เปรียบเทียบประสิทธิภาพการบดเคี้ยวด้วยวิธีวิเคราะห์ชิ้นขี้ผึ้งก่อนและหลังการใส่ฟันเทียมทั้งปากล่างคร่อมรากเทียม

นางสาวนันทพร โชคปรีชา

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A comparison of masticatory efficiency using the wax cube analysis method before and after implant-retained lower complete denture insertion

Ms. Nuntaporn Chokpreecha

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Prosthodontics
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Thesis Title	A COMPARISON OF MASTICATORY EFFICIENCY USING THE WAX CUBE ANALYSIS METHOD BEFORE AND AFTER IMPLANT-RETAINED LOWER COMPLETE DENTURE INSERTION
By	Miss Nuntaporn Chokpreecha
Field of Study	Prosthodontics
Thesis Advisor	Assistant Professor Orapin Kaewplung, 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, Ph.D.)

THESIS COMMITTEE

…….. Chairman
(Associate Professor Mansuang Arksornnukit, Ph.D.)

……. Thesis Advisor
(Assistant Professor Orapin Kaewplung, Ph.D.)

…….. Examiner
(Assistant Professor Atiphan Pimkhaokham, Ph.D.)

…….. Examiner
(Associate Professor Patita Bhuridej, Ph.D.)

…….. External Examiner
(Associate Professor Rumpai Rochanakit)

นันทพร โชคปรีชา : เปรียบเทียบประสิทธิภาพการบดเคี้ยวด้วยวิธีวิเคราะห์ชิ้นขี้ผึ้งก่อนและหลังการใส่ฟันเทียมทั้งปากล่างคร่อมรากเทียม. (A comparison of masticatory efficiency using the wax cube analysis method before and after implant-retained lower complete denture insertion) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ.ทญ.ดร. อรพินท์ แก้วปลั่ง, 51 หน้า.

การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบประสิทธิภาพการบดเคี้ยวของผู้ป่วยฟันเทียมคร่อมรากเทียมในขากรรไกรล่างโดยวิธีวิเคราะห์ชิ้นขี้ผึ้ง มีผู้เข้าร่วมวิจัยจำนวน 33 คน (ชาย 15 คน หญิง 18 คน อายุเฉลี่ย 67.48 ± 6.17ปี) เป็นผู้ป่วยที่ได้รับการใส่ฟันเทียมทั้งปากแบบถอดได้จากภาควิชาทันตกรรมประดิษฐ์ คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย โดยที่ฟันเทียมมีประสิทธิภาพในการใช้งานได้ดี มีเสถียรภาพดีแต่มีปัญหาเรื่องการยึดอยู่ของฟันเทียมชิ้นล่าง แบ่งผู้ป่วยเป็น 2 กลุ่มตามความสูงของกระดูกขากรรไกรล่างเป็นกลุ่มกระดูกสูงและกลุ่มกระดูกต่ำ ผู้เข้าร่วมวิจัยเข้ารับการผ่าตัดฝังรากฟันเทียม 2 ตัวบริเวณฟันเขี้ยวในขากรรไกรล่างในการผ่าตัดครั้งที่ 1 และใน 3 เดือนต่อมาทำการผ่าตัดครั้งที่ 2 เพื่อยึดติดรากฟันเทียมกับหลักยึดชนิดลูกบอลและยึดกับฟันเทียมเดิม การประเมินประสิทธิภาพการบดเคี้ยวทำโดยใช้วิธีวิเคราะห์ชิ้นขี้ผึ้งจำนวน 3 การทดสอบได้แก่ 1. ก่อนผ่าตัดฝังรากฟันเทียม 2. ภายใน 1 สัปดาห์หลังใส่ฟันเทียมคร่อมรากเทียม และ 3. หลังใส่ฟันเทียมคร่อมรากเทียมเป็นเวลา 1 เดือนโดยแต่ละครั้งของการทดสอบจะเคี้ยวชิ้นขี้ผึ้งจำนวน 4 ชิ้นนำชิ้นขี้ผึ้งที่ผ่านการเคี้ยวแล้วมาถ่ายภาพและวิเคราะห์ความสามารถในการบดเคี้ยวด้วยโปรแกรมอิมเมจเจ ผลของประสิทธิภาพการบดเคี้ยวจะแสดงเป็นร้อยละของความสามารถในการบดเคี้ยวของแต่ละการทดสอบซึ่งจากสถิติวิเคราะห์ พบว่า มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติของค่าเฉลี่ยร้อยละของความสามารถในการบดเคี้ยวระหว่างการทดสอบแต่ละครั้ง ($P \leq .001$) โดยที่ค่าเฉลี่ยร้อยละของความสามารถในการบดเคี้ยวหลังใส่ฟันเทียมคร่อมรากเทียม 1 สัปดาห์เท่ากับ 23.94 ± 6.58 (ก่อนฝังรากฟันเทียม เท่ากับ 15.43 ± 4.36) และเพิ่มขึ้นเป็น 28.17 ± 6.16 หลังใส่ฟันเทียมคร่อมรากเทียมไปแล้ว 1 เดือน แต่ความสูงของกระดูกไม่ส่งผลต่อประสิทธิภาพการบดเคี้ยวในแต่ละการทดสอบ ($P>.05$) จากการศึกษานี้สรุปได้ว่าผู้ป่วยไร้ฟันมีความสามารถในการบดเคี้ยวดีขึ้นหลังใส่ฟันเทียมคร่อมรากเทียมในขากรรไกรล่างและความสูงของกระดูกขากรรไกรล่างไม่มีผลต่อความสามารถในการบดเคี้ยวหลังใส่ฟันเทียมล่างคร่อมรากฟันเทียม

