In Vivo Study of Brushing Force Produced by Three Types of Toothbrush Filaments from Two Brands

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Abstract

Manual tooth brushing is a tool used for maintaining daily oral health. The purpose of this in vivo study was to investigate tooth brushing force produced by three types of filament from two brands of manual toothbrush. The study enrolled 36 healthy volunteers. Tooth brushing force was measured using a force transducer and a physiological recording system. All volunteers were instructed to brush using the modified Bass technique. Three filament types from Berman® and Oral-B® were assessed in this study. We found that the diameters of the filaments from Berman® medium, soft, and extra soft toothbrushes were 360.19±2.31, 277.04±2.16, and 142.89±18.42 µm, whereas those from Oral-B® were 312.22±3.82, 270.33±3.76, and 195.18±13.65 µm, respectively. The brushing force with Berman® medium toothbrush was significantly higher than that with the soft and extra soft toothbrushes, whereas the brushing force of Oral-B® medium toothbrush was higher than that of the extra soft toothbrush. Although Oral-B® soft toothbrush and Berman® soft toothbrush had similar filament diameter, the former required more brushing force. It was concluded that toothbrush filament types (diameter) could affect brushing force and should be considered when selecting suitable toothbrush for each oral condition.

Keywords: *Tooth-brushing force/ Toothbrush filament/ Oral health/ Toothbrush*

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Introduction

A manual toothbrush is the commonly used mechanical equipment for maintaining oral health. Currently marketed toothbrushes are available in several designs with several filament tips, filament diameters, and materials. For a low price, easy to find, and short-term use, several manufactures are competing to meet the demand from customers, especially the demand regarding the efficacy of toothbrushes. High brushing force results in tissue injury such as gingival abrasion and recession.[1] Several studies have suggested that the optimal tooth-brushing force should be below 240 grams.[2, 3] A force higher than 300 grams can induce gingival recession that manifests in necks of cervical margins.[3, 4] Under normal conditions, brushing force is not the primary factor considered while considering tissue injury. Other negative factors such as oral tissue inflammation or dentine sensitivity might contribute to the overall sensory perception.[5] Therefore, high-force manual tooth brushing contributes to tooth abrasion and eroded enamel and dentin, which activates mechanoreceptors and nociceptors.[6] The prolonged activation of mechanoreceptors and nociceptor after high-force brushing causes the efflux of dentinal fluid, leading to dentin hypersensitivity and dental pain.[2,7]

Understanding the concept of high-force brushing to nociception, it would be interesting to determine the brushing force that is produced by various filament diameters and brands of toothbrushes in healthy volunteers. The findings will benefit individuals who previously had a disease of the oral mucosa. Therefore, the purpose of this experiment was to investigate the brushing forces produced by six toothbrushes including medium, soft, and extra soft brushes of Berman® and Oral-B®

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trademarks available in Thailand markets. The filament diameter of all toothbrushes was examined.

Materials and methods

1. Ethical approval

The study protocol was approved by the Ethical Committee of the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University (MU-DT/PY-IRB 2013/039.1211).

2. Subjects

This study enrolled 36 right-handed dental students with a mean age of 25.5 years. All participants gave consent upon being informed about the purpose and detailed procedures of the study. The inclusion criteria were as follows: providing informed consent, good general health, age between 21 and 30 years, and habitual use of manual toothbrush using the modified Bass technique. Exclusion criteria were age <21 years or >30 years and those declining to participate.

3. Toothbrushes

Berman® (Berman Innovative Care company, Thailand) and Oral-B® (Oral B company, Vietnam) toothbrushes of three filament types were used (Figure 1A–1E): Berman® type Active Medium, Berman® type Active Soft, Berman type Complete Extrasoft, Oral-B® type All-rounder Medium, Oral-B® type All-rounder Soft, and Oral-B® type Micro Thin Extrasoft.

