บทวิทยาการ
Original Article

การเปรียบเทียบระดับคอนดรอยตินซัลเฟต และระดับความเจ็บปวด ในระยะการปรับตำแหน่งฟันเริ่มต้นทางทันตกรรมจัดฟันที่ใช้ระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรงและแบร็กเกตแบบธรรมดา

พิรุณ เหลืองโรจนกุล* พลภัทร์ ตรีภูวพฤทธิ์* ปรัชญา คงทวีเลิศ ศิริวรรณ องค์ไชย** ธีระวัฒน์ โชติกเสถียร***

บทคัดย่อ

วัตถุประสงค์: เพื่อเปรียบเทียบระดับคอนดรอยตินซัลเฟตในน้ำเหลืองร่องเหงือกและระดับความเจ็บปวด (ระหว่างช่วงก่อนให้แรง กับช่วงให้แรง) ในระยะการปรับตำแหน่งฟันเริ่มต้นทางทันตกรรมจัดฟันที่ใช้ระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรงและแบร็กเกตแบบธรรมดา

วัสดุอุปกรณ์และวิธีการ: กลุ่มตัวอย่างเป็นผู้ป่วยทางทันตกรรมจัดฟันที่ไม่จำเป็นต้องมีการถอนฟันร่วมด้วย จำนวน 13 ราย (เพศชาย 3 ราย เพศหญิง 10 ราย อายุ 19.28 ± 2.28 ปี) ยึดติดแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง (Damon®3MX) (กลุ่มทดลอง) และแบร็กเกตแบบธรรมดา (Mini diamond®) ที่มัดด้วยยางมัดอิลาสโตเมอริกที่ผิวฟันของฟันบนด้านซ้ายหรือด้านขวาจำนวนข้างละ 7 ซี่ โดยการสุ่มใช้ลวดคอปเปอร์นิเกิลไทเทเนี่ยม ขนาดเส้นผ่าศูนย์กลาง 0.014 นิ้ว สำหรับระยะการปรับตำแหน่งฟันเริ่มต้นทางทันตกรรมจัดฟัน เก็บตัวอย่างน้ำเหลืองร่องเหงือกรอบฟันเขี้ยวบน และฟันกรามน้อยซี่ที่หนึ่งบนขวาและซ้ายโดยใช้แถบกระดาษ PERIOPAPER™ ในช่วงก่อนให้แรง (เป็นข้อมูลพื้นฐาน) และช่วงระหว่างให้แรง (ในวันที่ 1, 3, 5, 7, 14, 21 และ 28 เป็นข้อมูลทดลอง) วัดระดับคอนดรอยตินซัลเฟตในน้ำเหลืองร่องเหงือกโดยใช้วิธีคอมเพททิทีพอิไลซ่า ร่วมกับ WF6 แอนติบอดี และเปรียบเทียบระดับระหว่างระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง กับระบบแบร็กเกตธรรมดา โดยใช้สถิติแมนวิทนีย์ (Mann-Whitney U-test) เปรียบเทียบระดับคอนดรอยตินซัลเฟตในน้ำเหลืองร่องเหงือก ระหว่างช่วงก่อนให้แรงกับช่วงให้แรง โดยใช้ระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง หรือระบบแบร็กเกตธรรมดา อย่างใดอย่างหนึ่ง โดยใช้สถิติวิลคอกสันซายแลง (Wilcoxan signed-rank test) ใช้คะแนนวีเอเอสเพื่อประเมินระดับความเจ็บปวดของผู้ป่วย และเปรียบเทียบระดับระหว่างระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรงกับระบบแบร็กเกตธรรมดา โดยใช้สถิติแมนวิทนีย์ (Mann-Whitney U-test)

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Corresponding author at: Dhirawat Jotikasthira, Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Suthep Road, Muang, Chiang Mai 50200, Thailand; Fax:+66 53222844;
E-mail address: dhirawat.j@gmail.com

* ภาควิชาทันตกรรมจัดฟันและทันตกรรมสำหรับเด็ก มหาวิทยาลัยเชียงใหม่
** ภาควิชาชีวเคมีและศูนย์ความเป็นเลิศสำหรับนวัตกรรมทางชีวเคมีศูนย์ความเป็นเลิศทางด้านวิศวกรรมเนื้อเยื่อและเซลล์ต้นกำเนิด มหาวิทยาลัยเชียงใหม่
* Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Chiang Mai, Thailand
** Department of Biochemistry and Center of Excellence for innovation in Chemistry, Thailand Excellence Center for Tissue Engineering and Stem Cells, Chiang Mai University, Chiang Mai, Thailand

