ผลของรูปแบบการสบฟันของฟันเทียมทั้งปากต่อสมรรถนะการบดเคี้ยว และแรงสบฟันสูงสุด

นายวีรวัฒน์ นิวัฒเจริญชัยกุล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาทันตกรรมประดิษฐ์ ภาควิชาทันตกรรมประดิษฐ์
คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2555

Effect of complete denture occlusal schemes on masticatory performance and maximum occlusal force

Mr. Weerawat Niwatcharoenchaikul

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Prosthodontics

Department of Prosthodontics

Faculty of Dentistry

Chulalongkorn University

Academic Year 2012

Thesis Title	Effect of complete denture occlusal schemes on masticatory performance and maximum occlusal force
By	Mr. Weerawat Niwatcharoenchaikul
Field of Study	Prosthodontics
Thesis Advisor	Wacharasak Tumrasvin, D.D.S., Ph.D.
Thesis Co-advisor	Associate Professor Mansuang Arksornnukit, D.D.S., M.S., Ph.D.

Accepted by the Faculty of Dentistry, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

…….. Dean of the Faculty of Dentistry

(Assistant Professor Suchit Poolthong, D.D.S., M.S., Ph.D.)

THESIS COMMITTEE

…….. Chairman

(Assistant Professor Prarom Salimee, D.D.S., Ph.D.)

…….. Thesis Advisor

(Wacharasak Tumrasvin , D.D.S, Ph.D.)

…….. Thesis Co-advisor

(Associate Professor Mansuang Arksornnukit, D.D.S., M.S., Ph.D.)

…….. Examiner

(Assistant Professor Niyom Thamrongananskul, D.D.S., Ph.D.)

…….. External Examiner

(Associate Professor Rumpai Rochanakit, D.D.S., M.S.)

วีรวัฒน์ นิวัฒเจริญชัยกุล : ผลของรูปแบบการสบฟันของฟันเทียมทั้งปากต่อสมรรถนะการบดเคี้ยว และแรงสบฟันสูงสุด (EFFECT OF COMPLETE DENTURE OCCLUSAL SCHEMES ON MASTICATORY PERFORMANCE AND MAXIMUM OCCLUSAL FORCE.) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : อ.ทพ.ดร. วัชรศักดิ์ ตุมราศวิน, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม: รศ.ทพ.ดร. แมนสรวง อักษรนุกิจ, 41 หน้า

วัตถุประสงค์ของการศึกษานี้เพื่อประเมินผลของรูปแบบการสบฟันของฟันเทียมทั้งปากสองชนิด ต่อสมรรถนะการบดเคี้ยวและแรงสบฟันสูงสุด โดยรูปแบบการสบฟันของฟันเทียมทั้ง-ปากสองชนิด คือ การสบฟันแบบได้ดุลสองข้างและการสบฟันแบบนิวโทรเซนทริก โดยสุ่มให้กับผู้ป่วยไร้ฟันจำนวน 10 คน แบ่งเป็นผู้ป่วยชาย 6 คนและผู้ป่วยหญิง 4 คน มีอายุเฉลี่ย 67.3 ปี ที่เข้ามารับการรักษาเพื่อใส่ฟันเทียมทั้งปาก ที่คลินิกบัณฑิตศึกษาภาควิชาทันตกรรมประดิษฐ์ คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ซึ่งการทดสอบสมรรถนะการบดเคี้ยวทำโดยวิธีการร่อนสารด้วยตะแกรงร่อนหลายตะแกรงและการทดสอบแรงสบฟันสูงสุดโดยการวัดแรงกัดบนแผ่นฟิล์มเดนทัลพรีสเกล เมื่อทำการบันทึกผลการทดลองในรูปแบบการสบฟันชุดแรกเสร็จสิ้น แล้วจะทำการเปลี่ยนรูปแบบการสบฟันเป็นแบบที่สองบนฐานฟันเทียมเดิม และทำการทดสอบเช่นเดียวกัน ผลการทดสอบพบว่า รูปแบบการสบฟันทั้งสองชนิด มีสมรรถนะการบดเคี้ยวแตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ ($p=0.07$) โดยเมื่อเพิ่มจำนวนครั้งการบดเคี้ยวในฟันเทียมทั้งปากที่มีรูปแบบการสบฟันทั้งสองแบบ พบว่าสมรรถนะการบดเคี้ยวเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.001$) อีกทั้งรูปแบบการสบฟันทั้งสองชนิด มีแรงสบฟันสูงสุดแตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ ($p=0.31$) สรุปได้ว่าฟันเทียมทั้งปากที่มีรูปแบบการสบฟันแบบได้ดุลสองข้างและการสบฟันแบบนิวโทรเซนทริก มีสมรรถนะการบดเคี้ยวและแรงสบฟันสูงสุดไม่แตกต่างกัน อย่างไรก็ตามเมื่อเพิ่มจำนวนครั้งการบดเคี้ยวจะให้สมรรถนะการบดเคี้ยวที่ดีขึ้นอีก สำหรับการประยุกต์ใช้ในทางคลินิก ฟันเทียมทั้งปากที่มีรูปแบบการสบฟันแบบนิวโทรเซนทริก ซึ่งให้สมรรถนะการบดเคี้ยวและแรงสบฟันสูงสุดเหมือนฟันเทียมทั้งปากที่มีรูปแบบการสบฟันแบบได้ดุลสองข้าง อย่างไรก็ตามในผู้ป่วยที่ใส่ฟันเทียมทั้งปากควรได้รับคำแนะนำให้เคี้ยวอาหารด้วยจำนวนครั้งการบดเคี้ยวที่มากที่สุดเพื่อให้เกิดความสามารถในการบดเคี้ยวที่ดีกว่า

ภาควิชา ทันตกรรมประดิษฐ์ ลายมือชื่อนิสิต.....

สาขาวิชา ทันตกรรมประดิษฐ์ ลายมือชื่อ อ. ที่ปรึกษาวิทยานิพนธ์หลัก.....

ปีการศึกษา 2555 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม.....

5276132332: MAJOR PROSTHODONTICS

KEYWORDS: COMPLETE DENTURE / MAXIMUM OCCLUSAL FORCE / MASTICATORY PERFORMANCE / NUMBERS OF CHEWING STROKE / OCCULSAL SCHEMES

WEERAWAT NIWATCHAROENCHAIKUL: EFFECT OF COMPLETE DENTURE OCCLUSAL SCHEMES ON MASTICATORY PERFORMANCE AND MAXIMUM OCCLUSAL FORCE. ADVISOR: WACHARASAK TUMRASVIN, D.D.S., Ph.D. CO-ADVISOR: ASSOC.PROF. MANSUANG ARKSORNNUKIT, D.D.S., M.S., Ph.D., 41 pp.