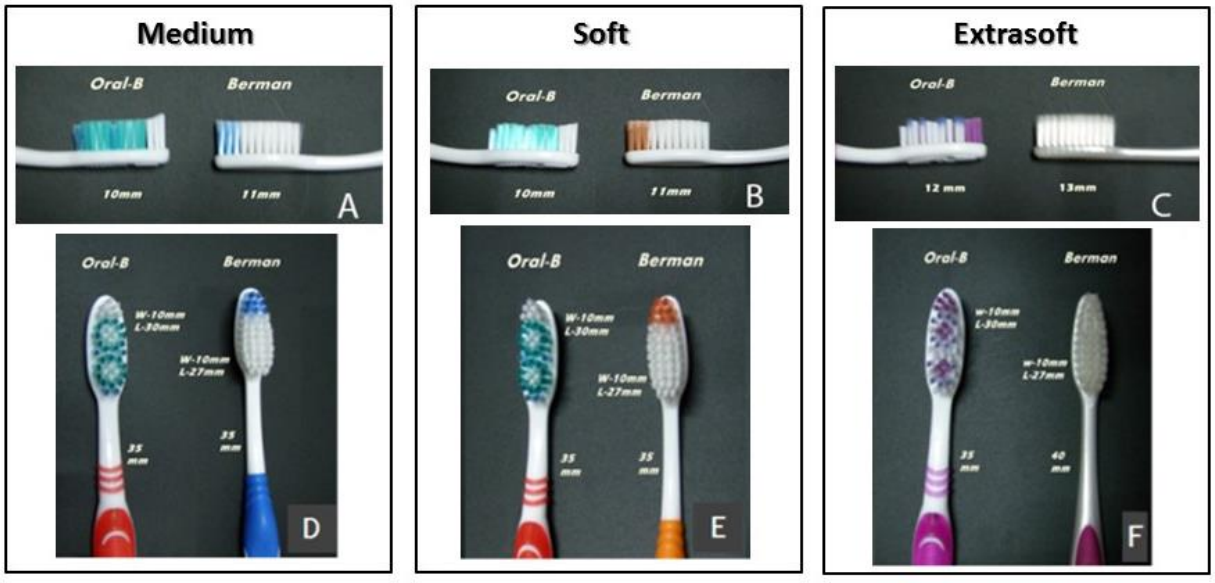

Figure 1 Berman® and Oral-B® toothbrushes with three filament types (medium, soft, and extra soft). A, B, and C show the lateral view and D, E, and F show the anterior view of toothbrushes

4. Test procedures

To compare the brushing force of the three types of Oral® and Oral-B® toothbrushes, each subject was required to brush using the modified Bass method. They were asked to randomly select one of the six toothbrushes at the first time. They were required to select another toothbrush the next day, for six consecutive days. The experiment was conducted for 30 min after lunch, and all volunteers were prohibited from cleaning their teeth before the experiment started. The dental arch was divided into 12 areas (Figure 3A). All volunteers brushed their teeth using the modified Bass brushing technique.

5. Assessment of brushing force

All toothbrushes were cut at 5 cm from their neck and were connected with a force transducer (MLT1030/D, BIOPAC® systems; Santa Barbara, CA, USA). The force transducer translated signal to a physiological recording system (MP100, Biopac®, USA). Calibration was performed directly before brushing by hanging standardized weights at the mid-point of the head of each individual toothbrush (range: 0–400 g). The Acqknowlege 3.9 software was used for data acquisition and transfer to Microsoft Excel. Mean brushing force was averaged for 12 areas of the dental arch during the 3-min brushing activity.

6. Filament diameter measurement

Filaments from all toothbrushes were examined using the Axio Observer (Carl Zeiss Microscopy GmbH, Germany). In the preparation phase, 8–10 filaments were randomly selected from the same areas of each toothbrush. Each filament was fixed in place before assessment using the Axio Observer and measurement using the AxioVision software (Carl Zeiss Microscopy GmbH, Germany). The filament diameter was measured at 1 mm below the tip.

7. Data analysis

Statistical Package for Social Science software (IBM SPSS 19.0; IBM Corporation, 1 New Orchard Rd, Armonk, New York 10504) was used for analyzing all data. Data on brushing force endured by different filament types and designs were analyzed using one-way analysis of variance followed by Dunnett's post hoc test for a significance level of $P<0.05$. Simple comparison between the two groups was performed using Student's t-test for independent samples. The level of significance was 0.05 in all statistical analyzes.