ผลการศึกษา: สำหรับฟันเขี้ยว (ยึดติดด้วยแบร็กเกตแบบธรรมดา) ค่ามัธยฐานของระดับคอนดรอยตินซัลเฟตระหว่างให้แรงมีค่ามากกว่าช่วงก่อนให้แรง (ข้อมูลพื้นฐาน) อย่างมีนัยสำคัญทางสถิติ สำหรับฟันเขี้ยว (ยึดติดด้วยแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง) ค่ามัธยฐานของระดับคอนดรอยตินซัลเฟตระหว่างให้แรงมีค่ามากกว่าช่วงก่อนให้แรง (ข้อมูลพื้นฐาน) อย่างไม่มีนัยสำคัญทางสถิติ สำหรับฟันกรามน้อยซี่ที่หนึ่ง (ไม่ว่ายึดติดด้วยแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง หรือด้วยแบร็กเกตแบบธรรมดา) ค่ามัธยฐานของระดับคอนดรอยตินซัลเฟตช่วงระหว่างให้แรงมีค่ามากกว่าช่วงก่อนให้แรง (ข้อมูลพื้นฐาน) อย่างไม่มีนัยสำคัญทางสถิติ สำหรับทั้งฟันเขี้ยวและฟันกรามน้อยซี่ที่หนึ่ง (ทั้งที่ยึดติดด้วยแบร็กเกตชนิดมัดในตัวแบบไม่มีแรงและด้วยแบร็กเกตแบบธรรมดา) ค่ามัธยฐานของระดับคอนดรอยตินซัลเฟตมีค่าไม่แตกต่างอย่างมีนัยสำคัญทางสถิติทั้งช่วงก่อนให้แรง (ข้อมูลพื้นฐาน) และช่วงระหว่างให้แรง ยกเว้นกรามน้อยซี่ที่หนึ่ง ระหว่างให้แรงในวันที่ 7 สำหรับทั้งฟันเขี้ยวและฟันกรามน้อยซี่ที่หนึ่ง ความเจ็บปวดและความไม่สบายระหว่างการเคลื่อนฟันของผู้ป่วยซึ่งได้รับแรงทางทันตกรรมจัดฟันด้วยระบบแบร็กเกตแบบดั้งเดิมมีค่าสูงกว่าระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง แต่ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($P>0.05$) โดยมีความเจ็บปวดเพิ่มสูงขึ้นหนึ่งวันหลังการให้แรงทางทันตกรรมจัดฟันหลังจากนั้นความเจ็บปวดลดลง

สรุป: ระหว่างระยะการปรับตำแหน่งฟันเริ่มต้นทางทันตกรรมจัดฟัน ทั้งระบบที่ยึดติดด้วยแบร็กเกตชนิดมัดในตัวแบบไม่มีแรงและด้วยแบร็กเกตแบบธรรมดา ทำให้เกิดการเปลี่ยนรูปของกระดูกเบ้าฟันเหมือนกัน ซึ่งประเมินได้จากการเพิ่มขึ้นที่เหมือนกันของระดับคอนดรอยตินซัลเฟตในน้ำเหลืองร่องเหงือกรอบฟัน แต่การเคลื่อนฟันด้วยระบบแบร็กเกตชนิดมัดในตัวแบบไม่มีแรง มีระดับความเจ็บปวด และระดับความไม่สบายระหว่างการเคลื่อนฟันของผู้ป่วยที่น้อยกว่า

การลงทะเบียนการทดลอง: การศึกษานี้ลงทะเบียนหมายเลข TCTR20180119002

คำสำคัญ: ระบบแบร็กเกตชนิดมัดในตัว การประเมินทางชีวเคมี การปรับตำแหน่งฟันทางทันตกรรมจัดฟัน

Comparisons of the Chondroitin Sulphate Levels and the Amount of Pain during Initial Orthodontic Leveling Phase between Passive Self-ligating and Conventional Bracket Systems[8]

Pirun Luengrojjanakul* Polbhat Tripuwabhrut* Prachya Kongtewelert** Siriwan Ongchai** Dhirawat Jotikasthira*

Abstract

Purpose: To compare chondroitin sulphate (CS) levels in gingival crevicular fluid (GCF) and the amount of pain (between before loading and the loaded periods) during initial orthodontic leveling phase between passive self-ligating and conventional bracket systems.

Materials and methods*:* Thirteen patients (3 males and 10 females; aged 19.28 ± 2.28 years) who required non-extraction orthodontic treatment were recruited. Passive self-ligating (Damon®3MX) (as experimental) and conventional brackets (Mini diamond®) tied with elastomeric ligature (as control) (0.022 x 0.028 inch bracket slots) were randomly assigned and bonded to either right or left maxillary seven-tooth segment (using a split mouth technique). Orthodontic leveling was carried out using 0.014 inch diameter Copper Nickel Titanium wire. GCF samples around the left and right maxillary canines and first premolars were collected using PERIOPAPER™ strips before loading (as baseline data) and during the loaded periods (on days 1, 3, 5, 7, 14, 21 and 28 as experimental data). The CS levels in GCF were measured by competitive ELISA with WF6 monoclonal antibody, and were compared between the passive self-ligating and the conventional bracket systems during orthodontic leveling by the Mann-Whitney U-test. The differences in the CS levels in GCF between before loading and during the loaded period using either the passive self-ligating or the conventional bracket system were analyzed using the Wilcoxon signed-rank test. VAS scores were used to evaluate the patients' discomfort every visit between passive self-ligating and conventional bracket systems during orthodontic leveling. The differences in VAS scores during each experimental period were determined by the Mann-Whitney U-test.

Results: For the canines during the loaded periods bonded with the conventional bracket system, the medians of CS levels during the loaded period were significantly higher than those at baseline. For the canines bonded with the passive self-ligating bracket system and the first premolars (bonded using either the self-ligating or the conventional bracket system) during the loaded period, the medians of CS levels were insignificantly higher than those at baseline. For both the canines and the premolars (bonded with either the passive self-ligating or the conventional bracket system), the medians of CS levels during the loaded period were not significantly different. The median of the VAS scores for patients' discomfort with conventional bracket were insignificantly greater than that with passive self-ligating bracket.

Conclusion: During initial orthodontic leveling phase, both the passive self-ligating and the conventional bracket systems caused similar alveolar bone remodeling as revealed by similarly raised CS levels in GCF. However, the passive self-ligating bracket system might cause less pain and better comfort, though insignificantly, than did the conventional bracket system.