The aims of this study were to evaluate the effect of two complete denture occlusal schemes on masticatory performance and maximum occlusal force. Two complete dentures occlusal schemes, bilateral balanced occlusion and neutrocentric occlusion, were randomly delivered to 10 fully edentulous subjects (6 males and 4 females with the mean age of 67.3 years old), were referred to graduate prosthodontic clinic at Faculty of dentistry, Chulalongkorn University. The masticatory performance and the maximum occlusal force were obtained using multiple sieve method and pressure sensitive film respectively. Two occlusal schemes were interchanged on the intra-individual denture base. The tests were repeated similarly. Results showed both occlusal schemes demonstrated no significant differences on masticatory performance ($p=0.07$). The increasing of chewing strokes of both occlusal schemes showed significant differences on masticatory performance ($p<0.001$). Both occlusal schemes demonstrated no significant differences on maximum occlusal force ($p=0.31$). In conclusion, complete denture with bilateral balanced occlusion and neutrocentric occlusion demonstrated no significant differences on masticatory performance and maximum occlusal force. However, the more chewing strokes showed better masticatory performance. For clinical implication, Neutrocentric occlusion rendered the same masticatory performance and maximum occlusal force as the golden standard bilateral balanced occlusion. However, the complete denture wearers should be instructed to apply more chewing strokes for a better chewing ability.

Department: Prosthodontics Student's Signature……

Field of study: Prosthodontics Advisor's Signature……

Academic Year: 2012 Co-advisor's Signature……

ACKNOWLEDGEMENTS

I am grateful to Prosthodontics department of Chulalongkorn University for giving me a chance to study in Master program. For 4 years, I have learnt so many things with the excellent experts.

I would like to express my gratitude to all those who support me the possibility to complete this thesis. I thanks to Dr. Wacharasak Tumrasvin for his advice, encouragement, guidance, kindly assisted and continuous support from the initial until I complete this research project.

I am extremely my sincere gratitude to Associate Professor Dr. Mansuang Arksornnukit for his valuables guidance, advice and suggestions. This thesis would not have been finished without him.

Special thanks to my thesis committee members; Assistant Professor Dr. Prarom Salimee, Assistant Professor Dr. Niyom Thamrongananskul, Associate Professor Rumpai Rochanakit for their suggestions.

I am thankful to Assistant Professor Paipan Bidhyanon for her advice and suggestions of the statistical analysis for this experiment.

This study was supported by Chulalongkorn University Centenary Academic Development Project.

CONTENTS

Page

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Population in several countries shift to aging society. This is also applied to developing countries. There are many complete edentulism patients who need complete denture. The complete denture was necessary to restore speech, esthetic and chewing ability. It was stated that complete denture occlusal schemes promoted the denture with retention, stability and support which reflected the psychological comfort and longevity of denture.[1,2]As decreasing chewing ability was found in edentulism patients, thus fabricating the complete denture that be able to produce a high chewing ability should be considered. Occlusal schemes were the one factor that remain unclear in relation to chewing ability. There are various philosophies in complete denture occlusal scheme such as bilateral balanced occlusion, neutrocentric occlusion and lingualized occlusion.[2]Bilateral balanced occlusion provides multiple contact points during excursive movement to distribute the horizontal force. Patients who presented with deviated jaw relationship from ideal Ankle's classification I may encounter some problems in fully obtaining bilateral balanced occlusion benefits.[2] De Van proposed neutrocentric occlusion that utilized zero degree cusp teeth to balance the incline, to centralize the masticatory force and to overcome the difficulty in obtaining accurate jaw relation.[3] Moreover, it has been shown recently that zero cusp teeth generates less pressure transmission than cusp teeth.[4] In previous studies, there are controversy of the results of studies between chewing ability and occlusal schemes in complete denture wearers. This may be the result of the problems of study designs using compare the chewing ability between different occlusal schemes. Some studies compared different occlusal scheme by different groups.[5-11] It was doubts of studies about the difference in individual's chewing ability. The others studies tried to control

individual's chewing ability by comparing two sets of complete denture and occlusal schemes for the intra-individual patient.[12-15] It was doubts of studies about denture quality. However, there were not many studies that compared the chewing ability between different occlusal scheme for the intra-individual patient using the same denture base.[16-18] In view of the background, the aims of the study were to evaluate the effect of complete denture occlusal schemes on chewing ability in the intra-individual patient using the same denture base.

RESEARCH QUESTIONS

1. Do the different two types of occlusal schemes in complete denture affect masticatory performance?
2. Do the different two types of occlusal schemes in complete denture affect maximum occlusal force?
3. Do the numbers of chewing stroke in complete denture affect masticatory performance?

RESEARCH OBJECTIVES

1. To study the influence of complete denture occlusal schemes (Bilateral balance occlusion and Neutrocentric occlusion) on the masticatory performance and maximum occlusal force
2. To study the influence of numbers of chewing stroke on the masticatory performance

RESEARCH HYPOTHESES

1. Ho_1: The different occlusal schemes in complete denture do not affect masticatory performance.

   Ha_1: The different occlusal schemes in complete denture affect masticatory performance.

2. Ho_2: The different occlusal schemes in complete denture do not affect maximum occlusal force.

   Ha_2: The different occlusal schemes in complete denture affect maximum occlusal force.

3. Ho_3: The different chewing strokes in complete denture do not affect masticatory performance.

   Ha_3: The different chewing strokes in complete denture affect masticatory performance.

KEY WORDS: complete denture, maximum occlusal force, masticatory performance, numbers of chewing stroke, occlusal schemes

RESEARCH DESIGN

Clinical research and Laboratory experimental research

EXPECTED BENEFITS

This knowledge will lead to know the difference on masticatory performance and maximum occlusal force with different complete denture occlusal schemes. It will benefits to select the optimal complete denture occlusal schemes for edentulism patients.

CHAPTER II

REVIEW OF RELATED LITERATURES

Chewing ability is defined as the ability to break down the foods. There are two specific methods used to evaluate chewing ability[19]; the subjective and the objective methods. The subjective method uses a questionnaire to evaluate the chewing ability. The objective method using armamentarium and experiment in laboratory. The standard objective method is masticatory performance test proposed by Manly and Braley.[20] The masticatory performance was defined as the percentage ratio of test food size distribution caused by comminution at the certain number of chewing strokes.[5] The sieve size can be one[20] or multiple.[21] The maximum occlusal force was also considered as the other objective evaluations depicting the quality and performance of denture. This was registered by force transducer or pressure sensitive sheet (Dental prescale).[7,22,23] It was used to evaluate chewing ability which was directly related to the masticatory performance.[8,9,22-25]

Decreasing in chewing ability was observed in edentulism patient compared to dentate population.[6] Other factors, such as age, gender, personality type, denture experience, denture quality and occlusal schemes, also affected the chewing ability.[26] Masticatory performance was quite comparable in population aged between 35 to 75 years.[27]Effect of gender on masticatory performance and maximum occlusal force were different in natural dentition, while gender demonstrated significant on masticatory performance and occlusal force in complete denture wearer.[8] It was demonstrated that denture experience induced chewing ability.[27] The improvement in denture quality significantly affected masticatory performance and occlusal force in complete denture wearer.[25,28,29] The less number of natural teeth directly decreased chewing ability.[19] In elderly patients, most of them were observed to have natural tooth loss.[19] The maximum

value of masticatory performance and maximum occlusal force were observed in natural dentition. The removable partial denture and the complete denture wearer showed lower and the lowest masticatory performance and maximum occlusal force compared to natural dentition respectively.[8]

Several investigators have studied the effect of occlusal scheme on chewing ability, both objectively and subjectively. However, the controversy in various subject groups had not been well-controlled. Some studies compared two subject groups independently, each group was designed to use only one occlusal scheme.[5-11] Kimoto reported that no significant difference in patient's satisfaction and masticatory performance between bilateral balanced occlusion and lingualized occlusion. The study compared the two groups of participant with different occlusal schemes.[9] It might be errors from the difference in individual's chewing ability.