Results

Figure 1 shows differences in the filament and head design of Berman® and Oral-B® toothbrushes. Berman® toothbrushes had a standard head design, whereas Oral-B® toothbrushes had the all-rounder head design. The head, neck, and filament length of both toothbrushes were similar. Medium and soft filament had round-ended filament. Therefore, Oral-B® extra soft brushes had pointed, round-ended filament, whereas Berman® extra soft brushes had pointed, and cut-ended filament (Figure 2).

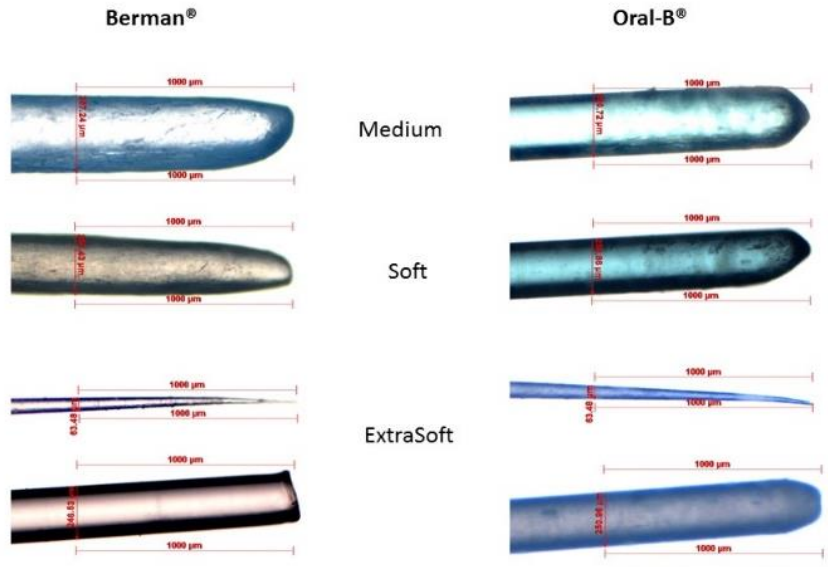

Figure 2 Ends of Berman® and Oral-B® toothbrush filament. All medium and soft filament types are round-ended. Berman® extra soft type has pointed together with cut-ended filaments. Oral-B® extra soft type has pointed together, with round-ended filaments.

The filament diameters of Berman® toothbrushes were 360.19±2.31, 277.04±2.16, and 142.89±18.42 µm, whereas that of Oral-B® toothbrushes were 312.22±3.82, 270.33±3.76, and 195.1±13.65 µm, respectively (Table 1).

Table 1 Diameter of each filament type of Berman® and Oral-B® toothbrushes

	Berman® (µm)	Oral-B® (µm)
Medium (n = 5)	360.19 ± 2.31	312.22 ± 3.82
Soft (n = 5)	277.04 ± 2.16	270.33 ± 3.76
Extrasoft (n = 5)	142.89 ± 18.42	195.18 ± 13.65

Values are expressed as mean ± standard error of mean of five samples of each toothbrush.

The brushing force endured by Berman® medium was significantly higher than that endured by soft and extra soft [$F(2,105) = 4.547$, $P<0.05$]. The Oral-B® medium toothbrush endured higher brushing force than extra soft [$F(2,105)=5.448$, $P<0.05$]. When the same filament type was compared, Oral-B® toothbrushes endured more brushing force than Berman® toothbrushes ($P<0.001$) (Figure 4).