ภาควิชา ทันตกรรมประดิษฐ์ ลายมือชื่อนิสิต .....

สาขาวิชา ทันตกรรมประดิษฐ์ ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก .....

ปีการศึกษา 2555 .....

5276112832 : MAJOR PROSTHODONTICS
KEYWORDS : IMPLANT-RETAINED LOWER COMPLETE DENTURE / WAX CUBE ANALYSIS METHOD / CHEWING ABILITY

NUNTAPORN CHOKPREECHA : A COMPARISON OF MASTICATORY EFFICIENCY USING THE WAX CUBE ANALYSIS METHOD BEFORE AND AFTER IMPLANT-RETAINED LOWER COMPLETE DENTURE INSERTION. ADVISOR : ASST. PROF. ORAPIN KAEWPLUNG, Ph. D., 51 pp.

The purpose of this study was to evaluation masticatory efficiency of implant-retained lower complete denture by using the wax cube analysis method. Thirty-three complete denture wearers (15 males and 18 females, mean age 67.48 ± 6.17 yrs) who received complete dentures treatment from Prosthodontic clinic, Faculty of Dentistry, Chulalongkorn University were selected. The quality and stability of dentures are acceptable except some retention problems of lower denture. All subjects were classified in to 2 groups from mandibular bone height as high and low bone group. First, two dental implant fixtures were placed at lower canine regions, then 3 months later the ball-type attachments were connected to lower denture. The wax cube analysis method was used to evaluate the masticatory efficiency at three times; 1. before implantation 2. within one week after insert implant retained lower complete denture and 3. one month after. Each test used four wax cubes. The chewed wax was captured and analyzed with the Image J program. The result of masticatory efficiency was shown in term of percentage of chewing ability. The result showed that there was a statistically significant difference in the mean values among 3 tests ($P \leq 0.001$). Means of percentage of chewing ability after insertion in one week was 23.94 ± 6.58 (baseline = 15.43 ± 4.36) and increased to 28.17 ± 6.16 in one month after but the level of bone could not induce in the subjects had a significant effect on their masticatory performance overtime ($P > 0.05$). From this study concluded that the edentulous patients can improve chewing ability significantly by 2-implant-retained lower complete denture treatment and mandibular bone height had no effect on chewing ability after treatment.

