Original Article

A Study of Cleaning Ability and Abrasivity of Toothpastes in Thailand

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Abstract

The objective of this study was to study the cleaning ability and abrasivity of toothpastes available from local markets in Thailand. Eleven toothpaste brands, Fluocaril (Original), Darlie (Natural Mint Double Action), Systema (Deep Impact), Kolbadent, Parodontax (Mint Gel), Oral-B (Tooth and Gum Care), Oralmed (Whitening Fresh Gel), Twin Lotus (Original), Close up (Menthol Chill), Colgate (Advanced Whitening), and Herbric were studied. The cleaning ability was determined by measuring the artificial stain density on bovine teeth (n=16 per brand) before (pre-score) and after (post-score) brushing with the tested toothpaste. The cleaning ability (Pellicle Cleaning Ratio, PCR) was calculated by comparing the density change generated by each brand of toothpaste to that from use of the ADA reference material (ADA), which was assigned a value of 100. The abrasivity was profilometrically determined by measuring the surface area of human enamel (n=8 per brand) and dentin (n=8 per brand) lost after brushing with the tested toothpaste. The area loss was compared with the area loss obtained from the ADA. All data were statistically analyzed using one way ANOVA with significance set at $p < .05$.

The results showed that the mean surface area loss of dentin ranged from 423.43±52.35 μm^2 for Fluocaril (Original) to 1,940.52±197.21 μm^2 for Herbric which were 0.40 and 1.84 fold of that of ADA, respectively. The mean of enamel surface area loss was lowest for Fluocaril (Original), 15.39±1.49 μm^2 (0.69 fold of ADA) and highest for Colgate (Advanced Whitening), 66.15±4.36 μm^2 (2.97 fold of ADA). The correlation coefficients between cleaning ability and abrasivity were 0.664 and 0.776 for dentin and enamel, respectively. The correlation coefficient between dentin abrasivity and enamel abrasivity was 0.792. In conclusion, all tested toothpastes had similar or better cleaning ability than the ADA reference material with abrasivity values within the ISO recommended limit and were safe for use on teeth.

Key words: Abrasivity; Cleaning Ability; Toothpaste

Introduction

The use of toothpaste has an important role in maintaining good oral health. The general purpose of toothpaste is to clean the tooth surfaces. This cleaning is achieved not only by mechanical brushing, but the abrasives and other components in the toothpaste also help in removing dental deposits including stains. However, the cleaning ability of

toothpaste is not included in the ISO toothpaste requirements. One of the ISO requirements for a toothpaste is the toothpaste abrasivity, for which there are two determination methods; radiotracer and profilometry.[1] Several reports have shown a direct relationship between toothpaste cleaning power and abrasivity to the tooth.[2,3] However, this is not always true depending on the type of abrasive, particle size, particle shape, and other ingredients.[4,5] In Thailand, there are more than thirty different brands of toothpaste comprising both local and foreign brands. Each brand usually is available in more than one formula. With many toothpastes in the Thai market, there have been a few studies on their properties and qualities.[3,6,7] A study in 2000, using a radiotracer method, found 22 out of 23 dentifrice brands had abrasivity within the ISO recommended values, and had cleaning ability values less than that of the ADA reference material (ADA).[3] In the present determination of abrasivity and cleaning ability, both toothpastes which had never been tested and toothpastes tested about 10 years ago were selected.

Materials and methods

Study toothpastes

Eleven toothpaste brands (Table 1) were purchased from department stores and grocery shops in Bangkok in 2008. Eight were selected as these formulations had not been tested previously, and the remaining three, while having been examined before, were selected to confirm the performance of the formulation.