Trial Registration: The study has been registered as TCTR20180119002.

Keywords: Self-ligating bracket; Biochemical assessment; Orthodontic leveling

Introduction

It was claimed that passive self-ligating bracket system required low force magnitude to create tooth movement, because there was less friction resistance to the wire, but some studies reported non-significant difference.[1,2] The performance of the self-ligating bracket system was similar to that of conventional system during the alignment stage[3] or in passive extraction-space closure.[4] The time to reach proper alignment did not differ between the two systems.[5] In contrast, it was concluded that self-ligating bracket systems could align teeth faster than conventional bracket systems in most cases.[6]

In respect of patient's discomfort, patients treated with conventional bracket system showed higher levels and longer duration of pain than those treated with self-ligating bracket system.[7] Moreover, patients treated with conventional bracket system often showed continuous pain, but patients treated with self-ligating bracket system showed pain only during chewing or biting.[8] It was also reported that the levels of 'substance P', an inflammatory mediator involving in periodontal ligament inflammation and pain development during orthodontic tooth movement, were significantly lower with the Damon® self-ligating bracket system in comparison with the conventional bracket system.[9]

Role for chondroitin sulphate (CS) levels in gingival crevicular fluid (GCF) as a biomarker for alveolar bone remodeling during orthodontic canine movement was suggested by our previous study.[10] CS comprises approximately 94 percent of the total glycosaminoglycans in alveolar bone. This fact suggests that alveolar bone is a major source of CS in GCF. Therefore, early changes in alveolar bone might be reflected by altered levels of CS in GCF, and this cannot be clinically observed.[11-14]

In our present study, we applied our patented monoclonal antibody, namely WF6, which recognized an epitope of native CS chains of embryonic shark cartilage proteoglycans.[15] This antibody has been used to monitor the changes of CS levels in GCF samples from patients during orthodontic treatment.[10,16-18] The aim of our investigation was to compare chondroitin sulphate (CS) levels in gingival crevicular fluid (GCF) and the amount of pain, before loading and the loaded periods, during initial orthodontic leveling phase between self-ligating and conventional bracket systems.

Materials and methods

Subjects

Thirteen healthy adults (3 males and 10 females; aged 19.28 ± 2.28 years, ranged from 14.08 to 22.42 years) who had mild to moderate crowding and required non-extraction orthodontic treatment were recruited in this study (Table 1). The inclusion criteria: 1. Similar minimal crowding on each side of the maxillary arch; 2. No evidence of periodontal or gingival problems with generalized probing depths < 3.0 mm and no radiographic evidence of periodontal bone loss; 3. Lack of antibiotic therapy during previous six months; 4. Absence of oral anti-inflammatory drug administration preceding the study; and 5. No pregnancy (women). All patients received repeated oral hygiene instruction. This study was approved by the Human Experimentation Committee of the Faculty of Dentistry, Chiang Mai University. Informed consent was obtained from all subjects.

Table 1 Age (years) distributed by gender and number of the subjects (n) in the present study

Gender	n	Age (years)			
		Min	Max	Mean	Std. deviation
Female	10	14.08	20.67	18.82	2.07
Male	3	17.67	22.42	20.81	2.72
Total	13	14.08	22.42	19.28	2.28

Experimental design

Passive self-ligating (Damon®3MX) (as experimental) and conventional brackets (Mini diamond®) tied with elastomeric ligature (as control) (0.022 x 0.028 inch bracket slots) were randomly assigned and bonded to either right or left maxillary seven-tooth segment (from central incisor to second molar) (using a split mouth technique). Leveling was carried out using a 0.014 inch Copper Nickel-Titanium wire.

GCF samples were collected before loading (as baseline data) and during the loaded period (on days 1, 3, 5, 7, 14, 21 and 28 as experimental data). The experimental teeth were gently washed, gently air-dried and then isolated by cotton roll. GCF samples were collected by PERIOPAPER™ strips (Oraflow Inc., Smithtown, NY, USA) which were placed into the mesiobuccal gingival sulcus of both left and right maxillary canines and first premolars for 30 seconds. Care was taken to avoid mechanical injury to the periodontal tissue. Strips contaminated with blood or exudates were discarded. Immediately after collection, two millimeters of the wetted area of the strips were cut and transferred to microcentrifuge tubes. All strips were stored at -80°C until further processing.

Competitive ELISA with WF6 monoclonal antibody

Microtiter plates (Maxisorp®, Nunc, Roskilde, Denmark) were coated overnight at room temperature with 10 µg/ml shark PG-A1 fraction (100 µl/well) in a coating buffer (20 mM sodium carbonate buffer, pH 9.6). The following morning, the plates were washed three times with PBS-tween 150 µl/well and dried.

Bovine serum albumin (BSA) 1% (w/v) 150 μl/well was added to all plates in the incubating buffer for 60 minutes at 37°C to block non-specific adsorption of other proteins to the plate. After washing, 100 μl/well of the mixture, sample or standard competitor (Shark PG-AlDl fraction: range 39.06–10,000 ng/ml) in mAb WF6 (1:100), were added. After incubation for 60 minutes at 37°C, plates were washed and then the IgM-specific peroxidase conjugated anti-mouse immunoglobulin (100 μl/well; 1:2000) was added and incubated for 60 minutes at 37°C. Then, the plates were washed again. After that, the peroxidase substrate (100 μl/well) was added and incubated at 37°C for 20 minutes to allow the color to develop. The reactions were stopped by the addition of 50 μl/well of 4M H_2SO_4. Eventually, the absorbance ratio at 492:690 nm was measured using a Titertek Multiskan® MCC/340 multiplate reader (ICN/Flow Laboratories, Costa Mesa, California, USA). Pertaining to the blinding of the outcome assessment to obliterate bias, the sample identification code was given, and confidentially kept until all data had been analyzed.

