MASTICATORY PERFORMANCE AND SELF-ASSESSED MASTICATORY ABILITY IN ORTHODONTIC PATIENTS USING REMOVABLE POSTERIOR BITEPLATE AND ORTHODONTIC BANDING CEMENT FOR BITE-RAISING: A RANDOMIZED CLINICAL TRIAL

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A Thesis Submitted in Partial Fulfillment of the Requirements
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ประสิทธิภาพการบดเคี้ยวและการประเมินความสามารถในการบดเคี้ยวด้วยตนเองในผู้ป่วยจัดฟันที่มีการยกระนาบการสบฟันด้วยเครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลังและวัสดุยึดติดแถบรัดจัดฟัน: การทดลองทางคลินิกแบบสุ่ม

น.ส.ปกฉัตร บุญภู

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Thesis Title	MASTICATORY PERFORMANCE AND SELF-ASSESSED MASTICATORY ABILITY IN ORTHODONTIC PATIENTS USING REMOVABLE POSTERIOR BITEPLATE AND ORTHODONTIC BANDING CEMENT FOR BITE-RAISING: A RANDOMIZED CLINICAL TRIAL
By	Miss Pokchat Bunpu
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ปกฉัตร บุญภู : ประสิทธิภาพการบดเคี้ยวและการประเมินความสามารถในการบดเคี้ยวด้วยตนเองในผู้ป่วยจัดฟันที่มีการยกระนาบการสบฟันด้วยเครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลังและวัสดุยึดติดแถบรัดจัดฟัน: การทดลองทางคลินิกแบบสุ่ม. (MASTICATORY PERFORMANCE AND SELF-ASSESSED MASTICATORY ABILITY IN ORTHODONTIC PATIENTS USING REMOVABLE POSTERIOR BITEPLATE AND ORTHODONTIC BANDING CEMENT FOR BITE-RAISING: A RANDOMIZED CLINICAL TRIAL) อ.ที่ปรึกษาหลัก : ผศ. ทพ. ดร.ชิษณุ แจ้งศิริพันธ์

วัตถุประสงค์ เพื่อศึกษาผลที่เกิดขึ้นต่อประสิทธิภาพการบดเคี้ยวและการประเมินความสามารถในการบดเคี้ยวด้วยตนเอง รวมทั้งเปรียบเทียบความแตกต่างที่เกิดขึ้นในผู้ป่วยจัดฟันที่มีการยกระนาบการสบฟันด้วยเครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลังและยกระนาบการสบฟันด้วยวัสดุยึดติดแถบรัดจัดฟัน

วัสดุและวิธีการ งานวิจัยนี้รวบรวมผู้ป่วยจัดฟัน ในคณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ที่มีสุขภาพดีไม่มีโรคประจำตัว มีชุดฟันธรรมชาติที่ไม่มีบริเวณไร้ฟันและมีอวัยวะปริทันต์อยู่ในสภาวะปกติ ซึ่งจำเป็นต้องรับการรักษาด้วยเครื่องมือจัดฟันชนิดติดแน่นร่วมกับการยกระนาบการสบฟัน จำนวน 12 ราย อายุเฉลี่ย 22.58±8.45 ปี แบ่งเป็น 2 กลุ่มโดยเท่ากัน กลุ่มที่หนึ่งได้รับการยกระนาบการสบฟันด้วยเครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลังและกลุ่มที่สองได้รับการยกระนาบการสบฟันด้วยวัสดุยึดติดแถบรัดจัดฟัน การทดสอบแบ่งออกเป็นสองส่วน ส่วนที่หนึ่งผู้ป่วยได้รับการทดสอบประสิทธิภาพการบดเคี้ยวผ่านการเคี้ยววัสดุทดสอบและส่วนที่สองเป็นการประเมินความสามารถในการบดเคี้ยวด้วยตนเองโดยให้ผู้ป่วยเคี้ยวอา หาร 8 ชนิด และทำแบบสอบถาม การเก็บข้อมูลทำที่ระยะเวลาก่อนใส่เครื่องมือ(T0) หลังใส่เครื่องมือทันที (T1) หลังใส่เครื่องมือ 1 เดือน (T2) และหลังใส่เครื่องมือ 3 เดือน (T3) การวิเคราะห์ข้อมูลภายในกลุ่มใช้สถิติการทดสอบความแปรปรวนแบบเกี่ยวข้องกัน (Repeated-measures ANOVA) ตามด้วยการเปรียบเทียบรายคู่ (Post-hoc test) หรือสถิติทดสอบฟรีดแมน (Friedman test) ตามด้วยการทดสอบเครื่องหมาย – ลำดับที่ของวิลค็อกซันชนิดอันดับที่มีเครื่องหมาย (Wilcoxon signed-rank test) ร่วมกับการปรับระดับนัยสำคัญ (Bonferroni correction) ส่วนการวิเคราะห์ข้อมูลระหว่างกลุ่มจะใช้ค่าการทดสอบความแตกต่างของสองประชากรที่เป็นอิสระกัน (Independent t-test) หรือการทดสอบแบบวิธีแมนน์-วิทนีย์ยู (Mann-Whitney U Test) โดยขึ้นกับลักษณะการกระจายของข้อมูล กำหนดนัยสำคัญทางสถิติที่ระดับ 0.05

ผลการศึกษา ผู้ป่วยที่ยกระนาบการสบฟันด้วยเครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลัง พบว่าประสิทธิภาพการบดเคี้ยวและการประเมินความสามารถในการบดเคี้ยวด้วยตนเองไม่มีความแตกต่างในแต่ละช่วงเวลาอย่างมีนัยสำคัญ ส่วนผู้ป่วยที่ยกระนาบการสบฟันด้วยวัสดุยึดติดแถบรัดจัดฟันพบความแตกต่างอย่างมีนัยสำคัญของประสิทธิภาพการบดเคี้ยวระหว่างระยะเวลา T0-T1 (*P*-value=0.023) และ T0-T2 (*P*-value=0.020) แต่การประเมินความสามารถในการบดเคี้ยวด้วยตนเองไม่พบความแตกต่างของแต่ละช่วงเวลาอย่างมีนัยสำคัญ สำหรับการเปรียบเทียบระหว่างกลุ่มทั้งประสิทธิภาพการบดเคี้ยวและการประเมินความสามารถในการบดเคี้ยวด้วยตนเองไม่พบความแตกต่างอย่างมีนัยสำคัญในทุกช่วงเวลา

สรุปผลการศึกษา ผู้ป่วยที่ใช้เครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลังมีประสิทธิภาพการบดเคี้ยวภายหลังการใส่เครื่องมือไม่แตกต่างจากตอนก่อนใส่ ในขณะที่การใช้วัสดุยึดติดแถบรัดจัดฟันพบว่าประสิทธิภาพการบดเคี้ยวไม่แตกต่างจากตอนก่อนใส่เมื่อระยะเวลาผ่านไป 3 เดือน ในแง่การประเมินความสามารถในการบดเคี้ยวด้วยตนเอง ทั้งสองกลุ่มไม่พบความแตกต่างอย่างมีนัยสำคัญในทุกช่วงเวลา เมื่อทำการเปรียบเทียบระหว่างสองวิธี พบว่าการยกระนาบการสบฟันด้วยเครื่องมือจัดฟันแบบถอดได้ที่มีแท่นกัดในส่วนหลังและการยกระนาบการสบฟันด้วยวัสดุยึดติดแถบรัดจัดฟันส่งผลประสิทธิภาพการบดเคี้ยวและการประเมินความสามารถในการบดเคี้ยวด้วยตนเองไม่แตกต่างกัน

สาขาวิชา	ทันตกรรมจัดฟัน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2563	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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KEYWORD: Masticatory performance, Masticatory ability, Bite-raising, Removable posterior biteplate, Orthodontic banding cement

Pokchat Bunpu : MASTICATORY PERFORMANCE AND SELF-ASSESSED MASTICATORY ABILITY IN ORTHODONTIC PATIENTS USING REMOVABLE POSTERIOR BITEPLATE AND ORTHODONTIC BANDING CEMENT FOR BITE-RAISING: A RANDOMIZED CLINICAL TRIAL. Advisor: Asst. Prof. CHIDSANU CHANGSIRIPUN, D.D.S., Ph.D.