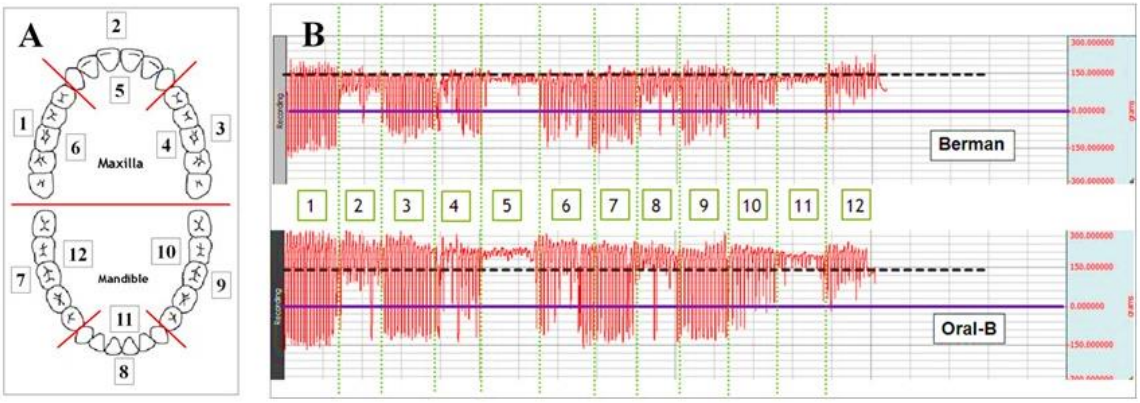

Figure 3 (A) The brushing pattern used in this experiment. Participants brushed for 180 s, allocating 15 s of brushing time each for all 12 areas. (B) Graphical results of brushing forces. Each toothbrush was taped to a force transducer (MLT1030/D, BIOPAC® systems, Santa Barbara, CA, USA) 5 cm below the head of toothbrush. It transferred the brushing force to a physiological recording system (MP100, Biopac®, USA).

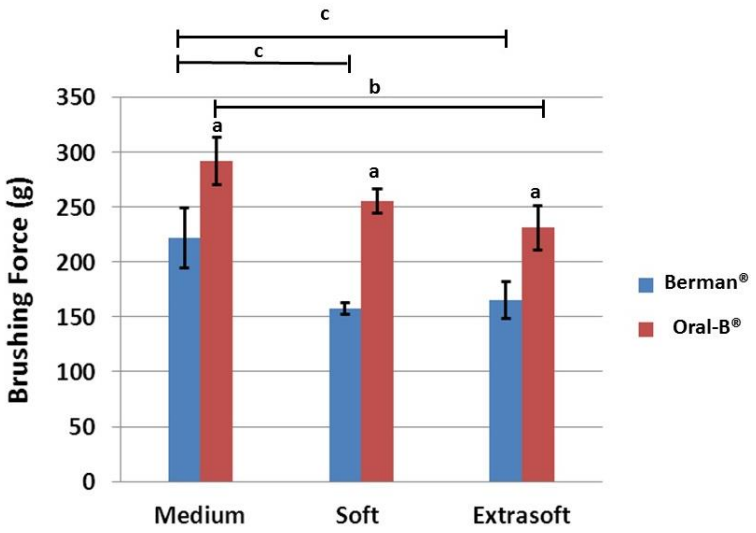

Figure 4 Brushing force of Berman® and Oral-B® toothbrushes of three filament types. Values are expressed as mean±standard error of mean of 36 volunteers. [a]$P<0.01$ compared with the same filament type, [b,c] $P<0.05$ compared with the same brand

Discussion

The study by Van der Weijden et al. revealed no gingival recession when using a manual brushing force of 212 g; however, a brushing force of over 375 g resulted in gingival recession around the neck of cervical margins.[8] Ganss et al. also evaluated the brushing force in 103 participants and similarly found that the mean brushing force was 234.5±71.4 g, which did not cause gingival recession.[2] In our experiment, the maximum force was observed with the use of Oral-B® medium toothbrush. The mean force using these brushes was 291.76±21.76 g, which is below the force that causes gingival recession. The brushing force using Oral-B® toothbrushes was higher than that using Berman®, approximately 80–100 g. All volunteers reported that Oral-B® toothbrushes provided more flexibility and softer filament touch compared with Berman® toothbrushes, encouraging subjects to brush with higher force. On the other hand, all volunteers complained about gingival irritation while using extra soft toothbrush. Low brushing forces seen with the extra soft filament in the present study could therefore be the result of nociceptive reflex. Alexander et al. reported that sharp-ended filament caused more gingiva irritation than round-ended filament.[9] In addition, Breitenmoser et al. found that cut-ended filament induced 30% more gingival lesions than round-ended filament.[4] and, ADA recommends toothbrushes with soft, round-ended filament as it causes the least gingiva irritation.[10]