Protein assay

Total protein concentration was determined by using the Bio-Rad protein assay, based on the Bradford dye-binding procedure. It was a simple colorimetric assay for measuring total protein concentration. The Bio-Rad protein assay was based on the color change of Coomassie Brilliant Blue G-250 dye in response to various concentrations of protein. The dye bound to primarily basic (especially arginine) and aromatic amino acid residues. Bovine serum albumin (BSA) standards (0-1,000 μl/well) and samples were added to the microtiter plates (10 μl/well) in triplicate. Dye Reagent Concentration and deionized distilled water were mixed together (1:4) and added to each well (200μl/well). The plates were incubated at room temperature for 5 minutes and the absorbance was measured at 620 nm. Protein concentrations were determined from a standard curve.

Evaluation of the amount of pain

The visual analog scale (VAS) scores were used to evaluate the patients' discomfort or sensation of pain every visit during aligning and leveling (Fig 1). The linear scale properties range from 0 (Absence of pain) to 10 (Worst possible or unbearable pain). Patients chose a number from 0 to 10 that represented the amount of pain that they felt.

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences version 17 for Windows (SPSS Inc., Chicago, Illinois, USA). The distribution of CS levels was determined by the Kolmogorov-Smirnov test. The differences in the CS levels in GCF between before loading and during the loaded period using either the self-ligating or the conventional bracket system were analyzed using the Wilcoxon signed-rank test. The differences between the medians of CS (WF6 epitope) levels around maxillary canines and first premolars bonded with the conventional bracket system and those bonded with the self-ligating bracket system, before loading and the loaded periods were determined by the Mann-Whitney U-test. The differences in VAS scores between the self-ligating bracket system and the conventional bracket system

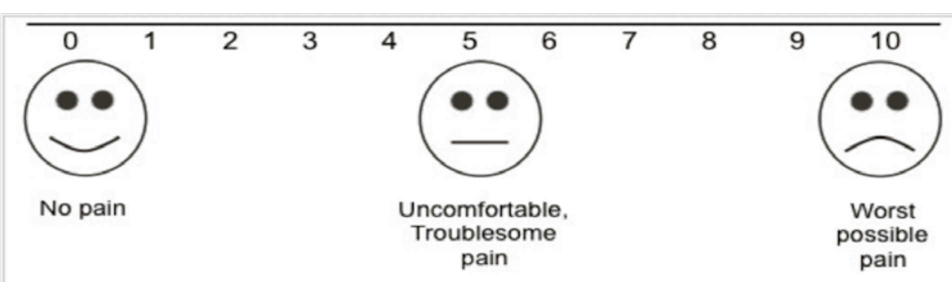


Fig. 1 Visual Analogue Scales (VAS)

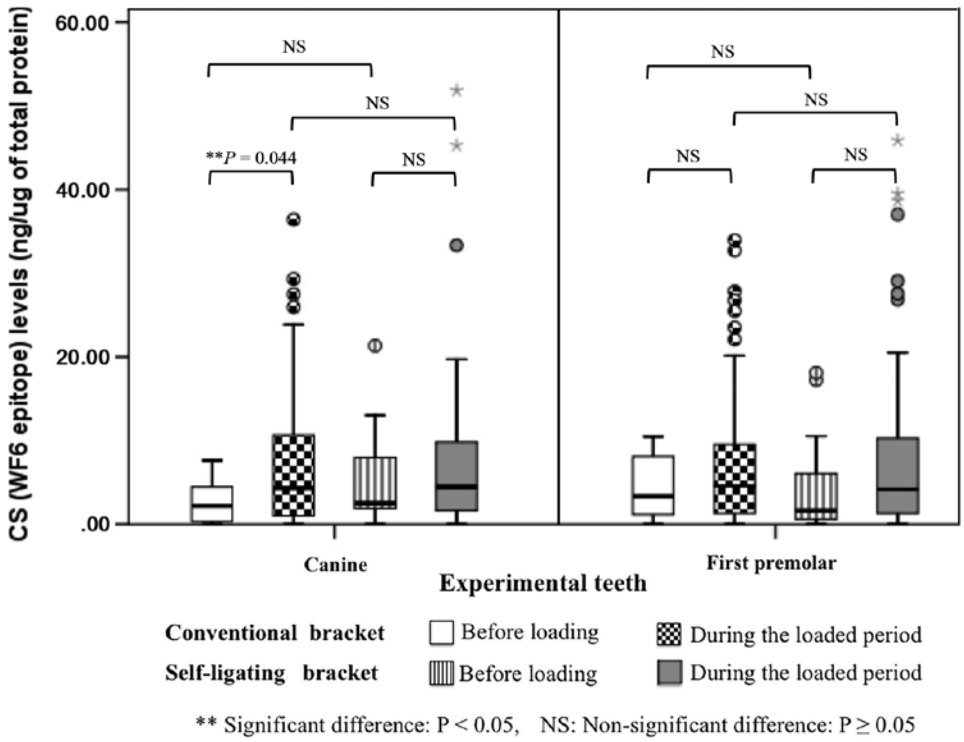


Fig. 2 Boxplot graphs of the medians of CS levels around the canines and the first premolars before loading (as baseline data) and during the loaded periods (as experimental data) bonded using either the conventional (as control) or the self-ligating (as experimental) bracket system

during each experimental period were determined by the Mann-Whitney U-test. The results were considered statistically significant at $P<0.05$.