Objective: To evaluate the masticatory performance and the masticatory ability before and after bite-raising with removable posterior biteplate and with orthodontic banding cement and compare the long-term effects between the two different bite-raising methods.

Materials and Methods: The 12 healthy, orthodontic, patients who have natural permanent dentition with healthy periodontium and required the bite-raising in the comprehensive fixed orthodontic appliances from the Faculty of Dentistry, Chulalongkorn University were collected (mean age 22.58±8.45 years). A group of patients was randomly divided into two groups of equal size. The first group used removable posterior biteplate and the other group used orthodontic banding cement. The procedures consisted of two parts. In part 1, the masticatory performance was analyzed by having the subjects chewed naturally on a portion of artificial test food. In part 2, the masticatory ability was analyzed by having the subjects chewed eight different foods and answered the questionnaire. Measurements were made before bite-raising (T0), immediately after bite-raising (T1), 1 month (T2), and 3 months after bite-raising (T3). For the within-group analyses, the statistical analyses were performed using the repeated measures ANOVA and further post hoc analysis when the normal distribution of outcome variable is assumed. Friedman test and Wilcoxon signed-rank test with Bonferroni correction were performed when the normal distribution is not assumed. The comparative differences of parameters between removable posterior biteplate and orthodontic banding cement, the independent t-test or the Mann-Whitney U test were used according to the data distribution. The significance level was set at 5%.

Results: The masticatory performance and the masticatory ability before and after bite-raising was not significantly different in the removable posterior biteplate group. While the orthodontic banding cement group found a significant difference for the masticatory performance between T0-T1 (*P*-value=0.023) and T0-T2 (*P*-value=0.020), there was no significant difference in the masticatory ability among each time points. The comparative results between the two methods revealed a nonsignificant difference for the masticatory performance and the masticatory ability.

Conclusion: There was no significant reduction of the masticatory performance after using the removable posterior biteplate. In contrast, the significant reduction of the masticatory performance in orthodontic banding cement needed 3 months to restore. Both methods did not affect the masticatory ability. For comparative results, the two bite-raising methods did not affect the masticatory performance and the masticatory ability differently.

Field of Study:	Orthodontics	Student's Signature .....
Academic Year:	2020	Advisor's Signature .....

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Chapter 1 Introduction

1.1 Background and rationale

The orthodontic dentistry is one of the important and popular treatment which focuses on the correction of teeth and jaws. The increasing numbers of orthodontic patients state that people are pay attention to teeth alignment problems more than in the past.

Many malocclusion types bring the patient to orthodontics treatment. A deepbite is one of the most common orthodontic problems (1) in which the upper anterior teeth extend out over the lower anterior teeth, and this causes esthetic problems. In more severe cases, the lower anterior teeth bite into the roof of the mouth, make chewing difficult and trauma to the soft tissue. In addition, undesirable consequences of deepbite such as flaring of upper anterior teeth, increasing crowding of the lower anterior teeth, periodontal problems are reported in some studies (2, 3).

A crossbite in which the upper posterior teeth contact inside or outside the lower posterior teeth and lower anterior teeth are in crossbite if they erupt in front of the upper anterior teeth also causes difficulty in chewing function for the patients. Normal jaws growth, neuromuscular, or temporomandibular joint function may be disturbed by crossbite malocclusion. It can cause dental, skeletal, or soft tissue abnormalities if left untreated. So, early correction of crossbite is indicated, even in mixed dentition (4-6).

The study of the global distribution of malocclusion resulted that there are 23.83% of deepbite problems and 8.27% of crossbite problems in Asian patients (7). To correct these problems, many orthodontists use conventional orthodontic appliances together with the bite-raising method. The purpose of the bite raiser is to prevent complete bite closure and keep specific groups of teeth out of the occlusion. The bite raising method will eliminate occlusal interferences that blocked the tooth movement (8).

Presently, many temporary bite-raising methods are being used, including two major categories, fixed and removable appliances. One of the removable appliances is a biteplate. Biteplate is a thick acrylic appliance with metal clasps that attach to the teeth. Wearing may uncomfortable and need attention at first. Adaptation and co-operation from the patients are required (9).

For fixed method by temporary bite-raising with orthodontic banding cement (10), bilateral occlusal build-ups were bonded on the first permanent molars. It is hygienic and less intrusive to the tongue space (8). Besides, orthodontic banding cement is easy to place on the tooth surface in one visit without any waiting period for the laboratory process, and cooperation from the patients is not necessary (11).

In addition, the changes in bite force and jaw muscles activities after bite-raising have resulted in many studies (12-15). Julien et al. stated that the maximum bite force explains some variation in masticatory performance (16). Pativetpinyo et al. reported an altered neuromuscular behavior during clenching and chewing immediately after temporary bite-raising with light-cured orthodontic band cement by electromyography test (17). Changsiripun and Pativetpinyo also reported that the masticatory function both objectively by the masticatory performance index and subjectively by the food intake ability test was reduced immediately after orthodontic banding cement bite-raising (18). Moreover, the contact area of the posterior dentition is also associated with masticatory performance. The subject with greater contact areas performs significantly better masticatory performance than the subject with smaller contact areas (16). Despite the increase on the vertical dimension being similar between the two bite-raising methods, it results in only two occlusal contact areas with the method adding orthodontic band cement compared to multiple contact areas on the biteplate. This might affect the masticatory function differently.

However, to the best of our knowledge, there is no published study that compares the consequence of opening the bite by adding orthodontic banding cement to the occlusal surfaces of the posterior teeth and by wearing removable posterior biteplate. In this study, masticatory performance and masticatory ability of the subjects before and after opening the bite with different methods for short and long-term duration (3 months) will be evaluated objectively and subjectively including the masticatory performance index and the masticatory ability recognition of the subjects.

1.2 Research questions

Q1: Does the bite-raising by adding orthodontic banding cement makes differences in the masticatory performance and the self-assess masticatory ability after using the appliance in short and long-term duration?

Q2: Does the bite-raising by removable posterior biteplate make differences in the masticatory performance and the self-assess masticatory ability after using the appliance in short and long-term duration?

Q3: Does the bite-raising by adding orthodontic banding cement affect the masticatory performance and the self-assess masticatory ability differently when compare with the bite-raising by removable posterior biteplate after using in short and long-term duration?

1.3 Research hypotheses

Ho1: The bite-raising by adding orthodontic banding cement makes no differences in the masticatory performance and the self-assess masticatory ability after using the appliance in short and long-term duration.

Ha1: The bite-raising by adding orthodontic banding cement makes differences in the masticatory performance and the self-assess masticatory ability after using the appliance in short and long-term duration.

Ho2: The bite-raising by removable posterior biteplate makes no differences in the masticatory performance and the self-assess masticatory ability after using the appliance in short and long-term duration.

Ha2: The bite-raising by removable posterior biteplate makes differences in the masticatory performance and the self-assess masticatory ability after using the appliance in short and long-term duration.

Ho3: The bite-raising by adding orthodontic banding cement does not affect the masticatory performance and the self-assess masticatory ability differently when compare with the bite-raising by removable posterior biteplate after using in short and long-term duration.