Cleaning ability test

The method used was described by Stookey et al., with minor modification (Oral Health Research Institute, Indiana).[5] Briefly, sixteen bovine specimens (8x8 mm.) were used for each brand of toothpaste. The specimens were embedded in moulds using cold cure acrylic. The stains on the specimens' surface were removed using 600-grit abrasive paper attached to an automatic polishing machine (Dps 3200, Imptech, South Africa). Then they were etched with acid solutions by immersion in 1% hydrochloric acid for 60 seconds, saturated sodium carbonate for 30 seconds, and 1% phytic acid for 60 seconds. The specimens were rinsed with de-ionized water for 5 minutes, and stained at 37°C in a staining mixture containing tea, coffee, *Micrococcus luteus*, and trypticase soy broth for approximately 40 hours. The stain density was measured (Pre-score) by a Spectrocolorimeter (UltraScan XE, Hunter Lab, USA). Specimens having an L* value in the range of 23-42 were selected and brushed with the test toothpastes or the ADA reference material (calcium pyrophosphate, Solutia Inc., USA). The brushing was performed using a brushing machine (V-8 Cross brushing machine, Sabri Dental Enterprises, USA), loaded with Oral-B medium toothbrushes, with a 150 g brush head load, for 800 strokes. The ADA slurry was prepared using 10 g of calcium pyrophosphate powder and 50 ml of a mixture containing 0.5% carboxymethyl cellulose and 10% glycerine. The test toothpaste slurry was prepared using 25 g of toothpaste and 40 ml of de-ionized water. After brushing, the specimen's stain was evaluated (Post-score). The cleaning ability was expressed as a Pellicle Cleaning Ratio (PCR) which was determined by the following equation:

$$\frac{\text{(Pre-score – Post-score) for test toothpaste}}{\text{(Pre-score – Post-score) for reference material}} \times 100.$$

The reference material was assigned to have a PCR of 100.

Abrasivity test

The abrasivity test was performed according to the ISO profilometry method.[1] Briefly, human dentin and enamel specimens were cut (7x5 mm., LxW) with a low speed cutting machine (Isomed1000, Buehler, USA), placed into moulds, embedded in cold cure acrylic, and polished with 600-grit abrasive paper on an automatic polishing machine (Dps 3200, Imptech, South Africa) to expose an area of the specimens. The specimens were then finely polished using 1,200-grit abrasive paper and 3-μm diamond polishing slurry and assayed for flatness with a contact profilometer (Talyscan150, Taylor Hobson, England) by measuring the surface roughness at the center of the specimen for 5 mm. perpendicular to the cross-brushing action as shown in Figure 1 (A). The tolerance of flatness of the surface for dentin and enamel was less than 1.0 μm and 0.1 μm, respectively.[8] The specimens were then covered with adhesive tape leaving a 3.0 mm. wide exposed area in the middle. Eight specimens were brushed with each of the test toothpastes or the ADA reference material prepared as previously described. Each sample was tested on each of the eight toothbrushes loaded on the test machine and the scores averaged to account for any possible differences in the brushes. Brush stroke count was maintained below ISO limits for each brush. Dentin and enamel specimens were brushed for 700 and 10,000 strokes, respectively. After