However, the other studies tried to control individual's chewing ability by comparing two sets of complete denture and occlusal schemes for the intra-individual patient.[12-15] There were two methods, which used to change occlusal schemes in the intra-individual patient. The first method is the duplication of denture base with different occlusal schemes. Brewer studied in patient satisfaction with 25 patients who used two sets of duplicated denture. The result showed the denture with non-anatomic teeth had greater patient's satisfaction than the denture with anatomic teeth.[15] Clough studied chewing ability using questionnaire. In the study, each patient received two sets of duplicated denture. The study showed the denture with lingualized occlusion had higher satisfisfaction score than the denture with neutrocentric occlusion.[12] Shetty studied 40 Africans who used two sets of duplicated denture. The study concluded that the denture with anatomic teeth had greater patient satisfaction than the denture with non-anatomic teeth.[14] Sutton used three sets of duplicated denture with bilateral balanced occlusion,

neutrocentric occlusion and lingualized occlusion to study patient satisfaction, sore spot, comfort. The study found the denture with bilateral balanced occlusion showed the highest patient's satisfaction.[13]The error of these previous studies from intaglio surface of different denture base and changes in vertical dimension from duplicated denture.

The relationship between denture quality and chewing ability had been also reported. The improved quality of complete denture induced more comfort in chewing, increase chewing ability, and more of food choices. Furthermore, good denture quality applied fewer chewing strokes and faster chewing than poor quality denture that referred to the better chewing.[28]

The second method is the modification of occlusal scheme in the same denture base such as grinding or adding artificial teeth, interchanging technique.[13,30] the interchangeable teeth with occlusal index was introduced by Khamis (Fig 2.1).[30] It might be repeated to fabricate any number of posterior teeth with the same vertical dimension and maxillomandibular relationship.

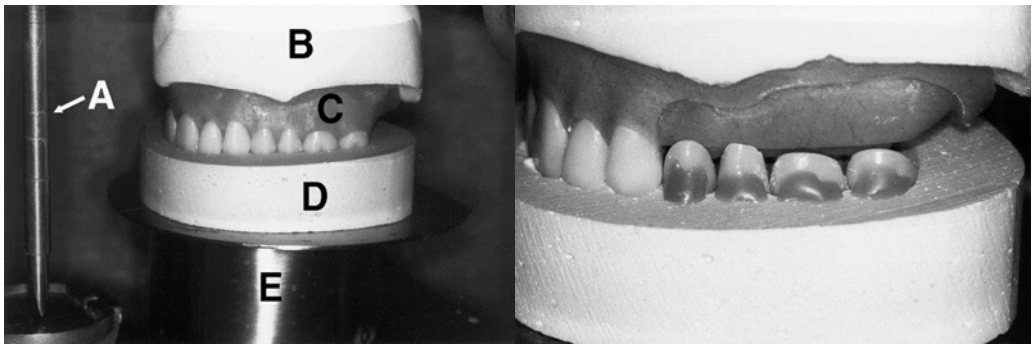

Figure 2.1 The interchanging technique with occlusal index.A, incisal pin; B, maxillary master cast; C, waxed trial denture; and D, occlusal index

The studies in the intra-individual patient with the same denture base were performed. Trapozzano compared masticatory performance between 20 degree and 0

degree cusp teeth. It was found that the denture with 20 degree cusp teeth, had greater masticatory performance than the denture with 0 degree cusp teeth.[17] Studied on three different cusp angle in five patients with the same denture base showed no significant differences in masticatory performance by sieve method.[16] 33 degree cusp teeth and lingualized occlusion were also demonstrated insignificant difference on masticatory performance using sieve method and interchanging technique.[18] However, there were only three studies that compared the chewing ability between different occlusal schemes, of the intra-individual patient using the same denture base.[16-18]

At present, bilateral balanced occlusion and neutrocentric occlusion are often used for fabricating complete denture in Thailand. However, which type of occlusal schemes provides better chewing ability for the complete denture wearer remains unclear. There were only three studies in masticatory performance and maximum occlusal force between bilateral balanced occlusion and neutrocentric occlusion. The aims of this study were to evaluate the effect of complete denture occlusal schemes, bilateral balanced occlusion and neutrocentric occlusion, on masticatory performance and maximum occlusal force using the same denture base in the intra-individual patient.

CHAPTER III

RESEARCH METHODOLOGY

Ten participants (6 males and 4 females with the mean age of 67.3 years) were recruited in this study. All participants classified as ACP classification I and II totally edentulous[31], were referred to Graduate prosthodontic clinic at Faculty of Dentistry, Chulalongkorn University. The study protocol was approved by the Research Ethical Committee of Chulalongkorn University, Faculty of Dentistry (No. 021/2011). The written informed consent was obtained from the subjects after a detailed explanation of the study prior to the study.

Table 2.1 Checklist for ACP classification I and II.

	Class I	Class II
Bone height-mandibular	21 mm or greater	16-20 mm
Residual ridge morphology-maxilla	Type A – resists vertical and horizontal, hamular notch, no tori	Type B – no buccal vestibule, no hamular notch, no tori
Muscle attachments-mandibular	Type A – adequate attached mucosa	Type B – no buccal attached mucosa
Maxillomandibular relationship	Class I	Class I
Oral menifestations of systemic disease	No	Mild

Two occlusal schemes, bilateral balanced occlusion and neutrocentric occlusion, were studied. For each patient, the first occlusal scheme was randomly selected and delivered. The masticatory performance test using multiple sieve method for 20, 40, 60 of chewing strokes and maximum occlusal force using pressure sensitive film were done after 2 months after denture delivery. Another occlusal scheme was interchanged on the same denture base by modified Khamis method (Fig 2.2),[30] the patient underwent the same protocol after denture delivery.