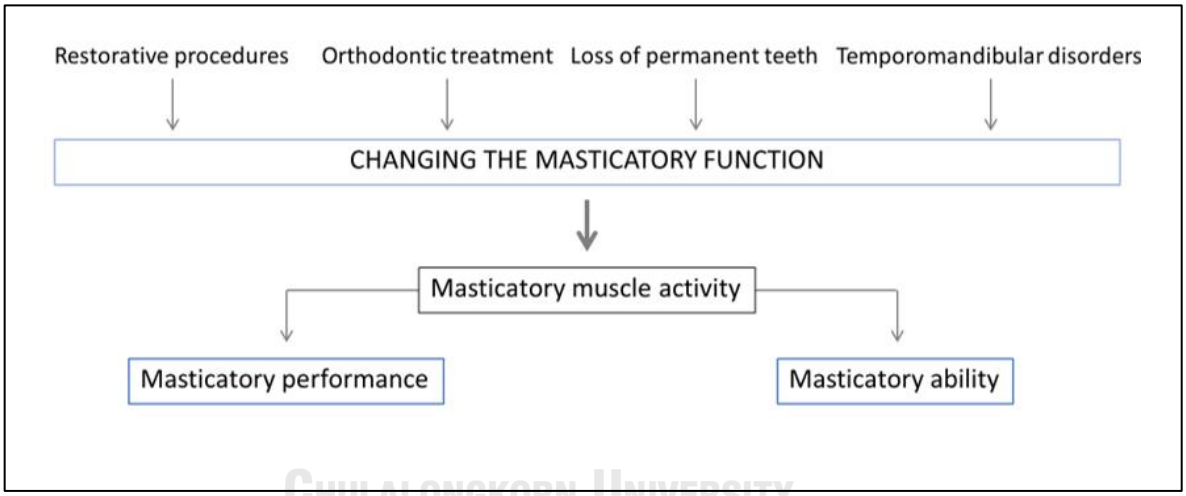
Ha3: The bite-raising by adding orthodontic banding cement affects the masticatory performance and the self-assess masticatory ability differently when compare with the bite-raising by removable posterior biteplate after using in short and long-term duration.

1.4 Research objectives

1. To compare the masticatory performance and the masticatory ability before and after bite-raising with orthodontic banding cement.
2. To compare the masticatory performance and the masticatory ability before and after bite-raising with removable posterior biteplate.
3. To compare the masticatory performance and masticatory ability between the bite-raising by adding orthodontic banding cement and by removable posterior biteplate.

1.5 Conceptual framework

Figure 1 Conceptual framework



1.6 Ethical considerations

This research was approved by the ethical committee of the Faculty of Dentistry, Chulalongkorn University on January 15, 2021 (HREC-DCU 2020-105).

Chapter 2 Review of literatures

2.1 Bite-raising methods

The study of the global distribution of malocclusion resulted that there are 23.83% of deepbite problems and 8.27% of crossbite problems in Asian patients (7). To correct these problems, many orthodontists use a conventional orthodontic appliance together with bite-raising methods. The purpose of the bite raiser is to prevent complete bite closure and keep specific groups of teeth out of the occlusion. The bite-raising method will eliminate occlusal interferences that blocked the tooth movement (8).

Many temporary bite-raising methods are being used nowadays, including two major categories, fixed and removable appliances. In 1803, Joseph Fox recommended placing a biteblock over the posterior teeth so that the force of occlusion could be removed before attempting to move the teeth (19). Biteblock or biteplate is a thick acrylic appliance with metal clasps that attach to the teeth. Wearing may uncomfortable and need attention at first. Adaptation and cooperation from the patient are required (9). The biteplate allows orthodontic movement of teeth without interference from the opposing teeth, eliminate the occlusal trauma that may be caused by the parafunctional habits that may develop or be accentuated during orthodontic tooth movement (10).

For fixed method by temporary bite-raising with orthodontic banding cement (10), bilateral occlusal build-ups were bonded on the first permanent molars. It is hygienic and less intrusive to the tongue space (8). Besides, orthodontic banding cement is easy to place on the tooth surface in one visit without any waiting period for the laboratory process and cooperation from the patient is unnecessary (11). It allows orthodontic tooth movement of teeth without interference and easy to place on the tooth surface in one visit.

However, the contact area of the posterior dentition is also associated with masticatory performance. Julien et al. concluded that subjects who have greater contact areas performed significantly better masticatory performance than subjects with smaller contact areas (16). Many studies have also stated that mastication performance is reduced by the loss of posterior teeth since these are the active tools in food comminution (20-24). Relate to temporary bite-raising by adding orthodontic banding cement to the occlusal surfaces of just 2-4 posterior molars may not produce optimum functional occlusion. Thus, this may affect the functional equilibrium of the masticatory system and cause occlusal trauma on molars when occlusal forces exceeded the reparative capacity of the attachment apparatus.

2.2 Influence of occlusal vertical dimension on the masticatory performance

Bite-raising methods both removable and fixed appliances for orthodontic treatment will increase the occlusal vertical dimension of the patient as much as the occlusal interferences that blocked the tooth movement were eliminated. Many studies concluded that improper vertical dimension changes could cause serious problems such as muscle pain, temporomandibular joint (TMJ) disorders, headaches, tooth grinding, and clenching (25-27). The research which studied the increased vertical dimension changes for restorative purpose found that there is an alteration of the jaw elevator muscle fibers and the position of the condylar head in the temporalis fossa (28). A recent study found that the EMG activity of the anterior temporalis significantly increased after three months of clear aligner wearing. This showed some effect of the two-layer clear aligners on the orofacial muscle at the mandibular posture position (MMP) (29). Pativetpinyo et al. also reported an altered neuromuscular behavior of superficial masseter and anterior temporalis muscles during clenching and chewing immediately after temporary bite-raising with light-cured orthodontic band cement by electromyography test (17). Related with many studies, the changes in bite force and jaw muscles activities after bite-raising are resulted (12-15).

Furthermore, changes in masticatory muscle length resulting from the vertical opening may influence the length-tension relationship. An optimum in muscle force measured under static conditions occurred at a jaw opening varying between 5 and 10 mm as measured at the first molar. Thus, increasing the vertical dimension of occlusion may increase bite force during mastication. An increase in the vertical dimension may thus influence the masticatory performance both in a negative way (hampered selection of food particles) and in a positive way (increased bite force and thus better breakage of food particles). Christensen reported an increase of tenderness to palpation in all masticatory muscles and concluded that increasing occlusal vertical dimension “apparently deranged the function of muscles and joints” (30). An increase of the occlusal vertical dimension in complete denture wearers also affects the hyoid bone position and masticatory muscle activity (31). Besides, The study was concluded that masticatory performance, mandibular movement during mastication, and the effort masticatory muscles required for chewing could be affected by the vertical facial pattern (32).

2.3 Masticatory performance and masticatory ability

Mastication is the action of breaking down food, preparatory to deglutition. The proper amount of nutrition appears to be related to how well the food is masticated. To evaluate the masticatory function, an objective masticatory function defined as masticatory performance and a subjective defined as masticatory ability will be measured.

2.3.1 Masticatory performance

The masticatory performance is widely assessed by three main categories, including comminution methods, mixing ability methods, or other methods (33). In detail, comminution methods include all methods which test food is chewed into smaller particles and follow by sieve method.

When the particles of artificial test food comminuted by patients, it will be expectorated onto a paper filter which placed over the beaker. The particles will be rinsed and dried, then put in a sieving machine, and the particles retained on each sieve will be weighted on digital scales. The reduction in food particle sizes during mastication can be considered as the result of a selection and a breakage process. Breakage is the process by which the selected particles are fractured between the teeth into fragments of variable number and size. Breakage may depend on tooth morphology, the amount and coordination of the jaw-muscle activity (controlling the bite force and its direction), fracture characteristics of the food, and particle size and shape (28). Second, mixing ability methods will be performed by chewing two-color gum and assessing visual or electronic colorimetric analyses. The color-mixing test could be used routinely to evaluate masticatory function. The advantage of the mixing ability methods is that they can be easily used in daily dental practice to determine the masticatory capabilities of a subject before and after oral rehabilitation. The colorimetric test can be evaluated the ability of the patient to homogenize an initially two-color support into a single monochrome phase, and thus to form a homogeneous bolus (34). Last, the other method such as measuring the number of posterior occlusal contacts or measuring by electromyography, kinematics, force sensors, or video in relation to masticatory performance can be used.