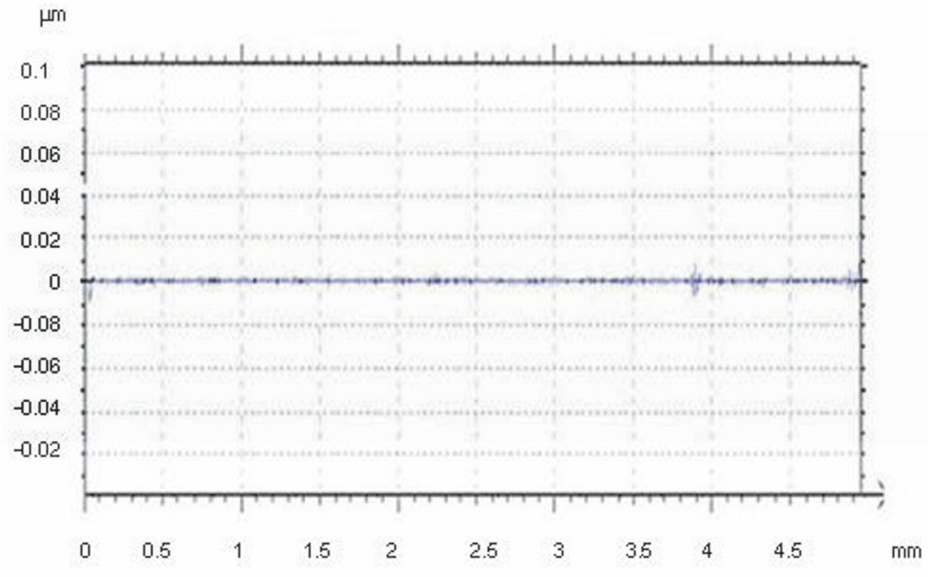
Table 1 *Test toothpaste's description*

Products	Active ingredients	Manufacturer
Close up (Menthol Chill)	3.0% Agglomerated silica, 15.0% Silicon dioxide (hydrated silica), 0.1% Triclosan, 0.22% Sodium fluoride	Unilever (Vietnam)
Colgate (Advanced Whitening)	20% Silicon dioxide (high cleaning silica), 5.5% Silicon dioxide, 0.22% Sodium fluoride	Colgate Palmolive (Thailand) Co., Ltd.
Darlie (Natural Mint Double Action)	45% Dicalcium phosphate dihydrate, 0.76% Sodium monofluorophosphate	Colgate Palmolive (Thailand) Co., Ltd.
Fluocaril (Original)	0.683% Sodium monofluorophosphate, 0.221% Sodium fluoride	IDS manufacturing Ltd.
Twin Lotus (Original)	*Streblus asper* Lour, Sorbitol, Clove, Flavour	Twin Lotus Co., Ltd.
Herbric	0.3% Chamomile extract, 0.1% Thymol, 0.1% Sage extract, 1.2% Peppermint oil, 0.01% Menthol, 0.22% Sodium fluoride	General Care Product Co., Ltd.
Kolbadent	*Streblus asper* Lour, Clove oil, Mint	Sahapan Group (Thailand) Co., Ltd.
Oral-B (Tooth and Gum Care)	0.2% Sodium fluoride	IDS manufacturing Ltd.
Oralmed (Whitening Fresh Gel)	22% Silica, 0.8% Peppermint, 0.3% Myrrh, 0.3% Chamomile, 0.15% Sage, 0.22% Sodium fluoride	Greater Poly Manufacturing Co., Ltd.
Parodontax (Mint Gel)	45% Sodium bicarbonate, 1.248% Rhatany tincture, 0.954% Expressed juice of Echinacea, 0.624% Chamomile tincture, 0.624% Myrrh tincture, 0.146% Sage oil, 0.221% Sodium fluoride	Neocosmed Co., Ltd.
Systema (Deep Impact)	0.03% Epsilon-Aminocaproic acid, 0.02% Cetylpyridinium chloride, 0.22% Sodium fluoride	Lion (Thailand) Co., Ltd.

brushing, the specimens were rinsed with de-ionized water, the protective tape was removed and the surface roughness of the specimens was measured using the same co-ordinates as before. The area under the curve from the two taped edges of the exposed area was calculated by TalyScan150 software as shown in Figure 1 (B).

Statistical analysis

All data were analyzed using one way ANOVA. Tukey's test was used to determine if the differences of the means were significant ($p < .05$). The correlation of parameters was analyzed using Pearson correlation.



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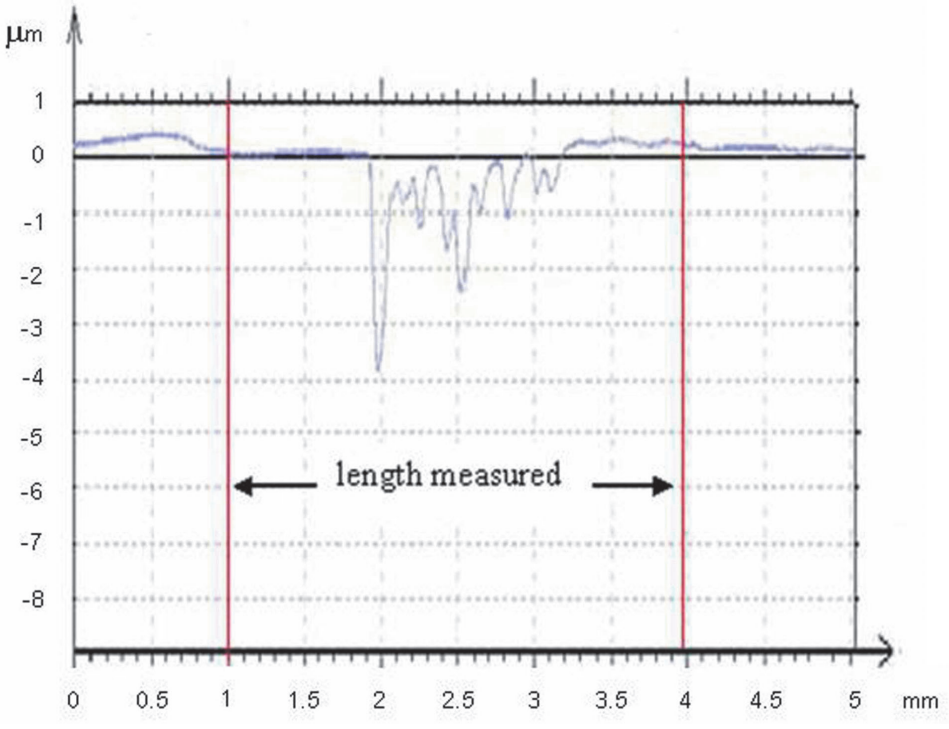