Although tooth brushing force, which is mechanical stimuli, might also activate mechanosensitive receptors (transient receptor potential channel) in the dentinal tubules,[11] leading to adverse effects such as dentin hypersensitivity, tooth surface loss, and traumatic in the periodontium tissue, this is unlikely since most of the times, the tooth is covered with enamel and none of the subjects in this study complained of dentine hypersensitivity. There might be two different mechanisms that are related to the findings of the study. The overall higher force in Oral-B® (in which subjects reported a softer feel) could be explained by less irritation to the gum and hence less protective reflex whereas the lower force with soft filaments compared to hard filaments is probably explained by "von Frey Hair" effect (i.e. the amount of applied force is directly related to the stiffness of the filament). The former mechanism occurs when the filaments mainly stimulate the gum or oral mucosa but the latter mechanism occurs during filament-tooth contact.

Conclusion

This study assessed the tooth-brushing force of toothbrushes manufactured by two brands, Berman® and Oral-B®, and three filament types (medium, soft, and extra soft) by enrolling 36 healthy volunteers who brushed their teeth using the modified Bass technique. The mean brushing force was higher with medium than with soft and extra soft filament. Oral-B® toothbrushes tended to result in higher force than Berman® toothbrushes. However, the effect of toothbrush head has not comprehensively investigated in this study. Our results provide basic information for choosing appropriate toothbrushes in dental patients whose brushing force needs to be reduced.

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การศึกษาในร่างกายของแรงแปรงฟันระหว่างขนแปรงสามชนิดจากแปรงสองยี่ห้อ

ณัฐพล โรจน์เพ็ญเพียร* อารี วนสุนทรวงศ์**

บทคัดย่อ

การแปรงฟันเป็นวิธีที่ได้รับการยอมรับสำหรับการดูแลสุขภาพช่องปากในแต่ละวัน วัตถุประสงค์ของการศึกษานี้คือเพื่อศึกษาแรงแปรงฟันในร่างกายที่เกิดจากขนแปรงสามขนาดเส้นผ่านศูนย์กลางจากแปรงสีฟันธรรมดาสองชนิดในตลาด โดยทำการศึกษาในอาสาสมัครที่มีสุขภาพช่องปากดีจำนวน 36 คน วัดแรงแปรงฟันโดยใช้ตัวแปลงสัญญาณแรงและระบบบันทึกทางสรีรวิทยา อาสาสมัครทุกคนได้รับคำแนะนำให้แปรงด้วยเทคนิคมอดิฟายด์ แบส ผลการวิจัยพบว่าเส้นผ่านศูนย์กลางของเบอร์แมนชนิดขนแข็งปานกลาง นุ่มและนุ่มพิเศษเท่ากับ 360.19±2.31, 277.04±2.16 และ 142.89±18.42 ไมโครเมตร ส่วนออรัลบีมีเส้นผ่านศูนย์กลาง เท่ากับ 312.22±3.82, 270.33±3.76 และ 195.18±13.65 ไมโครเมตรตามลำดับ แรงแปรงฟันของแปรงสีฟันของเบอร์แมนชนิดขนแข็งปานกลางสูงกว่าแบบขนนุ่มและขนนุ่มพิเศษมากอย่างมีนัยสำคัญทางสถิติ ในขณะที่แรงแปรงฟันของขนแปรงออรัลบีชนิดปานกลางมากกว่าขนแปรงชนิดนุ่มพิเศษ แม้ว่าขนแปรงชนิดนุ่มของออรัลบี และเบอร์แมนจะมีเส้นผ่านศูนย์กลางใกล้เคียงกัน แต่พบว่าออรัลบีชนิดขนนุ่ม มีแรงแปรงมากกว่าเบอร์แมนชนิดขนนุ่ม สรุปได้ว่าชนิด (ขนาด) ของขนแปรงมีผลต่อแรงแปรงฟันและควรเป็นข้อพิจารณาส่วนหนึ่งในการเลือกแปรงสีฟันที่เหมาะสมกับของช่องปากแต่ละบุคคล

คำไขรหัส: *แรงแปรงฟัน/ ขนแปรงสีฟัน/ แปรงสีฟัน/ สุขภาพช่องปาก*

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