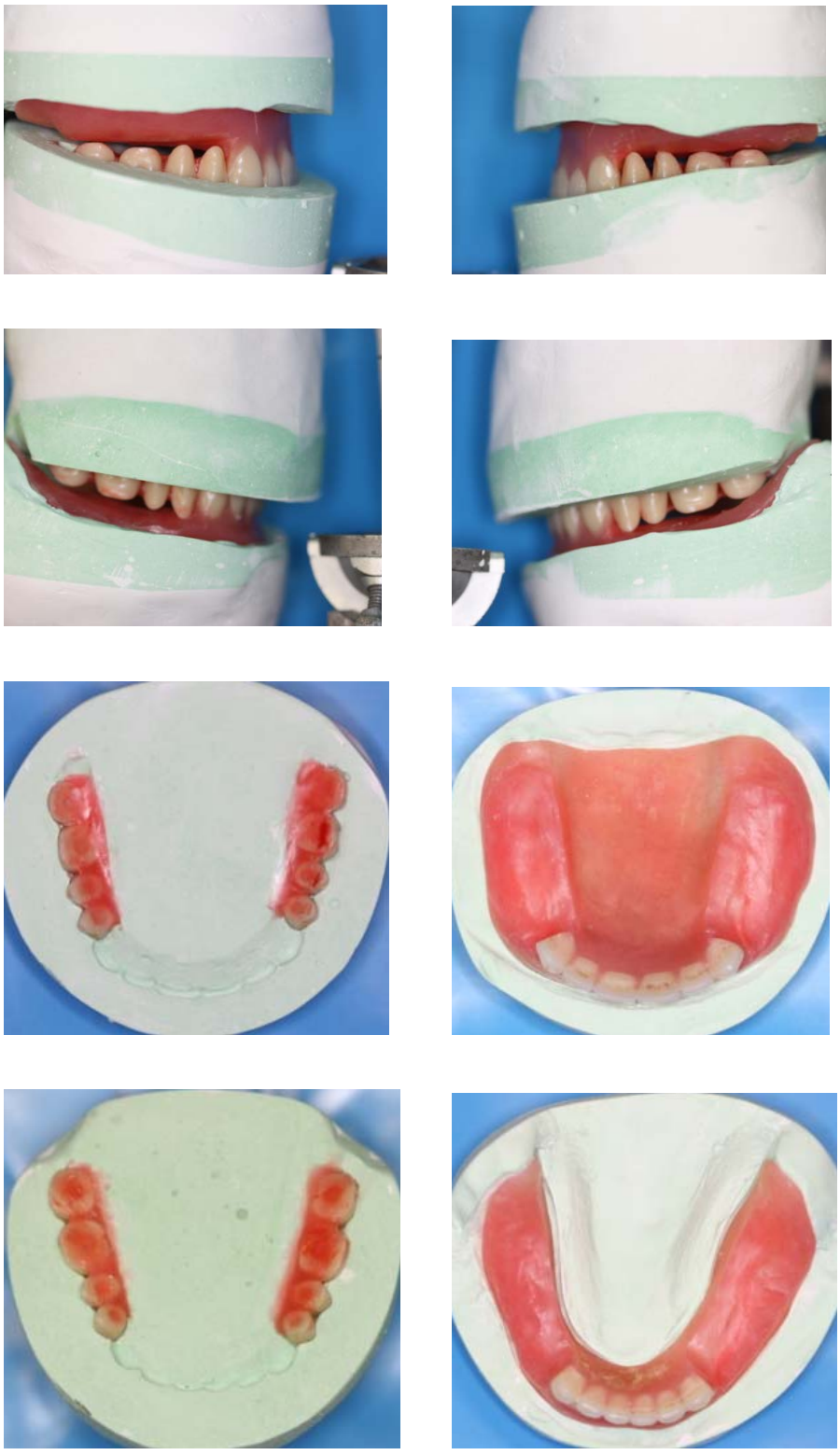

Figure 2.2 Modified Khamis method was used to interchange to the other occlusal scheme.

Before the tests, the maxillary and mandibular dentures were confirmed for denture quality using the Kapur method (Table 2.2).[10]

Table 2.2 Kapur method used for scoring denture retention and stability.

Score	Retention	Stability
0	No retention. When a denture is seated in its place, it displaces itself	No stability. When a denture base demonstrates extreme rocking on its supporting structures under pressure
1	Minimum retention. When a denture offers slight resistance to vertical pull and little or no resistance to lateral force	Some stability. When a denture base demonstrates moderate rocking on its supporting structures under pressure
2	Moderate retention. When the denture offers moderate resistance to vertical pull and little or no resistance to lateral force	Sufficient stability. When a denture base demonstrates slight or no rocking on its supporting structures under pressure
3	Good retention. When a denture offers maximum resistance to vertical pull, and sufficient resistance to lateral force	

Clinically poor dentures = sum score of <6

Clinically fair dentures = sum score of 6-8

Clinically good dentures = sum score of >8

Prior to the test, each denture was scored separately for its retention and stability using Kapur method. The scores of denture quality were ranged in 0-5. The sum score of maxillary and mandibular denture of 6 or more was determined as clinically satisfactory and accepted in the study.

Evaluation of chewing ability

Masticatory performance: multiple sieve method[7,8,11,20,21]

The sieving method is used to evaluate masticatory performance, which is based upon internationally-accepted standard sieving method. The patients were assigned to chew test foods in the numbers of stroke. Masticatory performance was evaluated by the distribution of particles of a comminuted food in a series of sieves of chewing tests. The reproducible results were the median particle size. The median particle size was used to compare difference in efficiency of comminution of food between the subjects.

Experimental procedure

The subjects were positioned in the upright position in a chair. Each subject was asked to chew in a habitual way and was instructed to chew peanuts weigh 3 grams in 20 strokes and then repeated the step 3 times, with 1 minute resting during each time. The tested food was collected after 20 chewing strokes into the collection cup. The test of 40, 60 chewing strokes were carried out in the same manners. The tested food after each number of chewing strokes were pooled and dried 24 hours in the incubator at 37°C. The performance was measured by dividing the weight of the test food passing

through 12 standard sieves (Retcsh Technology GmbH, Hann, Germany) including size 5.6, 4.75, 4, 3.55, 3.35, 3.15, 2.8, 2, 1.4, 1, 0.5, 0.25 mm in diameter (the number and size of sieve mesh were determined by pilot study) with vibratory sieve shaker AS 200 digit (Retcsh Technology GmbH) at 70 Hz for 3 minutes (Fig. 2.3).

Figure 2.3 Sieve mesh and vibratory sieve shaker was used to select and collect comminuted peanuts (Available from: http://www.retsch.com/products/sieving/sieve-shakers/as-200-digit)

Table 2.3 Vibratory Sieve Shaker AS 200 digit. (Available from: http://www.retsch.com/products/sieving/sieve-shakers/as-200-digit)

Performance data	AS 200 digit
Applications	separation, fractioning, particle size determination
Application examples	Chemicals, coffee, nuts, sand, seeds
Measuring range	20 µm - 25 mm
Product advantage	Suitable for dry and wet sieving Excellent separation efficiency even with short sieving time

Tested food retained on each sieve was used to calculate the cumulative weight percentage. The formula of weight percent is follows:

Weight percent = {mass retained on each sieve/total sample mass}*100

The median particle size was calculated by plotting the cumulative weight percentages of comminuted food that passed through each sieve using Microsoft Excel. The median particle size is the theoretical sieve size that 50 percents comminuted food weight can pass. Therefore, the smaller median particle size shows the better chewing ability.