A systematic review of measurement properties of methods for objectively assessing masticatory performance concluded that mixing ability methods have moderate to strong level of evidence for validity and moderate level of evidence for reliability. For comminution methods, it has strong level of evidence for reliability and moderate but negative level of evidence for validity (33). However, Oliveira et al. stated that the sieve method is the gold standard to evaluate the masticatory efficiency for complete denture wearers (35).

Sieve method is the procedure to determine the degree of food breakdown. After the test foods were chewed, rinsed, and dried, they will be put in a sieving machine. The sieving machine contained stacks of different sieve apertures; the operator can adjust the vibrating frequency and duration to separate particles of different sizes. The particle size distribution of test food will be analyzed using single-sieving method (36, 37) or multiple-sieving method (38, 39). Single sieve method, the food particles will be sieved through the standard sieve aperture, while multiple sieve method, the food particles will be sieved through multiple stacks of different sieve apertures. The single sieve method requires less amount of work since only one weight measurement of food particles is needed. The multiple sieve method is more time-consuming because the weight measurement must be done for every stack to calculate the median particle size. On the other hand, the reliability of the single sieve method may be lower than the multiple sieve method because one standard aperture may deviate too much from the median particle size of the chewed food. For routine clinical examination, the single sieve method is convenient and reliable if the sieve diameter is chosen close to the median particle size of all subjects. The multiple sieve method is recommended for masticatory performance evaluation as it provides more detailed information (40).

Since the comminution methods require test food, a condensation silicone impression material can be used as a standard test food. The product called Optosil® (Heraeus Kulzer, Hanau, Germany) had minimal taste and smell, unaffected by water, and could be stored for seven days without losing dimensional stability is proposed as a material of choice (41).

2.3.2 Masticatory ability

A subjective masticatory function is defined as masticatory ability. These subjective assessments include measurements of the self-satisfaction of the masticatory function that has been studied by interviewing subjects as to their own assessment of the function, such as the food intake ability index (FIA), Visual Analogue Scale (VAS), and oral health impact profile (OHIP). Masticatory ability appeared to be closely related to the number of teeth (42). Thus, subjects with an inadequate dentition compensate or reduced their chewing performance by swallowing larger food particles (43).

Chapter 3 Materials and methods

3.1 Methods

Study design

A randomized clinical trial

Population

Volunteers aged 14-40.

Sample size calculation

The sample size was calculated from the equation for estimating the infinite population mean.

$$n = \frac{z^2_{1-\frac{\alpha}{2}}\,\sigma^2}{d^2}$$

α: significant level 0.05 d: Error = 0.10 Z (0.975) = 1.959964

From the previous study (18): Standard deviation (**σ**) = 0.25. The data were calculated and the sample size was 25 per group. The result was inflated by a 20% margin to allow for loss to follow-up and drop out. The total sample size needed was a minimum of 30 per group.

The subjects

The subjects were randomly divided into two groups of equal size, matched according to gender and vertical skeletal pattern. This was undertaken by one author using random numbers.

- Group 1 received the removable posterior biteplate.
- Group 2 received the orthodontic banding cement.

Subjects were initially screened by one author to check whether they fit the criteria of the study. They have received a clinical examination. Before starting the experimentation, the aims and the method of the study were explained to all subjects and written informed consent to participate in the study was obtained from each patient. The patients with posterior biteplate were monitored the compliance rate by self-recording on the schedule forms.

3.2 Inclusion criteria in both groups

- Patients aged 14-40 who have a natural permanent dentition with healthy periodontium.
- Patients treated by comprehensive fixed orthodontic appliances whose bite-raising are required.
- All participants had no significant facial deformity or symptoms of cranio-mandibular disorders and no temporomandibular symptoms based on the assessment protocol of Schiffman et al. (44)

3.3 Exclusion criteria in both groups

- Patients with food allergies including dried peanuts, cookies, apples, dried cuttlefish, boiled rice, boiled eggs, tofu, and jelly
- Patients who have systemic diseases or undergoing medications that might affect the masticatory functions
- Patients with poor compliance
- Patients whose bite-raising phase is completed before three months

The following tests were performed on each subject.

1. Masticatory performance before (T0), immediately (T1), 1 month (T2), and 3 months (T3) after using the bite-raising oral appliances
2. Masticatory ability before (T0), immediately (T1), 1 month (T2), and 3 months (T3) after using the bite-raising oral appliances

3.4 The removable posterior biteplate fabrication

Maxillary and mandibular alginate impressions were obtained. Master casts of an upper and lower dental arch were prepared for the fabrication of the biteplate. The clasps were designed for sufficient retention and adjusted until the biteplate fit properly to the dentitions. All the biteplates were manufactured under standardized laboratory conditions and followed the manufacturer's instructions. The acrylic plates were made from acrylic resin (Orthocryl EQ, Dentaurum, USA). The acrylic resin powder and monomer liquid were mixed to a thick syrup consistency and built an acrylic ledge occlusal to the posterior teeth with resin. Acrylic were occluded against opposing teeth. Then, placed the model and acrylic resin into a humid pressure pot for 20 minutes. The pressure was adjusted to approximately 30 psi. At the end of the curing cycle, evacuated the pressure and removed the model and cured acrylic. Once the fabrication was completed, the acrylic biteplate was flattened and removed excess acrylic by using a carbide cone or taper bur and a lab handpiece. After that, the biteplate was pumiced and polished. Have the patient seated the appliance and bit down on double-sided articulating paper. The posterior biteplate acrylic was adjusted until there is even and simultaneous contact on both sides, all the antagonist teeth; at least one contact point per tooth were contacted on the biteplate, making the 2-mm clearance between upper and lower incisors.

3.5 The orthodontic banding cement fabrication

The upper first molars were polished, rinsed, dried, and isolated. The trapezoidal-shaped orthodontic banding cement (Ultra Band-Lok BLUE, Reliance Orthodontic Products, Inc., Itasca, IL) was placed on the palatal cusps of the upper first molars. The Light-curing unit, providing a minimum of 600 milliwatts of continuous output, was used to cure material by positioning the tip in close proximity to the occlusal surface of the molars for 30 seconds. Next, we checked the occlusion with articulating paper and polished it with white stone until there was

even with one contact point on each side and the 2-mm clearance appeared between upper and lower incisors.

3.6 Protocol for measuring masticatory performance and masticatory ability

3.6.1 Objective evaluation by measurement of masticatory performance

The masticatory performance was determined by having the subjects chew naturally on a portion of 14 quarter tablets of artificial food for 30 cycles as the examiner counted the number of chewing cycles (45). After completion, the chewed particles were expectorated onto the filter paper which was placed over the beaker. The subjects were asked to rinse the mouth with water until all particles were removed. The masticated particles were rinsed with disinfectants (Sodium hypochlorite 0.5%) and dried in an oven at 80 °C for 1 hour and then separated using a multiple sieve method, stacking on a mechanical shaker and vibrated (Vibratory Sieve Shaker AS 200 digit) for 2 minutes (45).