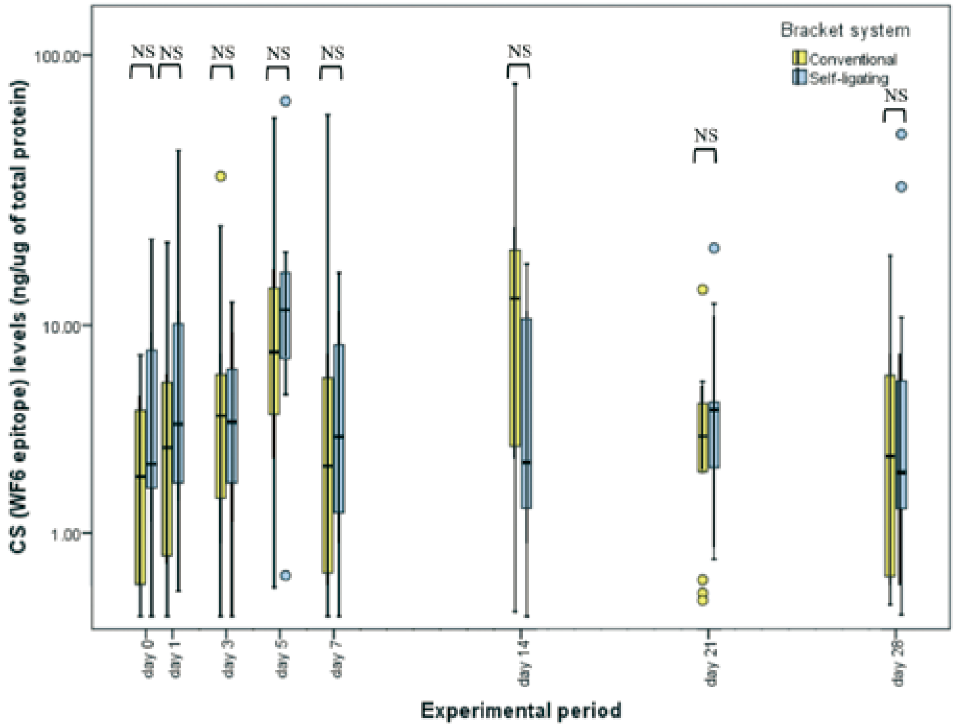
Results

All patients had good oral hygiene, and had no clinical sign of gingival and periodontal inflammation, especially on the experimental teeth, implying that patient oral hygiene was well controlled throughout the study.

CS levels in GCF around experimental teeth before loading and during the loaded period

For the canines bonded using either the conventional or the self-ligating bracket system, before loading, the medians of CS levels were 2.18 and 2.52 ng/μg of total protein, respectively, and were non-significantly different (P>0.05). During the loaded period, the medians of CS levels were 4.43 and 4.50 ng/μg of total protein, respectively, and were also non-significantly different (P>0.05). For the canines bonded using the conventional bracket system, during the loaded period, the median of CS levels was significantly higher than that before loading (P=0.044). For the canines bonded using the self-ligating bracket system, during the loaded period, the median of CS levels was non-significantly higher than that before loading (P>0.05) (Fig 2).

For the first premolars bonded using either the conventional or the self-ligating bracket system, before loading, the medians of CS levels were 3.77 and 1.62 ng/μg of total protein, respectively, and were non-significantly different (P>0.05). During the loaded period, the medians of CS levels were 4.61 and 4.18 ng/μg of total protein, respectively, and were also non-significantly different (P>0.05). For the first premolars bonded using the conventional bracket system, during the loaded period, the median of CS levels was non-significantly higher than that before loading (P>0.05). For the first premolars bonded using the self-ligating bracket system, during the loaded period, the median of CS levels was non-significantly higher than that before loading (P>0.05) (Fig 2).



** Significant difference: P < 0.05, NS: Non-significant difference: P ≥ 0.05

Fig. 3 Boxplot graphs of the medians of CS (WF6 epitope) levels around the canines bonded with the conventional bracket system and those bonded with the self-ligating bracket system, respectively, on day 0 (before loading as baseline data) and on days 1, 3, 5, 7, 14, 21, 28 (during the loaded period as experimental data)

The medians of CS (WF6 epitope) levels around the canines bonded with the conventional bracket and those bonded with the self-ligating bracket

The medians of CS (WF6 epitope) levels around the canines bonded with the conventional bracket and those bonded with the self-ligating bracket on day 0 (before loading as baseline data) and on days 1, 3, 5, 7, 14, 21, 28 (during the loaded period as experimental data) are shown in Fig 3.

The differences between the medians of CS (WF6 epitope) levels around the canines bonded with the conventional bracket and those bonded with the self-ligating bracket on day 0 and on days 1, 3, 5, 7, 14, 21, 28 were not significant (P>0.05).