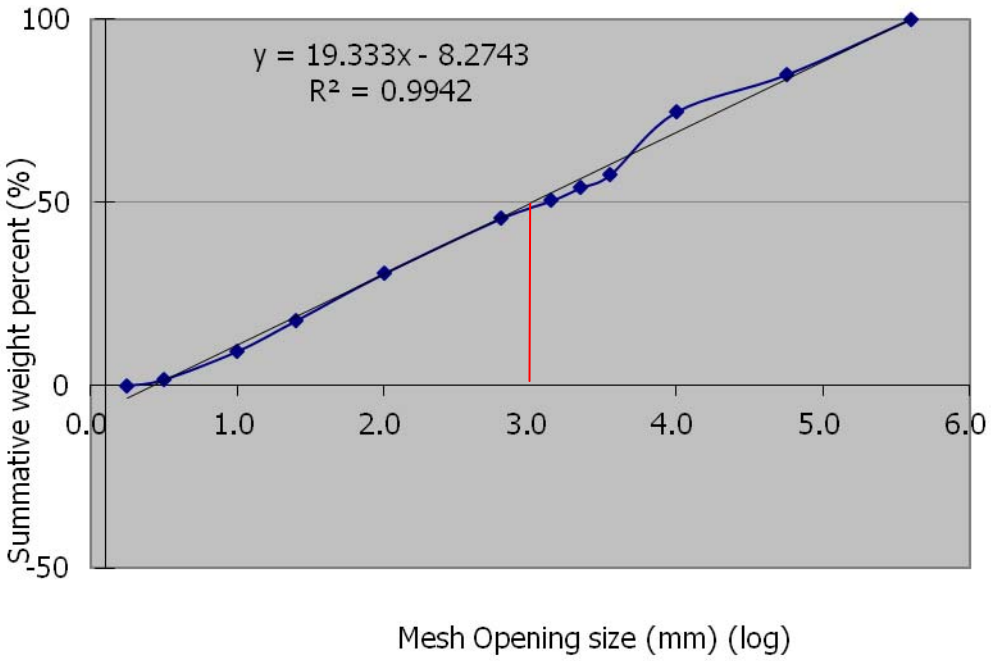

Figure 2.4 Plotting the cumulative weight percentages of comminuted food that passed through each sieve for evaluation the median particle size

Maximum Occlusal force[7,22,23]

Maximum occlusal force were measured with horseshoe-shaped pressure-sensitive films (Dental Prescale 50H, R type, Fujifilm, Tokyo, Japan) (Fig 2.3) which measured force in full arch of complete denture. Color variation and area depend on the amount of applied pressure within a range of 5 to 120 MPa. Each subject was positioned in the upright position. The subjects were asked to bite the pressure-sensitive film that positioned between dental arches of complete denture with maximum clenching in the intercuspal position for 5 seconds. The procedure was performed 3 times. The imprinting of occlusion on the film was analyzed by a computerized image scanner (Occluzer FPD705, Fujifilm). The three readings were their averaged. The system analyzed occlusal force and contact area by measuring density and area of the color.

Figure 2.5 Dental prescales were used to evaluate maximum occlusal force

Figure 2.6 The patients were asked to bite the dental prescale with maximum clenching

Statistical analysis

The data were analyzed by the statistic package for the social science version 17 (SPSS, Chicago, IL). Shapiro-Wilk was used to confirm the normality of masticatory performance data since the number of sample were less than 30. The masticatory performance data was analyzed by the SigmaStat 2.03 (Systat Software Inc., San Jose, CA). All of the statistic analysis, a P-value below 0.05 was considered statistically significant.

To study effect on masticatory performance with normal distribution of means of data, as the data of masticatory performance is a ratio scale (median particle size: millimeter). The 2-way repeated measure ANOVA was used to detect the significant of masticatory performance on two main effects of occlusal schemes (bilateral balance occlusion and neutrocentric occlusion) and numbers of chewing stroke within the intra-individual patient. The 1-way repeated measurement ANOVA was used to detect the significant differences of chewing strokes of each occlusal schemes. Tukey's Honestly Significant Difference (HSD) test was used for post hoc multiple comparison.

The paired T test was used to compare the maximum occlusal force between bilateral balance occlusion and neutrocentric occlusion.

CHAPTER IV

RESULTS

Masticatory performance test

The means and standard deviation of median particle size are shown in Figure 2.7

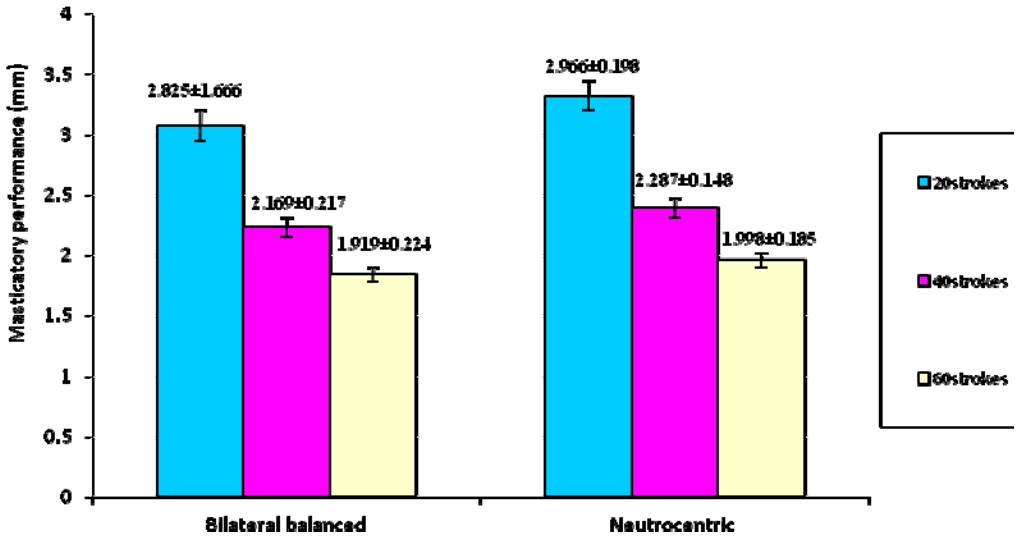

Figure 2.7 The means and standard deviations of the median particle size in each occlusal scheme and numbers of chewing stroke.

Bilateral balanced occlusion exhibited a similar pattern of the median particle size as neutrocentric occlusion. However, increasing in chewing strokes resulted in smaller median particle size

The 2-way repeated measure ANOVA suggested no interaction between occlusal schemes and chewing strokes. The complete denture using bilateral balanced occlusion showed no statistically significant difference comparing to the complete denture using neutrocentric occlusion of equal chewing strokes ($p=0.072$). The increase numbers of chewing stroke were significantly higher in the masticatory performance ($p<0.001$). Tukey's HSD showed statistically significant difference for increasing chewing strokes from 20 to 60 both bilateral balanced and neutrocentric groups. Both occlusal schemes, the masticatory performance of 60 chewing strokes were significantly higher than the masticatory performance of 20, 40 chewing strokes, and the masticatory performance of 40 chewing strokes were significantly higher than the masticatory performance of 20 chewing strokes.