Test food preparation

The test food that proposed to use is polydimethylsiloxane condensation silicone impression material. OptoSil® (Heraeus Kulzer, Hanau, Germany) is considered as an appropriate test food for assessing masticatory performance by its ideal properties which can be standardized, does not dissolve in water, and can be stored for seven days without losing its mechanical properties (46-48). OptoSil® had no pre-determined lines of cleavage; it was easily formed into standard sizes and weights and easily examined after mastication (41). To standardize the bolus shape and size, a 5-mm thick acrylic template with 20 mm diameter holes for the manufacturing of the OptoSil® tablets was used. The putty and paste components of the OptoSil® were mixed by the following protocol (46-48). Before mixing, we placed a 12-inch-long sheet of wax paper on a horizontal flat working surface with the template on top. After wearing latex gloves (with or without powder), one level scoop (provided by the manufacturer) of PUTTY and a line of PASTE that is 3 cm long

and approximately 2 mm wide were prepared. Removed the PUTTY from the scoop with fingers and flattened it gently into a small bowl shape in the palm and applied the PASTE-HARDENER to the center of the PUTTY-bowl with a spatula. Less than 3 cm of paste will significantly increase the setting time of the OptoSil®. Begin the kneading process by curling the fingertips under the bowl, lifting it up and holding it between both index fingers, middle fingers, and thumbs, then mashed the PUTTY vigorously between the thumbs and first two fingers folded the edges back on top of the mass of putty and mashed it again. Continue this kneading process for 30 s ensuring that no streaks or evidence of the PASTE is present in the PUTTY and that no PASTE remains on the gloves.

Rolled the PUTTY between both hands into a cigar-like shape and immediately placed the PUTTY into the template, completely filling the wells without regard to excess, taking no longer than 30 s. Delays of more than 30 s will prevent the smooth flow of the OptoSil® into the template. Next, fold the wax paper over the template and flattened the PUTTY as smooth as possible by running the roller individually over all the PUTTY-wells. Let the OptoSil® set for at least 15 min before removing the tablets from the template to ensure consistent hardness. After hardening for 1 hour, OptoSil® tablets were cut into quarters and packed for each subject. The manufacturer guarantees dimensional stability of the OptoSil® for at least seven days, so the bags were labeled with a start date, weight in grams. Unused OptoSil® was discarded after seven days.

Multiple sieve method

The chewed test foods were sieved through a stack of 12 sieves with apertures between 8.0 and 0.5 mm and a bottom plate. The distribution of particle sizes by weight of the comminuted test foods were mathematically described by a cumulative function (49):

$$Q_w^-(X) = 1 - 2^{-(X/X_{50})^b}$$

Where Qw – (X) is the fraction by weight of particles with a size smaller than X. The median particle size by weight, X50, is the aperture of a theoretical sieve through which 50% of the weight can pass, whereas the variable ‘‘b’’ represents the size spread of the distribution (broadness variable). Increasing values of b correspond to curves with steeper slopes and thus to distributions of particle sizes that are less broad.

To reduce bias, the chewed particles were coded by co-investigator before the multiple sieving and data recordings was done by the main investigator. After that the data were decoded and classified into different group according to bite-raising method for statistical analyses.

3.6.2 Subjective evaluation by measurement of masticatory ability

The Food Intake Ability (FIA) was performed using a self-assessed questionnaire by asking the masticatory ability for eight different foods, including dried peanuts, cookies, apples, dried cuttlefish, boiled rice, boiled eggs, tofu, and jelly (50, 51). After having the subjects chew each test food, the FIA questionnaires were scored. This questionnaire consists of 5 Likert scales in terms of the masticatory ability lists: ‘cannot chew at all’ (1 point), ‘difficult to chew’ (2 points), ‘cannot say either way’ (3 points), ‘can chew some’ (4 points), and ‘can chew well’ (5 points).

Data acquisition: The total FIA score was calculated using the average score of eight foods. The FIA scores of four hard foods (dried peanuts, cookies, apples, dried cuttlefish), the scores of four soft foods (boiled rice, boiled eggs, tofu, and jelly) and the mean difference of the scores of four phases were also calculated.

3.6.3 Compliance monitoring in removable posterior biteplate group

A three-point Likert scale was used to monitor patient compliance; Poor compliance, moderate compliance, and good compliance were defined as when the patients wear the appliance less than 16 hours per day, more than 16 hours per day, and regularly as suggested by the clinician, respectively (52).

3.7 Statistical analysis

1. The normal distributions of the variables were verified by the Shapiro-Wilk test.
2. For comparisons between T0, T1, T2, and T3 in each group, the repeated measures ANOVA and further post hoc analysis were employed when the normal distribution of the outcome variable is assumed. Friedman test and followed by Wilcoxon signed-rank test with Bonferroni correction were performed when the normal distribution is not assumed. For comparing the differences of parameters between removable posterior biteplate and orthodontic banding cement at each time point, the independent t-test or the Mann-Whitney U test were used according to the data distribution.
3. All statistical analyses were carried out using the SPSS statistical package program. The level of significance was determined at 0.05 significant level.

Chapter 4 Results

4.1 The demographics data of the study participants

The study participants consisted of 12 healthy orthodontic patients (mean age 22.58±8.45 years). They were collected from the Faculty of Dentistry, Chulalongkorn University and randomly divided into two groups of equal size. The first group was treated by using a removable posterior biteplate while the other group underwent orthodontic banding cement. Table 1 presented the demographics of the study participants. The male: female ratio and skeletal hypodivergent: normodivergent ratio was 1:5 in each group. The mean overbite before bite-raising was 3.08±1.90 and the mean overbite decreased by 2.13 ± 1.05 mm after performing bite-raising in all participants. The study timeline, including excluded and dropout numbers, was shown in Appendix 1.

Table 1 Participants' Demographic Characteristics
(Mean ± Standard Deviation)

	Removable posterior biteplate	Orthodontic banding cement	*P*-value
Male: female	1:5	1:5	-
Hypodivergent: normodivergent	1:5	1:5	-
Age (years)	24.67±8.55	20.50±8.57	.419
Overbite before bite-raising (millimeters)	3.00±1.64	3.17±2.29	.888
Overbite changes (millimeters)	1.92±0.38	2.33±1.47	.528

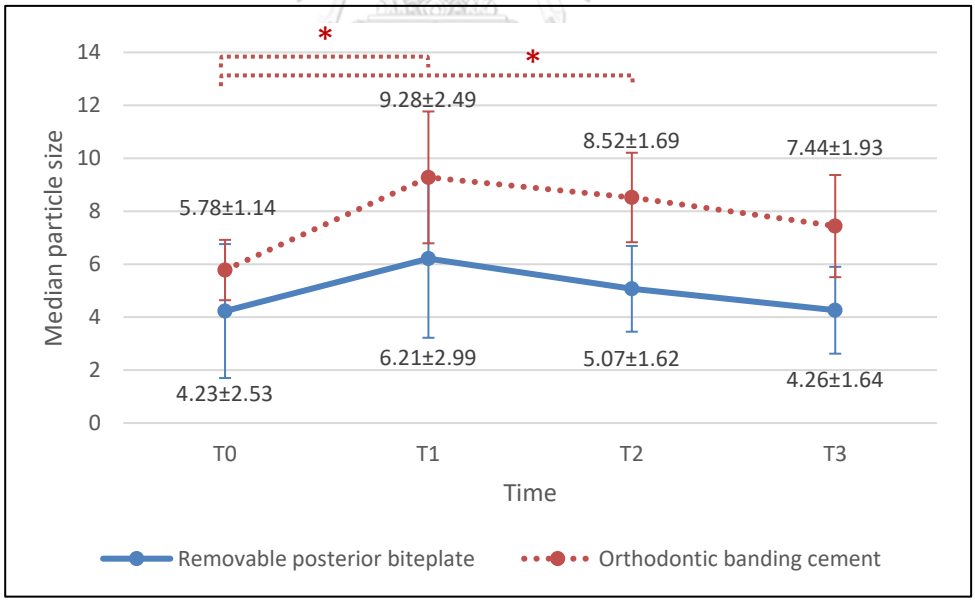
Statistical analyses by Independent t-test.