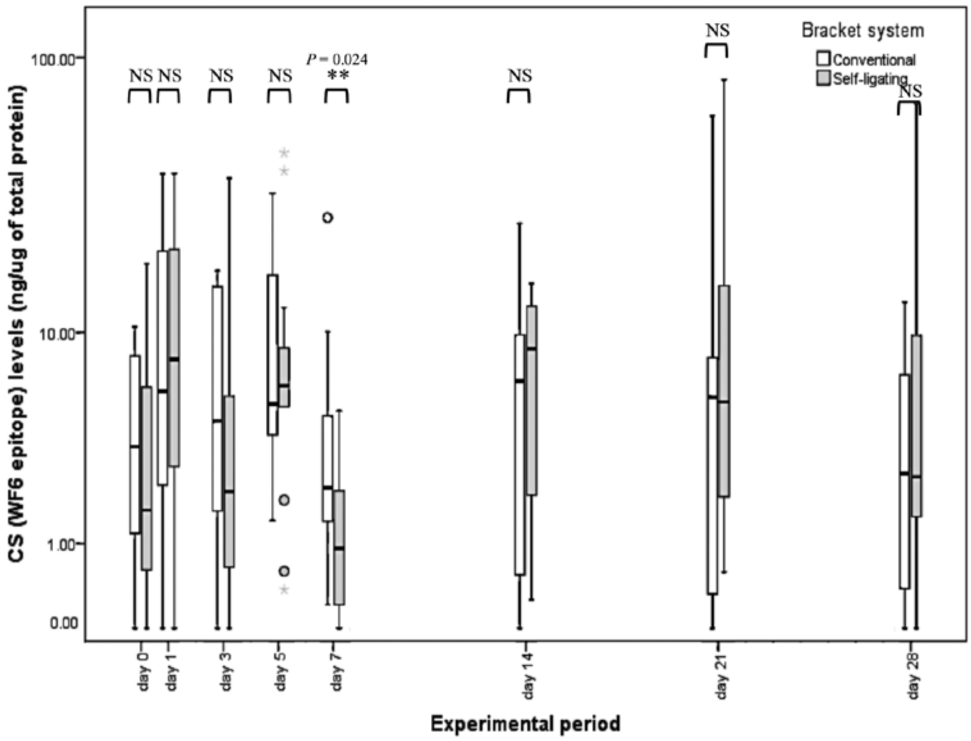
The medians of CS (WF6 epitope) levels around the first premolars bonded with the conventional bracket and those bonded with the self-ligating bracket

The medians of CS (WF6 epitope) levels around the first premolars bonded with the conventional bracket and those bonded with the self-ligating bracket on day 0 (before loading as baseline data) and on days 1, 3, 5, 7, 14, 21, 28 (during the loaded period as experimental data) are shown in Fig 4.

The differences between the medians of CS (WF6 epitope) levels around the first premolars bonded with the conventional bracket and those bonded with the self-ligating bracket on day 0 and on days 1, 3, 5, 14, 21, 28 were not significant (P>0.05). However, the differences between the medians of CS (WF6 epitope) levels around the first premolars bonded with the conventional bracket and those bonded with the self-ligating bracket on day 7 was significant (P=0.024).

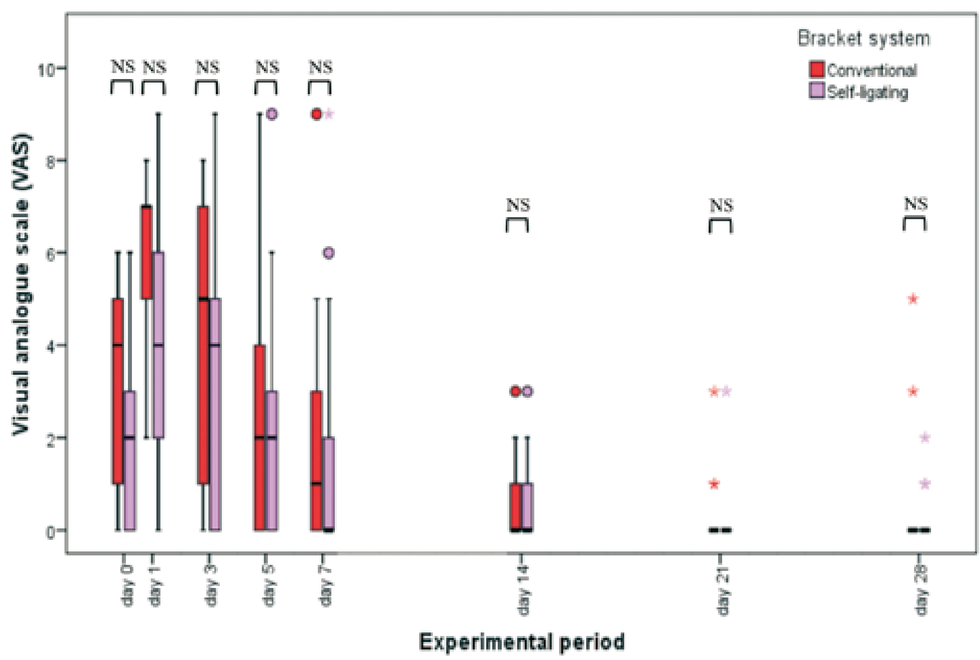
The visual analog scale scores

The VAS scores represented the patients' sensation of pain every visit. The VAS scores resulting from the conventional bracket (n = 13) and the self-ligating bracket (n = 13) are shown in Fig 5. With both bracket systems, the VAS scores had a peak one day after force application, then they gradually decreased.



