indicated that they felt notable improvements in oral hygiene and teeth appearance.

Table 6: Subject satisfaction questionnaire results.

Question	Average score	SD
1. Over all, how satisfied are you with the Silk'n toothbrush device?	2.15	0.80
2. What are some aspects of the device that can be improved?	Add sonic movement – 16.6% Smaller brush head - 16.6% Softer bristles - 16.6% Improve the charging cradle – 8.3% Improve the battery – 8.3% Add digital display – 8.3% No improvement needed – 8.3%	
3. How satisfied are you with the safety of using the Silk'n Toothbrush?	1.33	0.492
4. How satisfied are you with the ease of treatment with Silk'n Toothbrush?	1.62	0.65
5. How satisfied are you with the level of improvement in oral hygiene after brushing with Silk'n Toothbrush?	2.00	0.91
6. How satisfied are you with the level of teeth shade whitening after using the Silk'n Toothbrush?	2.46	1.20
7. How satisfied are you with the level of improvement in calculus (tartar) after using the Silk'n Toothbrush?	2.45	1.05
8. How satisfied are you with the level of improvement in teeth stains after using the Silk'n Toothbrush?	2.38	1.12
9. Have you noticed difference in breath odor after using the Silk'n Toothbrush?	Yes: 11.1% No: 88.9%	
10. Have you noticed difference in the condition of your gums after using the Silk'n Toothbrush?	Yes: 22.2% (better feeling, reduced sensitivity) No: 77.8%	
11. Have you noticed difference in the appearance your teeth after and general feeling of the oral cavity after using the Silk'n Toothbrush? Please specify.	Yes: 75%, No: 25% Whiter (brighter) teeth – 66.7% More efficient cleaning – 55.5% Less plaque – 33.3% Less calculus (tartar) – 33.3% Reduction in gum bleeding – 22.2% Shinier teeth – 11.1% Reduction in teeth sensitivity – 11.1% Improved teeth appearance – 11.1%	

1. DISCUSSION AND CONCLUSIONS

This pilot study provides an evaluation of the change in teeth shade, stains, calculus, plaque and oral hygiene, following two months of brushing with the RF toothbrush.

Safety analysis indicates that brushing with the Silk'n toothbrush is safe and no adverse events were reported.

Objective results of teeth shade as measured by the Vita EasyShade device indicate on a notable trend of teeth whitening following one and two months of brushing. Notable reductions in teeth stains and calculus were shown as well, as exemplified by digital photographs taken before and after treatment. In addition to these objective results, data obtained by satisfactory questionnaires indicate on high satisfaction of the users with the device operation, device safety, improvement of oral hygiene, plaque, calculus, gums condition and teeth appearance.

The success criterion of this study was define as an average whitening of at least 1 shade following two months of brushing according to the VitaPan classical tooth shade guide, and using the Vita EasyShade® device. The average shade reduction was found to be 1.25 ± 0.93 and 1.27 ± 0.96 for visit 5 and visit 6 respectively as compared to baseline, which indicates that the success criterion of the study was met. Moreover, a statistical analysis using the unstructured mixed model indicates on a significant effect of whitening following 1 and 2 months of brushing ($p < 0.001$), while the difference in teeth shade between visit 5 and 6 was found to be insignificant ($p = 0.918$). These results indicate on teeth whitening, which occurs during the first month of brushing and is maintained throughout the second month of brushing.

Although this initial pilot study included merely 12 subjects, the teeth shade results were documented for 12 teeth per subject (measuring the average shade of each tooth separately), accounting for 144 teeth that provide a meaningful sample size for this evaluation. Moreover, our analysis indicated that the subject age significantly influences the teeth shade, such that older subjects in our study were found to have darker teeth. This result is correlated with known evidence from the scientific literature^{1,2}, and thus corroborate the validity and authenticity of our results.

The results of this study indicate that the Silk'n toothbrush offers a safe and effective in-home technique for teeth whitening, reduction of calculus and stains and improvement of oral hygiene.

2. References

1. Sharad Vaidya et al. Objective measurement of shade color in age estimation. *J Forensic Dent Sci.* 2015 Sep-Dec; 7(3): 171–174.
2. Sathesh B Haralur. Effect of Age on Tooth Shade, Skin Color and Skin-Tooth Color Interrelationship in Saudi Arabian Subpopulation. *Journal of International Oral Health* 2015; 7(8):33-36.