4.2 The effects of the bite-raising on the masticatory performance

Intraclass Correlation Coefficient (ICC) for the test on masticatory performance ranged from 0.957 to 0.992, with an average of 0.981, which showed very good intra-observer reliability.

To assess the masticatory performance, the median particle size (MPS) of the silicone material, chewed by the patients, was analyzed. Figure 2 reported the MPS of the removable posterior biteplate and orthodontic banding cement group for all time points. The mean MPS of the removable posterior biteplate group at T0 was 4.23±2.53, the value increased immediately at T1 (6.21±2.99) and decreased gradually at T2 (5.07±1.62) and T3 (4.26±1.64), the MPS was not significantly different among every time points. The mean MPS of the orthodontic banding cement group at T0 was 5.78±1.14; the value also increased immediately at T1 (9.28±2.49) and decreased gradually at T2 (8.52±1.69) and T3 (7.44±1.93). The statistical analysis revealed a significant difference in the MPS value between T0-T1 (*P*-value=0.023) and T0-T2 (*P*-value=0.020).

Figure 2 The MPS values before bite-raising (T0), immediately (T1), 1 month (T2), and 3 months after bite-raising (T3) (Mean ± Standard Deviation)



MPS = Median Particle Size

* Significant difference (*P*-value < .05, Repeated-measures ANOVA followed by Bonferroni post-hoc test).

Table 2 Comparison of the different MPS values (Δ) between removable posterior biteplate group and orthodontic banding cement group (Mean ± Standard Deviation)

Difference (Δ)	MPS Removable posterior biteplate	MPS Orthodontic banding cement	*P*-value
T0-T1	1.98±1.23	2.75±1.23	.302
T0-T2	1.50±1.03	2.74±1.27	.095
T0-T3	1.10±0.80	2.40±2.06	.181
T1-T2	1.46±1.73	1.14±0.58	.671
T1-T3	2.03±1.89	2.19±1.48	.875
T2-T3	1.21±0.74	1.27±1.65	.935

MPS = Median Particle Size

Statistical analyses by Independent t-test.

In table 2, the comparative results of the different MPS (Δ) between removable posterior biteplate group and orthodontic banding cement group revealed nonsignificant difference for all time gaps between the two methods.

4.3 The effects of the bite-raising on the masticatory ability

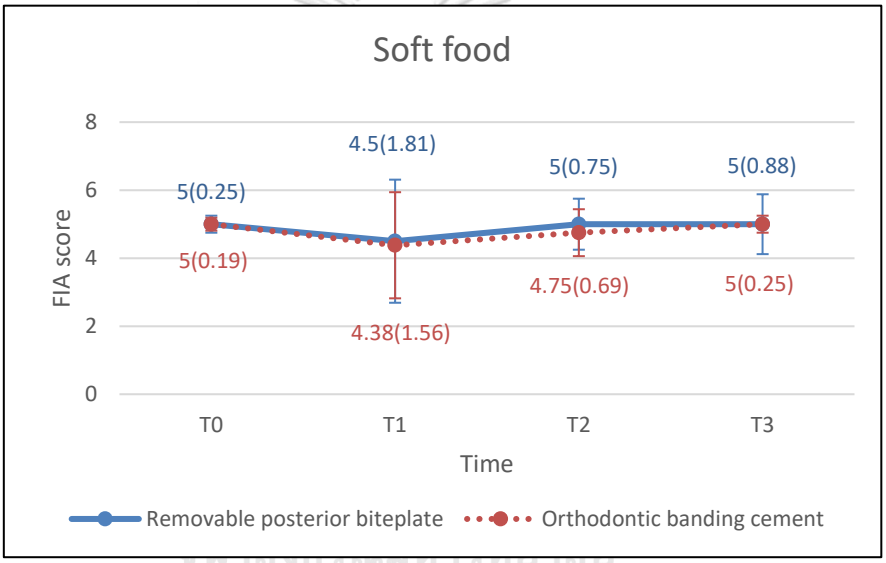
Intraclass Correlation Coefficient (ICC) for the test on masticatory ability ranged from 0.891 to 0.987, with an average of 0.962, which showed very good intra-observer reliability.

The masticatory ability was analyzed by having patients chewed eight different foods and answered the Food Intake Ability (FIA) questionnaire. The FIA score of the removable posterior biteplate and orthodontic banding cement group for every time points are plotted in figure 3. The mean total FIA score of the removable posterior biteplate group at T0 was 4.44±1.47 then decreased immediately at T1 (3.50±1.50), the total FIA and FIA subscores for soft food and hard food were reduced by 21%, 10%, and 32%, respectively. Afterward, the total scores increased gradually at T2 (4.31±1.25) and T3 (4.75±1.88). However, the FIA score in every time point was not significantly different from each other.

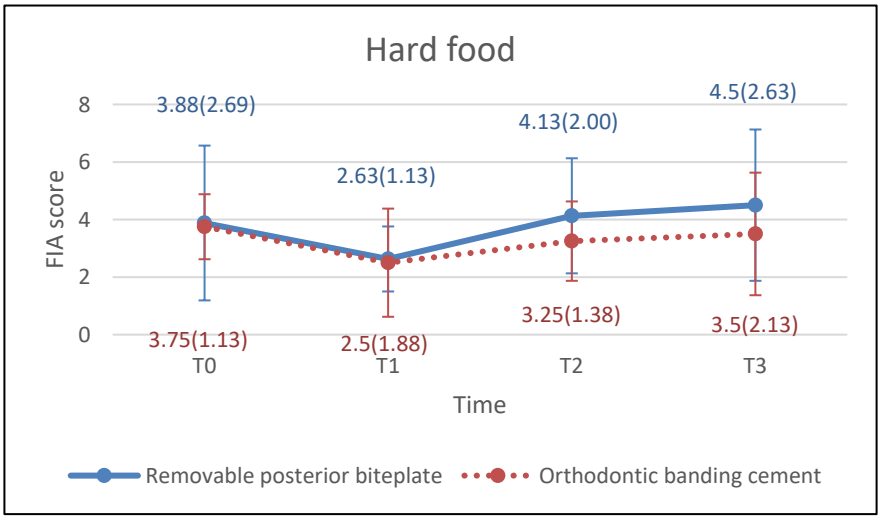
Similar changes were observed in the orthodontic banding cement group; the mean total FIA score at T0 was 4.38±0.66. At T1, the score was reduced to 3.50±1.38, while the total FIA and FIA subscores for soft food and hard food were reduced by 20%, 12%, and 33%, respectively. Afterward, the scores increased gradually at T2 (4.06±0.94) and T3 (4.25±1.31).

Figure 3 The soft food (A), the hard food (B), the total FIA score (C) before bite-raising (T0), immediately (T1), 1 month (T2), and 3 months after bite-raising (T3) [Median (Interquartile Range)]

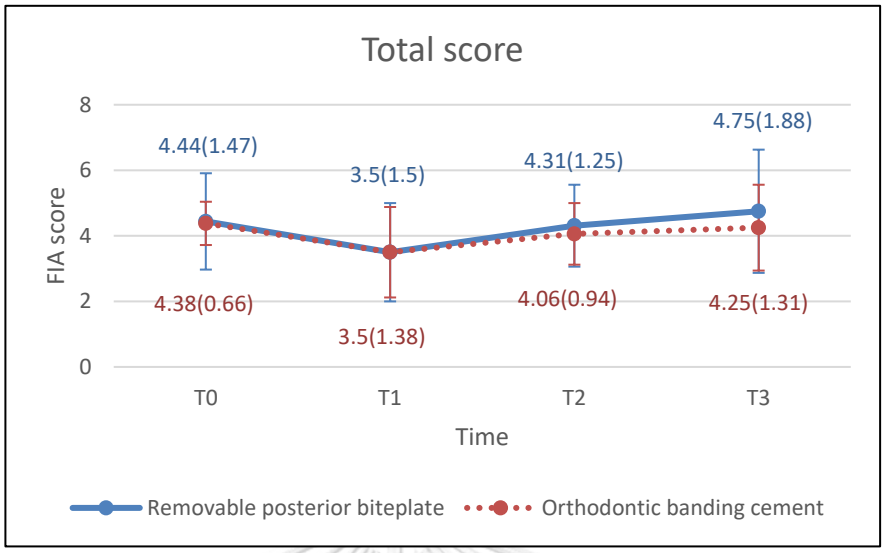
(A)



(B)



(C)



FIA = Food Intake Ability

Statistical analyses by Friedman test and Wilcoxon Signed Ranks test with Bonferroni correction.