Table 2.4 Masticatory performance of two complete denture occlusal schemes.

Masticatory performance	Statistically significant difference
20 chewing strokes of bilateral balanced occlusion : 20 chewing strokes of neutrocentric occlusion	P = 0.395
40 chewing strokes of bilateral balanced occlusion : 40 chewing strokes of neutrocentric occlusion	P = 0.609
60 chewing strokes of bilateral balanced occlusion : 60 chewing strokes of neutrocentric occlusion	P = 0.885

Table 2.5 Masticatory performance when increasing of numbers of chewing stroke.

Masticatory performance	Statistically significant difference	
	Bilateral balanced occlusion	Neutrocentric occlusion
20 : 40 chewing strokes	<0.001	<0.001
20 : 60 chewing strokes	<0.001	<0.001
40 : 60 chewing strokes	0.017	0.004

Maximum occlusal force

Maximum occlusal force was related to masticatory performance, the means and standard deviation of maximum occlusal force are shown in Figure 2.8.

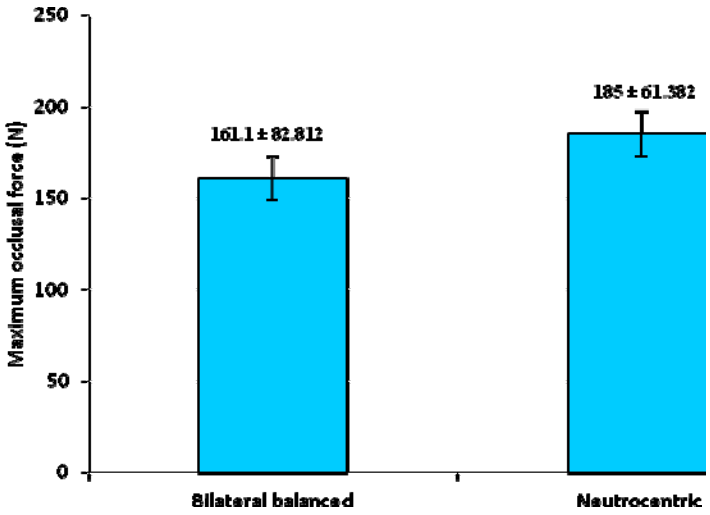

Figure 2.8 The means and standard deviations of maximum occlusal force

Paired T test shows no statistic significant differences in maximum occlusal force between the two different occlusal schemes (p=0.310).

Table 2.6 Maximum occlusal force of two complete denture occlusal schemes.

Maximum occlusal force	Statistically significant difference
Bilateral balanced occlusion : Neutrocentric occlusion	P=0.310

CHAPTER V

DISCUSSION AND CONCLUSION

DISCUSSION

In this study, the chewing ability was determined by masticatory performance and maximum occlusal force. When the masticatory tests were completed, the interaction between occlusal schemes and number of chewing strokes on masticatory performance were not observed.

Statistic analysis showed no statistically significant difference on masticatory performance between bilateral balanced occlusion and neutrocentric occlusion. This support the finding of the previous studies .[16,18] Therefore, the null first hypothesis was accepted. It could be assumed that occlusal scheme did not affect the masticatory performance in the intra-individual patient. With different occlusal schemes, the chewing pattern, tone of masticatory muscle and the preparation of food bolus onto the occlusal surface of denture teeth may not change in the intra-individual patient. In addition, the important factors on masticatory performance were well controlled; ten participants were comparable in range 35-75 years old. Ridge quality and oral status were selected based on ACP classification I and II. The dentures were fabricated by only one prosthodontist. Moreover, this might also result from the higher score of Kapur evaluation which depicted the good denture quality in terms of retention and stability. The interchangeable teeth technique used to fabricate the complete denture by replacing posterior teeth in the same denture base also resulted in unchanges of vertical dimension and maxillomandibular relationship.

When comparing masticatory performance with different of numbers of chewing strokes, interesting results were observed. The masticatory performance indicated statistically significant when increased numbers of chewing strokes. In both bilateral balanced occlusion and neutrocentric occlusion, the increasing in number of chewing strokes yielded a better masticatory performance. Although the recommended chewing stroke utilized for masticatory performance test, by peanuts as a test food, were 20.[5] In this study, both bilateral balanced occlusion and neutrocentric occlusion, showed higher masticatory performance when increasing the chewing strokes from 20 to 60 chewing strokes because food was comminuted until it could be further processed into selection, comminution and fragment of the food particles. The results showed that the more number of chewing strokes should be recommended to patients when complete denture was delivered.

In this study, the roasted peanut was used as a test food for masticatory performance test because the comminution of the particle was easily done during chewing. The absorbed water could be easily eliminated than using carrot as test food. The agglomerate of comminuted particle can be separated for evaluation by sieving procedures.[17]However, the results of masticatory performance test with the sticky natural food such as meat, vegetables may differ from this study. The cusp teeth may chew easier than zero degree cusp teeth.

In this study, the maximum occlusal forces that obtained from occlusal table of denture teeth were observed. Both bilateral balanced occlusion and neutrocentric occlusion showed no significant differences on maximum occlusal force observed by the dental prescale. The dental prescale is a pressure sensitive thin film that calculated the sum of force of all surface contacts in complete denture, which optimal usage in the occlusal force test as the complete denture is one unit. The approach did not require specific armamentarium and timing. The dental prescale is minor changes in vertical

dimension during clenching resulted from the thickness of the prescale sheet that would not affect maximum occlusal force compared with original force transducer. It had been shown that the change in vertical dimension affected occlusal force.[22,24,25]

This study was conducted on a small sample size due to the limitation of study design. The study was a controlled longitudinal clinical study, subjects were treated with 2 well constructed complete denture occlusal scheme by single experienced prosthodontist to ensure the consistency of constructing procedure. Moreover, numbers of subject with qualified fully edentulous arches who can participate entirely study procedure were limited. The chewing ability of complete denture was investigated by considering in several related factors that could affect the individual patient chewing ability. Initially, according to the previous studies, complete denture wearers with a low mandibular ridge height (≤ 15 mm) performed lower masticatory performance and occlusal force than those with a high mandibular ridge height (≥ 16mm).[9,24] The subjects of this study were limited to American college of prosthodontic(ACP 1999) classification I and II totally edentulous patients.[31] Within this limitation, their mandibular ridge height were higher than sixteen millimeters, for controlling of oral condition and ridge condition. Poorly fitting denture showed a lower level of masticatory performance and occlusal force than well-fitting denture.[25,28,29] For this study, the modified Kapur method was used to comfirm the denture quality before start the measurements.[10] This ensured the optimal retention, stability and support of dentures prior to the masticatory performance test and occlusal force test. This study was investigated using intra-individual patient for controlling any individual differences and denture experience.