B

Fig. 1 *Specimen surface roughness (A) before brushing (B) after brushing.*

Results

The mean Pellicle Cleaning Ratio (PCR) of the test toothpastes, seen in Table 2, ranged from 151.52±7.88 for Colgate (Advanced Whitening) to 101.06±5.63 for Fluocaril (Original). In the dentin abrasivity assay, dentin surface area loss ranged from 1,940.53±197.21 μm^2 for Herbric to 423.43± 52.35 μm^2 for Fluocaril (Original), which were 1.84 and 0.40 fold of ADA respectively (Table 3). The enamel surface area loss ranged from 66.15±4.36 μm^2 for Colgate (Advanced Whitening) to 15.39±1.49 μm^2 for Fluocaril (Original), which were 2.97 and 0.69 fold of ADA respectively (Table 4). According to ISO recommendations, the abrasivity of a toothpaste for dentin and enamel shall not exceed 2- and 4- fold, respectively, of the ADA.

Table 2 *Pellicle Cleaning Ratio of toothpastes*

Product name	Mean±SEM
Reference material (ADA)	100.00±2.82
Fluocaril (Original)	101.06±5.63
Darlie (Natural Mint Double Action)	101.88±6.25
Twin Lotus (Original)	106.43±9.29
Systema (Deep Impact)	107.06±7.82
Oralmed (Whitening Fresh Gel)	107.08±7.57
Parodontax (Mint Gel)	110.55±5.83
Close-up (Menthol Chill)	117.07±6.24
Oral-B (Tooth and Gum Care)	117.72±5.87
Kolbadent	134.67±5.93
Herbric	144.59±5.22
Colgate (Advanced whitening)	151.52±7.88

The data were analyzed using Tukey's test.

Values within brackets do not significantly differ ($p > .05$).

Therefore, all toothpastes in this study were within the ISO recommended values. After analysis of the PCR and abrasivity with Tukey's test, the toothpastes could be assigned into 4 groups as shown in parentheses (Tables 2-4).

The correlation coefficients between dentin surface area loss and enamel surface area loss, dentin surface area loss and cleaning ratio, and enamel surface area loss and cleaning ratio were 0.792, 0.664, and 0.776, respectively (Table 5). The results show that these parameters were significantly correlated.

Table 3 *Dentin surface area loss of test toothpaste in comparison with the ADA reference material*

Product name	Mean±SEM (μm^2)	Fold of ADA
Fluocaril (Original)	423.43±52.35	0.40
Darlie (Natural Mint Double Action)	533.37±55.52	0.51
Reference material (ADA)	1,055.06±92.40	-
Systema (Deep Impact)	1,059.35±101.51	1.00
Kolbadent	1,088.84±76.77	1.03
Parodontax (Mint Gel)	1,109.11±67.77	1.05
Oral-B (Tooth and Gum Care)	1,376.48±95.96	1.30
Oralmed (Whitening Fresh Gel)	1,495.14±125.25	1.42
Twin Lotus	1,512.03±137.37	1.43
Close up (Menthol Chill)	1,710.51±136.50	1.62
Colgate (Advanced Whitening)	1,830.25±229.01	1.73
Herbric	1,940.53±197.21	1.84

The data were analyzed using Tukey's test. Values within brackets do not significantly differ ($p > .05$).