Last, the comparative results of the different FIA score (Δ) between removable posterior biteplate group and orthodontic banding cement group, as shown in Table 3, was not noticed any significant difference at any time gaps.

Table 3 Comparison of the different FIA score (Δ) between removable posterior biteplate group and orthodontic banding cement group [Median (Interquartile Range)]

	Soft food FIA score			**Hard food FIA score**			**Total FIA score**		
Difference (Δ)	Removable posterior biteplate	Orthodontic banding cement	***P*-value**	Removable posterior biteplate	Orthodontic banding cement	***P*-value**	Removable posterior biteplate	Orthodontic banding cement	***P*-value**
T0-T1	-0.50(1.56)	-0.38(1.75)	.310	-0.63(1.88)	-1.00(0.88)	.589	-0.69(1.22)	-0.56(1.19)	1.000
T0-T2	0.00(0.50)	-0.13(0.56)	1.000	0.00(1.19)	-0.50(1.34)	.394	0.00(0.72)	-0.31(0.97)	.394
T0-T3	0.00(0.38)	0.00(0.06)	.589	0.38(0.81)	-0.13(1.19)	.310	0.06(0.78)	0.06(0.56)	.818
T1-T2	0.50(1.44)	0.25(1.69)	.394	0.88(1.31)	0.88(2.06)	.699	1.00(1.03)	0.88(1.41)	.699
T1-T3	0.50(1.69)	0.38(1.81)	.699	1.00(2.31)	1.38(1.94)	1.000	0.88(1.25)	0.75(1.69)	.818
T2-T3	0.00(0.13)	0.13(0.63)	.485	0.00(1.19)	0.13(0.44)	.485	0.00(0.66)	0.19(0.69)	.394

FIA = Food Intake Ability

Statistical analyses by Mann-Whitney U Test

Chapter 5 Discussion

5.1 Influences of gender, ages, and skeletal patterns on masticatory function

For the digestion process, one of the critical parts is mastication. Impaired mastication may affect the systemic, mental, and physical functions of the body through many different mechanisms. There are several factors that can influence masticatory function, including sexes, ages, sagittal skeletal patterns, and occlusal vertical dimension.

In the previous studies, gender was reported to have an effect on masticatory performance. The significantly further mastication cycles and longer mastication durations were observed in females compared to males (53). Males were also observed to have significantly larger maximum occlusal force than females (54-56). Moreover, Okiyama et al. confirmed a positive correlation between maximum occlusal force and masticatory performance; it is suggested that a larger maximum occlusal force was associated with a higher masticatory performance (57). The masticatory function may also be affected by ages. Palinkas et al. demonstrated significantly lower muscle thickness values and lower bite force means in patients age 7–12 when compared to age 13-20 and 20-40 (56). For the elderly, the chewing duration, number of chewing cycles, and particle size reduction tend to increases progressively with age (58). These may result from the loss of natural teeth, as Ikebe et al. suggested that the correlation between age and masticatory performance may not exert a direct effect if natural dentition is maintained (54).

It has been widely accepted that vertical skeletal pattern has a great influence on the masticatory muscle function. Patients with short-face type generating the highest bite force beyond other types. While, the bite force of normal-face type was greater than the long-face type (59, 60). Yoon et al. reported similar results; lower bite force was observed in hyperdivergent facial pattern compared to hypodivergent facial pattern but for sagittal skeletal pattern which classified by ANB angle or Angle's

molar classification the values of the bite force were similar. The authors also discussed that the reduction of bite force may not primarily occur from the differences in skeletal pattern, but it was induced by the differences in occlusal contact area according to the skeletal pattern (61). In the present study, the removable posterior biteplate and orthodontic banding cement group have an equal ratio of male and female and the age of participants was in the range of 14-40 years. The vertical skeletal pattern in both groups consisted of hypodivergent and normodivergent as an equal ratio as well. The value was presented in table 1, there was no significant difference can be detected between two groups.

5.2 Influences of occlusal vertical dimension and malocclusions on masticatory function

The alterations of occlusal vertical dimension could affect the masticatory function (12-15, 17, 28, 29). In a negative way, an increase in the vertical dimension may limit the selection of food particles and in a positive way by increasing bite force and cause better breakage of food particles. Our research controlled the fabrication of the bite raising to create an approximately 2-mm clearance between upper and lower incisors in every patient. The vertical dimension changes after raised bite were not significantly different between two methods.

Numerous studies have shown that masticatory performance and masticatory ability are reduced in patients with malocclusions. The patients with open bite and crossbite can have functional limitations as well as Class III malocclusion which may create the largest functional impairment, followed by Class II and Class I malocclusions (62). Patients with jaw deformities, including mandibular retrognathism or mandibular prognathism, resulted in impaired masticatory function even though the occlusal relationship of the upper and lower teeth was greatly improved by orthognathic surgery (63-66). The number of functional tooth units was also confirmed as a key of masticatory performance. The fewer functional tooth units, the

more impairment of mastication occurred. Hatch et al. reported that not only the number, but the distribution of functional tooth units also be an important factor affecting chewing performance (67). Corresponding with functional tooth units, patients with greater contact areas are better able to break down foods (16, 68-70). The bite-raising method is some kind of creating temporary malocclusions to the patient. The only two occlusal contact areas with the method of adding orthodontic band cement compared to multiple contact areas on the removable posterior biteplate might affect the masticatory function in a different way.

5.3 The effects of the bite-raising on the Masticatory performance

A comminuting method is a useful tool for measuring masticatory performance. Optosil® silicon is an alternative material rather than natural food to assess the chewing function of the patient. Despite the fact that they have dissimilar properties, Optosil® are minimal taste and smell, unaffected by water, and could be stored for seven days without losing dimensional stability (40). Moreover, Elgestad et al. reported strong reliability and moderate validity with this method (33). After chewing on the silicon test materials, the chewing particles were analyzed with the sieving method. In the present study, the multiple sieve method was performed with a stack of 12 sieves with apertures between 8.0 and 0.5 mm and a bottom plate. More detailed and more accurate information on masticatory performance can be provided by using the multiple sieve method (40).

The orthodontic banding cement as a bite-raising material established only two posterior contact points in our research, which cause the alteration of the masticatory performance. The mean MPS, which determined the masticatory performance in a negative correlation, increased immediately after bite-raising and decreased gradually after 1 month and 3 months. There was a significant difference MPS between before and immediately after bite-raising, and before and 1 month after bite-raising. These findings may report that the masticatory performance of the orthodontic banding cement group was decreased after bite-raising, then recovered

after 3 months. On the other hand, the removable posterior biteplate, which established more posterior contact points did not cause a significant change. The significant MPI reduction found after bite-raising by orthodontic banding cement was consistent with that noted in previous studies. Hatch et al. demonstrated a reduction in MPI with a decreased number of functional tooth units and the distribution of functional tooth units might be a relevant factor affecting masticatory performance (67). Moreover, Owens et al. reported that the subjects with larger contact and near contact areas are better able to break down foods (68). We also compared the amount of MPS changes between two methods, and there was no significant difference.