The first occlusal scheme was randomly delivered, to control bias from adaptability in the first occlusal scheme. The second occlusal scheme was fabricated on the same denture base with interchanging technique using occlusal index, modified by the Khamis method.[30] The reliability of the tissue surface of denture was ensured by

this technique. This technique can be repeated to generate the second occlusal scheme on the original maxillary and mandibular denture base with the same maxillomandibular horizontal and vertical relationship.

Although, the other studies that used subjective method to evaluate the chewing ability between the different occlusal schemes reported inconsistent result.[12-15,17] The better occlusal scheme by patient preference could not indicate the better masticatory performance that measured objectively. The present study evaluated masticatory performance and maximum occlusal force by objective method. Further objective studies concurrent with the subjective studies would be beneficial for evaluating masticatory performance and patient's preference. With the well-fitted and well-constructed complete denture, the masticatory performance and maximum occlusal force were not significantly different regardless of the two occlusal schemes tested in this study.For clinical implication, neutrocentric occlusion can be advocated in the patient with difficulty in obtain accurate centric relation record and incompatible of arch size. However, the complete denture wearers should be instructed to apply more chewing strokes for a better chewing ability.

Conclusions

Within the limitation of this study, the following conclusions were drawn

1. For ACP classification I and II totally edentulous, both occlusal schemes with good denture quality (Kapur ≥score 6) demonstrated no significant differences on masticatory performance ($p = 0.07$) and maximum occlusal force ($p = 0.31$)
2. Both occlusal schemes, the number of chewing strokes of 60 showed better masticatory performance than 20 chewing stroke ($p < 0.001$).

REFERENCES

[1] Jacobson, T.E., and Krol, A.J. A contemporary review of the factors involved in complete denture retention, stability, and support. Part I: Retention. J Prosthet Dent. 49(1983):49:5-15.

[2] Jacobson, T.E., and Krol, A.J. A contemporary review of the factors involved in complete denture retention, stability, and support. Part II: Stability. J Prosthet Dent. 49(1983):165-172.

[3] DeVan, M.M. Concept of Neutrocentric occlusion. J Am Dent Assoc. 48(1954):165-169.

[4] Arksornnukit, M., Phunthikaphadr, T., and Takahashi, H. Pressure transmission and distribution under denture bases using denture teeth with different materials and cuspal angulations. J Prosthet Dent. 105(2011):127-136.

[5] Kapur, K.K.,and Soman S.D. Masticatory performance and efficiency in denture wearers. J Prosthet Dent. 14(1964):687-694.

[6] Brudevold, F. A Basic study of the chewing forces of a denture wearer. J Am Dent Assoc. 43(1951):45-51.

[7] Kerem, A., Ufuk, H., and Tatsuya, S. Masticatory performance, maximum occlusal force and occlusal contact area in patients with bilaterally missing molars and distal extension removable partial dentures. Int J Prosthodont. 22(2009):204-209.

[8] Yamashita, S., Sakai, S., Hatch, J.P., and Rugh, J.D. Relationship between oral function and occlusal support in denture wearers. J Oral Rehabil. 27(2000):881-886.

[9] Kimoto, S. et al. Prospective Clinical trial comparing lingualized occlusion to bilateral balanced occlusion in complete dentures: A Pilot Study. Int J Prosthodont. 19(2006):103-109.

[10] Kapur, K.K. A clinical evaluation of denture adhesives. J Prosthet Dent. 18(1967):550-558.

[11] Demers, M., Bourdages, J., Brodeur, J.M., and Benigeri, M. Indicators of masticatory performance among elderly complete denture wearers. J Prosthet Dent. 75(1996):188-193.

[12] Clough, H.E., Knodle, J.M., Leeper, S.H., Pudwill, M.L., and Taylor, D.T. A comparison of lingualized occlusion and monoplane occlusion in complete dentures. J Prosthet Dent. 50(1983):176-179.

[13] Sutton, A.F., Worthington, H.V.,and McCord, J.F. RCT comparing posterior occlusal forms for complete denture. J Dent Res. 86(2007):651-655.

[14] Shetty, N.S. Comparative observations of the use of cusp and zero-degree posterior teeth. J Prosthet Dent. 51(1984):459-460.

[15] Brewer, A.A., Reibel, P.R., and Nassif, N.J. Comparison of zero degree teeth and anatomic teeth on complete dentures. J Prosthet Dent. 17(1967):28-35.

[16] Kydd, W.L. The comminuting efficiency of varied occlusal tooth form and the associated deformation of the complete denture base. J Am Dent Assoc. 61(1960):465-471.

[17] Trapozzano, V.R. et al. An experimental study of the testing of occlusal patterns on the same denture bases. J Prosthet Dent. 2(1952):440-457.

[18] Koyama, M., Inaba, S., and Yokoyama, K. Quest for ideal occlusal patterns for complete dentures. J Prosthet Dent. 35(1976):620-623.

[19] Carlson, G.E. Masticatory efficiency: the effect of age, the loss of teeth and prosthetic rehabilitation. Int Dent J. 34(1984):93-97.

[20] Manly, R.S., and Braley, L.C. Masticatory performance and efficiency. J Dent Res. 29(1950):448-462.

[21] Olthoff, L.W., Van Der Bilt, A., Bosman, F., and Kleizen, H.H. Distribution of particle sizes in food comminuted by human mastication. Archs Oral Biol. 29(1984):899-903.

[22] Okiyama, S., Ikebe, K., and Nokubi, T., Association between masticatory performance and maximal occlusal force in young man. J Oral Rehabil. 30(2003):278-282.

[23] Tumrasvin, W., Fueki, K., and Ohyama, T. Factors associated with masticatory performance in unilateral distal extension removable partial denture patient. J Prosthodont. 15(2006):25-31.

[24] Fontijn-Tekamp, F.A., Slagter, A.P., Van Der Bilt, A., Van T Hof, M.A., Witter, D.J., Kalk, W.,and Jansen, J.A. Biting and chewing in over denture, full denture and natural dentitions. J Dent Res. 79(2000):1519-1524.

[25] Garrett, N.R., Perez, P., Elbert, C., and Kapur, K.K. Effects of improvements of poorly fitting dentures and new dentures on masseter activity during chewing. J Prosthet Dent. 76(1996):394-402.

[26] Leake, J.L. An index of chewing ability. J Public Health Dent. 50(1990):262–267.

[27] Ellsworth, K.K. Factors affecting the masticatory performance of complete denture wearers. J Prosthet Dent. 33(1975):122-136.

[28] Garrett, N.R., Perez, P., Elbert, C., and Kapur, K.K. Effects of improvements of poorly fitting dentures and new dentures on masticatory performance. J Prosthet Dent. 75(1996):269-275.

[29] Garrett, N.R., Kapur, K.K., and Perez, P. Effects of improvements of poorly fitting dentures and new dentures on patient satisfaction. J Prosthet Dent. 76(1996):403-413.

[30] Khamis, M.M.,and Hussein, S.Z. A procedure for constructing dentures with interchangeable teeth. J Prosthet Dent. 78(1997):609-613.