Department : Prosthodontics Student's Signature .....
Field of Study : Prosthodontics Advisor's Signature .....
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LIST OF ABBREVIATIONS

IOD	Implant-retained lower complete denture
CD	complete denture
ANOVA	Analysis of Variance
Fig	figure
mm	millimeter
SD	standard deviation
yrs.	years

CHAPTER I

INTRODUCTION

Over 94% of elderly (aged 60 years and over) in Thailand have lost their teeth at least one tooth. About 10.47% were edentulism (1) and most of them were rehabilitated with conventional complete denture. However, conventional complete denture wearers frequently reports problems deal with retention and stability of lower dentures which associated with anatomical and physiological changes such as absence of residual ridge height, limited vestibular depth, large and strong tongue etc. (2). Since the 1980s, osseointegrated dental implants have dramatically succeed in the rehabilitation of edentulism (3). In 2002 and 2009, two consensus statements (one from a symposium in Canada and the other from England) were issued that recommended that Mandibular two-implant retained overdentures as first choice standard of care for edentulous patients (4,5). Clinical studies over the last decade since the publication of first consensus have lanced, have been undertaken to determine the benefits to patients from used of mandibular two-implant retained overdentures. As the result of the quality of life and nutrition are directly associated with edentulism, most literatures aimed to study in masticatory function or satisfactions between conventional complete dentures and implant-retained lower complete denture (6-12). There were 2 broad categories of outcome measurement of chewing ability of prosthetic treatment. Most researchers have used the terms “subjective evaluation” and “objective evaluation” when referring to data gathered through lab tests and those gathered from a patients’ verbal report (13,14). The objective evaluation had superior to subjective evaluation in many aspects such as: was a

quantitative data, comparable and not depend on emotion or perception of subjects. The researchers developed several techniques for this method (15-17) but generally these are not used in clinics because they are quite complicated. Untill 2003, Sato and Fueki had developed a new method as paraffin wax cubed and evaluated masticatory function by analyzing the picture of chewed wax and suggested that their method was comfortable for both subjects as well as examiners (14,18-19). In 2010, Prapatrungsri K.et.al. were successfully in development of wax cube analysis method for practice in Thailand (20). Furthermore, it was confirmed that this method could be utilized clinically to evaluate chewing ability after dental treatment with removable partial denture and complete denture with uncomplicated process (21,22). The aim of this study was to compare masticatory efficiency between before and after implant-retained lower complete denture insertion of high bone group and low bone group by using the wax cube analysis method.

Research Question

1. Does the masticatory efficiency improve after implant-retained lower complete denture treatment evaluated by using wax cube analysis method?
2. Does mandibular bone height effect on masticatory efficiency of implant retained lower complete denture?

Objective

To evaluate masticatory efficiency of implant-retained lower complete denture by using the wax cube analysis method.

Hypothesis

Null hypothesis: No difference of masticatory efficiency between before and after implantation for implant-retained lower complete denture .

Alternative hypothesis: There is difference of masticatory efficiency between before and after implantation for implant-retained lower complete denture.

Expected Outcomes

1. To know the difference of masticatory efficiency between before and after implantation for implant-retained lower complete denture of high mandibular bone group and low mandibular bone group.
2. The results may be the basis for longitudinal study in early elderly population.
3. The results may be the basis for development of clinical guideline treatment in lower total edentulous of early elderly population.