5.4 The effects of the bite-raising on the Masticatory ability

A self-assessed questionnaire to evaluate the masticatory ability was proposed by Kim et al. asks the subject to chew 30 food types selected from general Korean food and rate their ability. They discovered a moderate correlation between the Food Intake Ability (FIA) and the bite force and concluded that the FIA score of the 30 food can be used to evaluate the masticatory function in Korean adults (51). According to Baba et al., the level of reproducibility of the FIA questionnaire was considered 'fair to good' and almost reached for 'excellent' reliability. Furthermore, they suggested that the validity is sufficient to discriminate subjects with different levels of perceived chewing ability in a typical target population (71). The FIA questionnaire used in our study was simplified to 8 different hardness foods with an effort to select the food texture as same as the key foods by those study (51).

The total FIA score and The FIA score for soft food and hard food of removable posterior biteplate and orthodontic banding cement group were reduced immediately after bite raising. These were consistent with the results reported by several investigators (72-74). Choi et al. found that the FIA score was decreased in the patient who has insufficient occlusal contact points (75). The bite-raising method increased the occlusal vertical dimension by adding material between upper and lower teeth, so the contact points were decreased. However, the immediate reduction of the FIA score for both groups did not have any statistical significance in

our study. Even though the biteplate may provide better occlusal contact points than orthodontic banding cement but the large and immediate reduction from the original may result in a similar perception for the patient. Thereafter the FIA score in both groups was restored until there were not significantly different from the initial score. The comparison between two methods showed similar results. These may explain by the compensatory adaptation mechanism (34). Numerous types of changes coming from either the environment or the individual such as dental wear, tooth loss, and occlusal changes result in an increased chewing cycle, an alteration of jaw movement, even in more expression of chewing force until the satisfied mean particle size of the bolus has been reached.

5.5 Benefits of the study

1. Preliminary data of the subject's response after using the bite-raising appliances on how the masticatory performance and masticatory ability will be affected was provided.
2. The orthodontists can instruct the patients with the bite-raising appliance on how their masticatory function would be.

5.6 Clinical application

Our study discovered the indifferent effects to masticatory performance and masticatory ability between the removable posterior biteplate and orthodontic banding cement. When bite-raising method is added from comprehensive fixed orthodontic appliances, other specific factors such as compliance and oral hygiene may be considered as the priority to determine the proper bite-raising method for each patient individually. However, our results are based on 1-3 mm of overbite changes by bite raising; if some other bite raiser height is used, an additional study may be required.

5.7 Limitations and suggestion

1. A study population with greater sample size is needed to determine a clearer picture of the effect of removable posterior biteplate and orthodontic banding cement for bite-raising on masticatory function.
2. Further parameters, including bite force, or occlusal contact areas, should be investigated to compare the findings with median particle size.

Chapter 6

Conclusion

The bite-raising method by removable posterior biteplate and by adding orthodontic banding cement on the occlusal surface of the upper first molars is widely used by orthodontists. For the objective findings, we discovered that orthodontic banding cement could worsen the masticatory performance, but the effect was temporary and recovered within three months. On the other hand, the removable posterior biteplate did not show a significant effect on the masticatory performance. However, both methods did not affect the masticatory performance differently. For the subjective findings, the two bite-raising methods immediately reduced the masticatory ability to chew either hard or soft food. Thereafter the reduction was regained. Similar to the masticatory performance, both methods did not affect the masticatory ability in a different manner.

From the results, these may be the reinforcement to the orthodontist's decision to choose the bite-raising appliance by the particular factors of each patient because the two bite-raising methods did not affect the masticatory function differently. Nonetheless, a further study with larger numbers of participants is required aiming to achieve more clearer picture of the effect of removable posterior biteplate and orthodontic banding cement for bite-raising on masticatory function.

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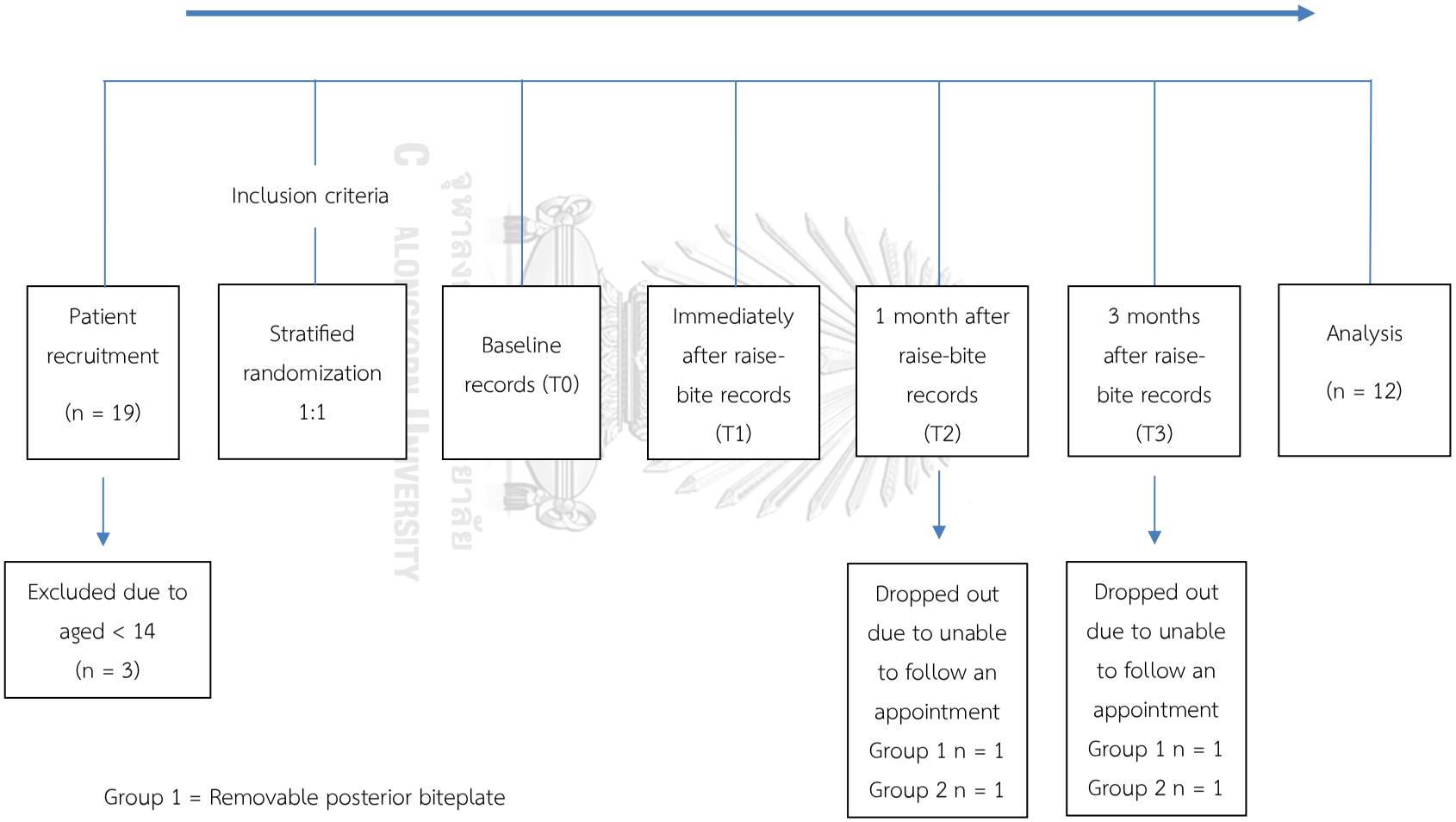
APPENDIX

Appendix 1 Study timeline



Group 1 = Removable posterior biteplate

Group 2 = Orthodontic banding cement

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