[31] McGarry, T.J.,Nimmo, A., Skiba, J.F., Ahlstrom, R.H., Smith, C.R., and Koumjian, J.H.Classification system for complete edentulism. The American College of Prosthodontics. J Prosthodont. 8(1999):27-39.

APPENDIX

The statistic analysis of masticatory performance

Descriptives

occ	Stroke				Statistic	Std. Error
bb	20	Data	Mean		2.8250	.05270
			95% Confidence Interval for Mean	Lower Bound	2.7058	
				Upper Bound	2.9442	
			5% Trimmed Mean		2.8217	
			Median		2.7883	
			Variance		.028	
			Std. Deviation		.16665	
			Minimum		2.62	
			Maximum		3.09	
			Range		.47	
			Interquartile Range		.28	
			Skewness		.396	.687
			Kurtosis		-1.148	1.334
	40	Data	Mean		2.1693	.06868
			95% Confidence Interval for Mean	Lower Bound	2.0139	
				Upper Bound	2.3247	
			5% Trimmed Mean		2.1781	
			Median		2.2300	
			Variance		.047	
			Std. Deviation		.21720	
			Minimum		1.74	
			Maximum		2.44	

			Range		.70	
			Interquartile Range		.35	
			Skewness		-.859	.687
			Kurtosis		.094	1.334
	60	Data	Mean		1.9197	.07080
			95% Confidence Interval for Mean	Lower Bound	1.7595	
				Upper Bound	2.0798	
			5% Trimmed Mean		1.9191	
			Median		1.9117	
			Variance		.050	
			Std. Deviation		.22389	
			Minimum		1.59	
			Maximum		2.26	
			Range		.67	
			Interquartile Range		.41	
			Skewness		.115	.687
			Kurtosis		-1.284	1.334
neu	20	Data	Mean		2.9663	.06273
			95% Confidence Interval for Mean	Lower Bound	2.8244	
				Upper Bound	3.1082	
			5% Trimmed Mean		2.9663	
			Median		2.9933	
			Variance		.039	
			Std. Deviation		.19838	
			Minimum		2.70	

		Maximum		3.23	
		Range		.53	
		Interquartile Range		.38	
		Skewness		-.048	.687
		Kurtosis		-1.499	1.334
40	Data	Mean		2.2873	.04698
		95% Confidence Interval for Mean	Lower Bound	2.1811	
			Upper Bound	2.3936	
		5% Trimmed Mean		2.2802	
		Median		2.2450	
		Variance		.022	
		Std. Deviation		.14856	
		Minimum		2.11	
		Maximum		2.59	
		Range		.48	
		Interquartile Range		.23	
		Skewness		.983	.687
		Kurtosis		.460	1.334
60	Data	Mean		1.9987	.05862
		95% Confidence Interval for Mean	Lower Bound	1.8661	
			Upper Bound	2.1313	
		5% Trimmed Mean		2.0046	
		Median		2.0350	
		Variance		.034	
		Std. Deviation		.18536	

	Minimum	1.69	
	Maximum	2.20	
	Range	.51	
	Interquartile Range	.31	
	Skewness	-.370	.687
	Kurtosis	-1.558	1.334

Shapiro-Wilk was used to confirm the normality of masticatory performance data since the number of sample were less than 30.

Tests of Normality

occ	Stroke		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
			Statistic	df	Sig.	Statistic	df	Sig.
bb	20	Data	.144	10	.200*	.934	10	.492
	40	Data	.174	10	.200*	.932	10	.464
	60	Data	.162	10	.200*	.959	10	.773
neu	20	Data	.143	10	.200*	.919	10	.352
	40	Data	.193	10	.200*	.923	10	.380
	60	Data	.261	10	.053	.865	10	.088

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Two Way Repeated Measures ANOVA (Two Factor Repetition)

Dependent Variable: data

Equal Variance Test: Passed (P = 0.762)

Source of Variation	DF	SS	MS	F	P
Subject	9	0.778	0.0864		
occ scheme	1	0.192	0.192	4.150	0.072
occ scheme x subject	9	0.417	0.0463		
stroke	2	9.333	4.666	158.898	<0.001
stroke x subject	18	0.529	0.0294		
occ scheme x stroke	2	0.0106	0.00530	0.354	0.706
Residual	18	0.269	0.0150		
Total	59	11.529	0.195		

The difference in the mean values among the different levels of occ scheme is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in stroke. There is not a statistically significant difference (P = 0.072).

The difference in the mean values among the different levels of stroke is greater than would be expected by chance after allowing for effects of differences in occ scheme. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The effect of different levels of occ scheme does not depend on what level of stroke is present. There is not a statistically significant interaction between occ scheme and stroke. (P = 0.706)

One Way Repeated Measures Analysis of Variance

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
n20 vs. b60	1.048	6	20.201	<0.001	Yes
n20 vs. n60	0.969	6	18.666	<0.001	Yes
n20 vs. b40	0.798	6	15.384	<0.001	Yes
n20 vs. n40	0.682	6	13.135	<0.001	Yes
n20 vs. b20	0.142	6	2.736	0.395	No
b20 vs. b60	0.906	6	17.465	<0.001	Yes
b20 vs. n60	0.827	6	15.929	<0.001	Yes
b20 vs. b40	0.656	6	12.647	<0.001	Yes
b20 vs. n40	0.540	6	10.399	<0.001	Yes
n40 vs. b60	0.367	6	7.065	<0.001	Yes
n40 vs. n60	0.287	6	5.530	0.004	Yes
n40 vs. b40	0.117	6	2.248	0.609	No
b40 vs. b60	0.250	6	4.817	0.017	Yes
b40 vs. n60	0.170	6	3.282	0.207	No
n60 vs. b60	0.0797	6	1.535	0.885	No

The statistic analysis of maximum occlusal force

One-Sample Kolmogorov-Smirnov Test

		BFbalanced	BFneutrocentric
N		10	10
Normal Parameters[a,,b]	Mean	161.1000	185.0063
	Std. Deviation	82.81299	61.38216
Most Extreme Differences	Absolute	.196	.164
	Positive	.196	.146
	Negative	-.146	-.164
Kolmogorov-Smirnov Z		.619	.519
Asymp. Sig. (2-tailed)		.838	.950

a. Test distribution is Normal.

b. Calculated from data.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BFbalanced - BFneutrocentric	-23.90633	70.29750	22.23002	-74.19413	26.38147	-1.075	9	.310

VITA

Mr. WeerawatNiwatcharoenchailkul was born in Bangkok, Thailand on January 4, 1983. In 2007, he was conferred the degree of Doctor of Dental Surgery (D.D.S.) from Faculty of Dentistry, Srinakharinwirot University. After graduation, she worked as a dentist at NikomKamsroi Hospital, Mukdahan, Thailand (2007-2008) and Dongluang Hospital, Mukdahan, Thailand (2008-2009).

In 2009, he started his post-graduated study for the Master of Science in Prosthodontics Program at the Faculty of Dentistry, Chulalongkorn University.