CHAPTER II

LITERATURE REVIEW

1. Prevalence of edentulism in Thailand and problem of conventional complete denture

Now a day all over the world faces to Population aging crisis. The elderly populations (aged 60 years and over) increase dramatically rapid as well as in Thailand. United Nations reported Population prospects that Thailand will have double size of elderly population from 8% in 2000 to 16% in 2020. It takes a very short time only 20 years compare to well-developed countries that take 70-100 years (23). It is necessary to well prepare for supporting elderly to reach high quality of their life in this situation. Dental services for elderly are also important. Although currently trend of dental service are promotion and prevention, problems from dental caries and periodontal disease still increase continuously. These are major factors of tooth loss in elderly. From 6th National Dental Health Survey found 94.04 % of elderly in Thailand (aged 60-74 yrs) have loss their teeth at least 1 tooth. About 10.47 % were edentulism that increased from 5th survey about 28 % (1,24). The overall prevalence of tooth loss increases with aged, the proportion of edentulous in this society will remain significant (25). The rate of edentulism increases at 4% per 10 years in elderly adults and increases to more than 10% per decade after age 70 (26).

When tooth loss, the major impact will affect to residual bone. From the fact that bone needs stimulation to maintain its form and density, when the tooth is lost, the lack of stimulation to the residual bone causes a decrease in trabeculae and bone density in the

area. It affected from external width, then height of the bone volume (27). After the initial extraction of teeth, the average first-year bone loss is 25% decrease in crestal bone width and more than 4 mm decrease in height. Additionally, the rate of resorption is 4 times greater in the mandible, compared with the maxilla (28). Bergman and Carlsson confirmed that bone loss is an ongoing process following tooth loss (29). Although the rate of bone loss is slower after the first year, the bone loss is continuous throughout life. It is generally accepted that residual ridge resorption is a major factor in the failure of traditional oral rehabilitation for edentulous patients. The volume of alveolar process is thought to be key for retention and stability of dentures. The greater vertical height of alveolar ridge, the greater surface area of the vestibular and sublingual regions, on which the denture rests (30).

The traditional standard of care for edentulous patients were conventional complete dentures. For many patients, these conventional complete dentures can improve their health and quality of their life from edentulism. These have allowed them to eat, to speak and to function in the society more easily than they could without any prostheses. Notwithstanding this, there were still have many obstacles to use removable dentures with no problems. Most commonly complaints from patients after complete denture treatment often associate with stability and retention of lower denture (31). As a result of mobility and discomfort from lower denture, these difficulties have been shown to be associated with social, phychological and functional disabilities (32). Causes of loosening of lower denture are from underextended or overextended border, incorrect base contour, poor tissue fit, retruded tongue and neutral zone problem (33). Furthermore, anatomic and physiologic deficiencies such as an absence of residual ridge height, tapered shape of residual ridge, limited vestibular depth, tapered arch form

also associated with this problem (34). There are several negative effects from removable dentures. Firstly, it can stimulate the bone loss more rapidly. The fact that removable denture does not stimulate or maintain bone, it accelerates bone loss. There is an evidence that over 40% of 10-year denture wearers have loss their bone more rapidly because of their poor fitting dentures (35). Secondly, it is decreased the bite force. The average bite force of dentate person is about 150-250 psi but reduced to only 50 psi in edentulous patient. Moreover, patients wearing complete dentures for more than 15 years may have a maximum bite force only 5.6 psi (36). Thirdly, masticatory efficiency is also decreased. It was less than one sixth comparing to dentate person (37,38). Lastly, the limitation in food selection also affects from removable denture. Complete denture wearers seem to adjust their diet toward food items that less coarse, softer, and easily to chew, and they generally consume less fruits and vegetables. This change in diet affects nutritional status, and generally, complete denture wearers have a low energy intake than dentate individuals (39). From all above reasons, if dentures could not well fabricate, they could not achieve the gold objectives of complete denture as the restoration of function, facial appearance, and the maintenance of the patient's health.

While the factors resulting in discomfort and looseness associated with dentures that cause of malpractice or non-anatomical problems may solves with the new denture well-fabrication, anatomical deficiencies need additional treatments. The American College of Prosthodontists has developed a classification system for complete edentulism. These guideline may help practioners determine appropriate treatments for their patients. They had mentioned that mandibular bone height type III and IV required implant treatment for adequate prosthodontics function (40).