** Significant difference: P < 0.05, NS: Non-significant difference: P ≥ 0.05

Fig. 4 Boxplot graphs of the medians of CS (WF6 epitope) levels around the first premolars bonded with the conventional bracket system and those bonded with the self-ligating bracket on day 0 (before loading as baseline data) and on days 1, 3, 5, 7, 14, 21, 28 (during the loaded period as experimental data)



** Significant difference: P < 0.05, NS: Non-significant difference: P ≥ 0.05

Fig. 5 Boxplot graphs of the medians of the VAS score induced with the conventional bracket and the self-ligating bracket systems

With conventional bracket, the medians of the VAS scores were non-significantly greater than those with self-ligating bracket at day 0 (immediately after loading) and on days 1, 3, 5, 7, 14, 21, 28 (during the loaded period).

Discussion

Self-ligating bracket system was claimed to provide advantages for both patients and orthodontists over conventional bracket system, and to cause decreased frictional resistance, reduced patient pain and discomfort, reduced chair time and overall treatment times, prolonged appointment intervals, improved oral hygiene and periodontal health, improved ergonomics, and conserved anchorage.[19-21]

Pertaining to the decreased frictional resistance, the difference between the conventional and the passive self-ligating bracket system could be better demonstrated if the bigger wire was used in association with the self-ligating brackets especially during orthodontic movement phase. Teeth subjected to orthodontic loading unavoidably resulted in biochemical changes, especially the CS levels in GCF, because very small changes in pressure or a minute force might be able to switch on tooth movement,[22] and could induce the biologic responses necessary for the induction of bone turnover. Accordingly, our present investigation could be implemented only in the initial orthodontic leveling phase.

Monitoring changes of CS levels in GCF is a non-invasive biochemical assessment for evaluating metabolic changes of deeper periodontal ligament and alveolar bone remodeling during orthodontic tooth movement.[11,23] Our present study also supported the fact that an increase of the CS levels in GCF was associated with the teeth undergoing orthodontic movement.[24] For osteoclasts' differentiation, it was reported that in monocyte-osteoclast cultures (mouse monocytic cells) first osteoclast appeared in culture on day 4-5 after plating, and that osteoclast numbers remained high for 2-3 days and then gradually decreased. In addition, in longer time of cells culture, they observed a second wave of osteoclast formation.[25] This study supported the fact that our results showed the peak of CS levels in GCF around the canines bonded with the conventional bracket and self-ligating bracket were detected on day 5 after initial force application and then gradually decreased. The CS levels of the premolars bonded with the conventional bracket and self-ligating bracket showed the peak levels of CS on day 1, 5 and 14 after initial force application and then gradually decreased. Insee and co-workers reported that the median CS (WF6 epitope) level was highest on day 7 after force application during maxillary canine distal movement, and then it gradually decreased.[10] This finding might be due to the different research design relating to the interval of sample collection between the study of Insee and co-workers[10] and ours. In our study, the GCF samples were collected more frequently (every other day in first week and then every week).

The differences between the medians of CS (WF6 epitope) levels around experimental maxillary canines and premolars bonded with the conventional bracket system and those bonded with the self-ligating bracket system, before loading and the loaded periods, were not significant. The explanation may be that both bracket systems have similar effect on the teeth undergoing orthodontic treatment, so the alveolar bone degradation activities were not different from each other.

VAS score was broadly used to evaluate the patients' discomfort or pain sensation in many research studies.[26-29] The results showed that the VAS scores for patients' discomfort or pain sensation under the conventional bracket system were non-significantly greater than those under the self-ligating bracket system. The results are supported by Yamaguchi and co-workers who stated that the self-ligating bracket system inhibited an increase in the substance P levels in the GCF.[9] Thus, the self-ligating bracket system may be useful to reduce the inflammation and pain resulting from orthodontic forces. The results from this study coincide with previous studies that reported the lesser pain intensity from tooth that bonded with the self-ligating bracket system in comparison with that bonded with the conventional bracket system.[3, 7, 21] Tecco and co-workers also concluded that patients bonded with the self-ligating bracket system showed lower levels and shorter duration of pain than those bonded with the conventional bracket system. A concern when interpreting the results of this study is the number of the patient. A sample size that is too small decreases the power of the study.

Conclusions

Collectively, during the initial orthodontic leveling phase, both the self-ligating and the conventional bracket systems caused similar alveolar bone remodeling as revealed by similarly raised CS levels in GCF. The self-ligating bracket system might cause less pain and better comfort than the conventional bracket system, though insignificantly.

Conflict of interest

The authors have no conflict of interest, with respect to authorship and/or publication of this article, to declare.

Ethical approval

The proposal of this study (No.9/2556) was approved by the Human Experimentation Committee, Faculty of Dentistry, Chiang Mai University, Thailand. Informed consent was obtained from all patients.