Table 4 *Enamel surface area loss of test toothpaste in comparison with the ADA reference material*

Product name	Mean±SEM (μm^2)	Fold of ADA
Fluocaril (Original)	15.39±1.49	0.69
Kolbadent	17.48±0.61	0.79
Darlie (Natural Mint Double Action)	18.40±1.80	0.83
Twin Lotus	20.50±1.44	0.92
Reference material (ADA)	22.24±1.49	-
Systema (Deep Impact)	24.46±2.37	1.10
Parodontax (Mint Gel)	26.33±3.25	1.18
Close up (Menthol Chill)	34.35±3.23	1.54
Oral-B (Tooth and Gum Care)	35.49±4.15	1.60
Oralmed (Whitening Fresh Gel)	37.07±3.76	1.67
Herbric	54.32±4.47	2.44
Colgate (Advanced Whitening)	66.15±4.36	2.97

The data were analyzed using Tukey's test. Values within brackets do not significantly differ ($p > .05$).

Table 5 *Correlations of dentin surface area loss (DSAL), enamel surface area loss (ESAL) and cleaning ratio (n = 11, 2-tailed)*

	DSAL	ESAL	Cleaning Ratio
DSAL	1.000	-	-
ESAL	.792*	1.000	-
Cleaning Ratio	.664*	.776*	1.000

*$p < .05$

Discussion

Ideally, a toothpaste should provide maximum cleaning and polishing with minimum abrasion to enamel and dentin.[9] In our study, the cleaning ability of all tested products was higher than the ADA reference material. Three brands, Fluocaril (Original), Darlie (Natural Mint Double Action), and Twin Lotus (Original), which were tested in a previous study, [3] had higher PCR values in the current study. This may suggest that the present formula of these toothpastes may have been changed in the interim. Colgate (Advanced Whitening) may have generated the highest PCR value due to its composition of 5.5% silicon dioxide and 20% high cleaning silicon dioxide, which is superior in cleaning efficacy compared with other abrasives. [4] Moreover, on its label, Colgate (Advanced Whitening) claims to be able to remove stains with micro-cleaning crystals which are reported to be more effective at stain removal than precipitated calcium carbonate (PCC) and dicalcium phosphate dihydrate (DCPD).[10] This new formula, Advanced Whitening, has abrasivity within the ISO recommended values while the previous formula, Colgate (Whitening), had exceeded the limit.[2] Fluocaril (Original) had the lowest cleaning ratio likely because its main ingredients are sodium monofluorophosphate and sodium fluoride which are non abrasive, with no other abrasive ingredients listed. Surprisingly, Herbric, which contains herb extracts, had quite high abrasivity on both dentin and enamel. This may be due to particulates from the herb extracts, or abrasives in the formulation which were not shown in the label. In addition, herb extracts when soluble in water may be acidic, which can affect the tooth surface causing surface roughness. The essential oils derived from herbs may be able to solublize tooth stains resulting in the high cleaning ability of Herbric. The essential oil content of Kolbadent may impart cleaning ability as well.

All the measured parameters in this study were significantly correlated and had values similar to the previous study, [3] except for the correlation between dentin and enamel abrasivity. This value was quite different, i.e. 0.19 in the previous study compared to 0.792 in the present study, the reasons for this difference are not clear. To put this study in clinical perspective, as abrasivity increased among the different toothpaste formulations, cleaning ability increased as well.

Conclusion

All tested toothpastes had similar or better cleaning ability than the ADA reference material with abrasivity values within the ISO recommended limit. Therefore, they were safe for use on teeth, and the choice for use would be up to the individual's personal preference.