2. Two Implant-retained mandibular overdenture

A large number of older adults have healthy and active post-retirement lives and they most expect social pleasures to continue throughout advanced life. Edentulous patients with a severely resorbed mandible often experience problems with their conventional dentures. The problems include pain during mastication and insufficient stability and retention of denture, especially with regard to the mandibular denture. Therefore, the demand for more complex dental services to meet their need and expectations of this population is increasing.

When the Brånemark dental implant philosophy was first formally introduced in the United States in 1982 (41), this has revolutionized treatment possibilities for edentulous patients. Although successful, the techniques used tend to be complicated, time-consuming, and expensive. During the initial time period, the most common implant prosthodontics treatment of choice for an edentulous mandible involved the placement of 5 or 6 implants and fabrication of a fixed-detachable, all implant supported prosthesis (42). From a restorative perspective, it does not seem to necessary that patients who have been edentulous for many years need fixed partial prostheses retained by implant. Simple overdenture prostheses retained by only a few implants could fulfill the needs of the patients as well (43). In 2002, the McGill consensus statement on overdentures was published. A panel of revavant experts in the field stated that: The evidence currently available suggests that the restoration of edentulous mandible with a conventional denture is no longer the most appropriate first choice prosthodontic treatment. There is now overwhelming evidence that a two-implant overdenture should become the first choice of treatment for the edentulous mandible (4). Furthermore, in 2009, a further consensus statement that was held in York was released as a support and follow-up to the McGill

consensus statement (5). Infact, even with other wise successful conventional complete denture treatment in the mandible, it has been shown that it is possible to achieve a higher clinical standard for success with the implant overdentures (44,45). A substantial body of evidence is now available demonstrating that patients' satisfaction and quality of life with implant-supported mandibular dentures is significantly greater than for conventional dentures (6-12). The preservation of bone also a great benefit of implant treatment. From the problem of ridge resorption as mentioned in previous topic, some studies found that the mean annual marginal bone loss to be 0.9 mm during the first year after implant placement and 0.1 mm in following years (46). The data are significant when considering the ability of implants to preserve alveolar bone.

3. Masticatory efficiency evaluation

The treatment goals in dentistry is the restoration of natural teeth or the replacement of missing teeth to achieve an acceptable masticatory function. A number of similar terms such as masticatory ability, masticatory efficiency or masticatory performance have been used interchangeably for masticatory function. Some authors use the terms as synonym only, whereas others propose specific definitions for the term they use. Carlsson defines "masticatory ability" as "an individual's own assessments of his or her masticatory function", whereas "masticatory efficiency" is defined as "the capacity to reduce food during mastication" (47). Bate defined "masticatory performance" as "the particle size distribution of food when chewed for a given number of strokes (48).

However, the essential of this topic is assessment of ability to chew food. There were 2 broad categories of outcome measurement of chewing ability of prosthetic treatment: laboratory based and patient based. Most researchers have used the terms

“subjective evaluation” and “objective evaluation” when referring to data gathered through lab tests and those gather from a patients’ verbal report (13). Some used term of “objective tests of masticatory performance” and “subjective assessment of masticatory ability” in order to assess ability to chew food (30).

Objective tests of masticatory performance

In test of masticatory performance, various test foods are given to subjects to chew and food particle size is analyzed using various laboratory techniques. Fractional sieving was a technique of separating the food after chewing for a given time period has been used since 1924 (49) and is still considered to be a viable method (15-16,50-51). The test foods have varied widely in chewing test including artificial food such as formalin-hardened gelatin, silicone impression materials, and various natural foods. However, there are some problems with this method: firstly, data analysis is messy and time-consuming. Secondly, these measures are applicable only to brittle substances, and not the different categories that the population eats. Lastly, it was difficulty to prepare test food or artificial test material uniformly in quality (30,52).