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References

1. Harradine N. Self-ligating brackets: where are we now? J Orthod. 2003;30:262-73.
2. Sims A, Waters N, Birnie D, Pethybridget R. A comparison of the forces required to produce tooth movement in vitro using two self-ligating brackets and a pre-adjusted bracket employing two types of ligation. Eur J Orthod. 1993;15:377-85.
3. Miles PG, Weyant RJ, Rustveld L. A clinical trial of Damon 2 versus conventional twin brackets during initial alignment. Angle Orthod. 2006;76(3):480-5.
4. Ong E, McCallum H, Griffin MP, Ho C. Efficiency of self-ligating vs conventionally ligated brackets during initial alignment. Am J Orthod Dentofacial Orthop. 2010;138(2):138 e1-7; discussion 38-9.
5. Pandis N, Polychronopoulou A, Katsaros C, Eliades T. Comparative assessment of conventional and self-ligating appliances on the effect of mandibular intermolar distance in adolescent non-extraction patients: a single-center randomized controlled trial. Am J Orthod Dentofacial Orthop. 2011;140(3):e99-e105.
6. Damon DH. The Damon low-friction bracket: a biologically compatible straight-wire system. J Clin Orthod. 1998;32(11):670-80.
7. Pringle AM, Petrie A, Cunningham SJ, McKnight M. Prospective randomized clinical trial to compare pain levels associated with 2 orthodontic fixed bracket systems. Am J Orthod Dentofacial Orthop. 2009;136(2):160-7.
8. Tecco S, D'Attilio M, Tete S, Festa F. Prevalence and type of pain during conventional and self-ligating orthodontic treatment. Eur J Orthod. 2009;31(4):380-4.
9. Yamaguchi M, Takizawa T, Nakajima R, Imamura R, Kasai K. The Damon system and release of substance P in gingival crevicular fluid during orthodontic tooth movement in adults. World J Orthod. 2009;10:141-6.
10. Insee K, Pothacharoen P, Kongtawelert P, Ongchai S, Jotikasthira D, Krisanaprakornkit S. Comparisons of the chondroitin sulphate levels in orthodontically moved canines and the clinical outcomes between two different force magnitudes. Eur J Orthod. 2014;36:39-46.
11. Last KS, Donkin C, Embery G. Glycosaminoglycans in human gingival crevicular fluid during orthodontic movement. Arch Oral Biol. 1988;33,907-12.

12. Samuels RH, Pender N, Last KS. The effects of orthodontic tooth movement on the glycosaminoglycan components of gingival crevicular fluid. J Clinic Periodontol. 1993;20: 371-7.
13. Pender N, Samuels RH, Last KS. The monitoring of orthodontic tooth movement over a 2-year period by analysis of gingival crevicular fluid. Eur J Orthod. 1994;16:511-20.
14. Waddington RJ, Embery G, Samuels RH. (1994) Characterization of proteoglycan metabolites in human gingival crevicular fluid during orthodontic tooth movement. Arch Oral Biol. 1994;39:361-8.
15. Pothacharoen P, Kalayanamitra K, Deepa SS, Fukui S, Hattori T, Fukushima N, Hardingham T, Kongtawelert P, Sugahara K. Two related but distinct chondroitin sulfate mimetope octasaccharide sequences recognized by monoclonal antibody WF6. J Bio Chemistry. 2007;282:35232-46.
16. Threesuttacheep R, Pothacharoen P, Kongtawelert P, Ongchai S, Jotikasthira D. Chatiketu P, Krisanaprakornkit S. Comparisons of chondroitin sulphate levels in orthodontically moved canines and clinical outcomes between two different force patterns. J Dent Specialities. 2015;3:5-15.
17. Tasanapanont J, Wattanachai T, Apisariyakul J, Pothacharoen P, Ongchai S, Kongtawelert P, Midtbø M, Jotikasthira D. Biochemical and clinical assessments of segmental maxillary posterior tooth intrusion. Inter J Dentistry. 2017, 2689642.
18. Limsiriwong S, Khemaleelakul W, Sirabanchongkran, Pothacharoen P, Kongtawelert P, Ongchai S, Jotikasthira D. Biochemical and clinical comparisons of segmental maxillary posterior tooth distal movement between two different force magnitudes. Eur J Orthod. 2017 https://doi.org/10.1093/ejo/cjx092.
19. Turnbull NR, Birnie DJ. Treatment efficiency of conventional vs self-ligating brackets: Effects of archwire size and material. Am J Orthod Dentofacial Orthop. 2007;131:395-9.
20. Harradine N. The History and Development of Self-Ligating Brackets. Seminars in Orthodontics. 2008;14:5-18.
21. Fleming PS, Johal A. Self-Ligating Brackets in Orthodontics. A Systematic Review. Angle Orthod. 2010;80:575-84.
22. Ren Y, Maltha JC, Van't Hof MA, Kuijpers-Jagtman AM. Optimum force magnitude for orthodontic tooth movement: a mathematic model. Am J Orthod Dentofacial Orthop. 2004;125:71-7.
23. Last KS, Stanbury JB, Embery G. Glycosaminoglycans in human gingival crevicular fluid as indicators of active periodontal disease. Arch Oral Biol. 1985;30:275-81.
24. Weddington RJ, Embery G. Proteoglycans and orthodontic tooth movement. J Orthod. 2001;28:281-90.
25. Akchurin T, Aissiou T, Kemeny N, Prosk E, Nigam N, Komarova SV. Complex dynamics of osteoclast formation and death in long-term cultures. PLoS One. 2008;3:e2104.
26. Luppanapornlarp S, Kajii TS, Surarit R, Iida J. Interleukin-1beta levels, pain intensity, and tooth movement using two different magnitudes of continuous orthodontic force. Eur J Orthod. 2010;32(5):596-601.
27. DeLoach LJ, Higgins MS, Caplan AB, Stiff JL. The visual analog scale in the immediate postoperative period: intrasubject variability and correlation with a numeric scale. Anesth Analg. 1998;86(1):102-6.
28. Bodian CA, Freedman G, Hossain S, Eisenkraft JB, Beilin Y. The visual analog scale for pain: clinical significance in postoperative patients. Anesthesiology. 2001;95(6):1356-61.
29. Ogura M, Kamimura H, Al-Kalaly A, et al. Pain intensity during the first 7 days following the application of light and heavy continuous forces. Eur J Orthod. 2009;31(3):314-9.