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บทวิทยาการ
Original Article

การศึกษาความสามารถในการทำความสะอาดและการขัดสีของยาสีฟันในประเทศไทย

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บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาความสามารถในการทำความสะอาดและการขัดสีของยาสีฟันในตลาดของประเทศไทย โดยทำการศึกษายาสีฟันจำนวน 11 ยี่ห้อ คือ ฟลูโอคาริล (ออริจินัล) ดาร์ลี่ (เนทูรัลมิ้นท์ดับเบิ้ลแอ็คชั่น) ซิสเท็มมา (ดีพอิมแพ็ค) คอลบาเด้นท์ พาโรดอนแท็กซ์ (มิ้นเจล) ออรัล-บี (ทูธแอนกัมแคร์) ออรัลเมด (ไวเทนนิ่งเฟรชเจล) ดอกบัวคู่ (ออริจินัล) ใกล้ชิด (เมนทอลชิล) คอลเกต (แอดวานซ์ไวเทนนิ่ง) และเฮอร์บริค ประเมินความสามารถในการทำความสะอาด โดยวัดค่าความเข้มคราบสีที่ถูกสร้างขึ้นบนชิ้นฟันวัว (n = 16 ต่อยี่ห้อ) ก่อนและหลังแปรงฟันด้วยยาสีฟันที่ต้องการทดสอบ คำนวณค่าความสามารถในการทำความสะอาด (สัดส่วนการทำความสะอาด, พีซีอาร์) โดยเปรียบเทียบค่าความเข้มสีที่เปลี่ยนแปลงจากการแปรงด้วยยาสีฟันชนิดต่าง ๆ กับสารอ้างอิงของสมาคมทันตแพทย์แห่งสหรัฐอเมริกาซึ่งกำหนดให้มีค่าเป็น 100 ประเมินการขัดสีด้วยวิธีโพลไฟโลเมทรีโดยหาค่าพื้นที่ที่หายไปของเคลือบฟัน (n = 8 ต่อยี่ห้อ) และเนื้อฟันมนุษย์ (n = 8 ต่อยี่ห้อ) หลังจากแปรงด้วยยาสีฟันตัวอย่าง เปรียบเทียบค่าที่ได้กับค่าพื้นที่ที่หายไปเมื่อแปรงด้วยสารอ้างอิงสมาคมทันตแพทย์แห่งสหรัฐอเมริกา วิเคราะห์ข้อมูลด้วยสถิติความแปรปรวนแบบทางเดียวที่ระดับนัยสำคัญเท่ากับ .05 ผลการศึกษาพบว่า ค่าเฉลี่ยของพื้นที่เนื้อฟันที่หายไปอยู่ในช่วงตั้งแต่ 423.43±52.35 ตารางไมโครเมตร สำหรับยาสีฟันฟลูโอคารีล ถึง 1,940.52±197.21 ตารางไมโครเมตร สำหรับยาสีฟันเฮอร์บริค ซึ่งคิดเป็น 0.40 และ 1.84 เท่าของสารอ้างอิงสมาคมทันตแพทย์แห่งสหรัฐอเมริกาตามลำดับยาสีฟันฟลูโอคารีลมีค่าเฉลี่ยของพื้นที่เคลือบฟันที่หายไปต่ำที่สุด คือ 15.39±1.49 ตารางไมโครเมตร (0.69 เท่าของสารอ้างอิงสมาคมทันตแพทย์แห่งสหรัฐอเมริกา) และยาสีฟันคอล-เกตมีค่าสูงสุด คือ 66.15±4.36 ตารางไมโครเมตร (2.97 เท่าของสารอ้างอิงสมาคมทันตแพทย์แห่งสหรัฐอเมริกา)ค่าสัมประสิทธิ์สหสัมพันธ์ระหว่างความสามารถในการทำความสะอาดกับการขัดสีของเนื้อฟันและเคลือบฟันเป็น 0.664 และ 0.776 ตามลำดับ ค่าสัมประสิทธิ์สห-สัมพันธ์ระหว่างการขัดสีต่อเนื้อฟันกับการขัดสีต่อเคลือบฟันเป็น 0.792 จึงสรุปได้ว่ายาสีฟันที่ทดสอบทุกชนิดมีความสามารถในการทำความสะอาดใกล้เคียงหรือดีกว่าสารอ้างอิงสมาคมทันตแพทย์แห่งสหรัฐอเมริกาโดยมีค่าการขัดสีอยู่ในค่ากำหนดของ ISO และปลอดภัยต่อฟัน