Another method is an evaluation of the ability to mix and knead a food bolus. Chewing gum and paraffin wax cube have been developed as test foods to evaluate masticatory performance based on their mixing ability (14,18-19). The mixing ability test assesses the masticatory performance by calculating the mixing ability index with a discriminant function, by which the degree of color mixing and the shape of the chewed test food are integrated into a one-dimensional value. The degree of mixing of the different colors can be determined by computer-assisted method or visual inspection. Both chewing gum and paraffin wax have advantages over the sieving method that it forms a bolus; then the manipulation of the food is relatively easy. Furthermore, image analysis of

these artificial test materials offers considerable advantages such as simplicity, speed, accuracy, reproducibility and hygiene (14).

In 2002, a two-colored wax cube method has been developed in Thailand to determine an individual's food mixing ability (20). This method has many advantages. It needs only a few minutes to perform the test and to analyze the sample. It does not give uncomfortable from any subject and also easy for the subject to understand the result of the test visually. This method can be utilized clinically to evaluate masticatory performance after dental treatment both in patients with normal dentition and removable dental prostheses (21). Furthermore, the paraffin wax cube has been developed into different level of hardness to evaluate masticatory function of totally edentulous patients. It was found that, the original and soft wax cubes are proper for use in totally edentulous patients because the hardness score of them are in the range common diets of these population (22).

Another techniques to measure chewing ability are muscle activity and maximum bite force by using Electromyography (EMG) or strain gauge. It has been suggested that subjects use a certain percentage of their maximum bite force during chewing (53). Some study has demonstrated that EMG activity of jaw-closing muscles during simulated chewing was force closely related to total force (54). It may believed that greater muscle activity during chewing could provide better masticatory performance. Bite force achieved by complete denture wearers has been assessed by several authors (55-57). When compared with dentate subjects, the bite force of complete denture wearers is around 20% of that achieved by dentate controls (57). This may explain why edentulous subjects report difficulty in chewing tough foods. However, some studies have found weak but significant associations between masticatory performance and EMG activity of jaw-closing

muscles during chewing (58). Even the advantage of this technique provided direct estimate of the energy spent, it was found a lot of disadvantages such as: requires special equipment, difficult to measure, analysis is time-consuming and high cost (52).

Subjective assessment of masticatory ability

The chief purpose of fitting oral prostheses is to enable the patients to recover their oral function. Therefore, to diagnose the effectiveness of the prosthesis, it is important to evaluate the oral function. To gather information from patients and/or study participants, an individual's masticatory ability that was assessed subjectively by questionnaires or personal interviews are commonly used. The most commonly used questionaires have category scales as their response measures. Several studies used visual analogue scales (VAS) for general satisfaction measurement that are explained by five factors lists by patients as important and directly related to treatment : comfort, stability, ability to chew, ability to speak, and aesthetics (59-61). Agerberg and Carlsson used a questionnaire to determine perceived chewing ability of dentate and edentulous individuals and reported that edentulous subjects tended to rate their chewing ability lower than dentate individuals (62). Other studies have measured both masticatory performance and masticatory ability. The result of objective and subjective assessment were weakly to moderately correlated (6,15,63). From the result of comparison between complete denture group and implant-retained overdenture group, the degree of satisfaction with their rehabilitation reported by the subjects was correlated neither to increased masticatory efficiency nor to improved oral function (6). Particularly in full denture wearers, Boretti and others suggested that patient-assessed measures of chewing function tend to be more positive than objective measures of chewing function (6). In the other hand, Slagter et al. found that there was a poor correlation between

measured mastication efficiency and patients perception of their ability to chewing but they wrote that the latter must be faulty' dentists cannot rely on asking denture wearers about chewing problems. This ability should be determined individually by series of chewing tests' (15).

From all above, this study has chosen the wax cube analysis method that is one technique of objective test for masticatory performance evaluation because many reasons. Such as it needs only a few minutes to perform the test and to analyze the sample and it can use clinically for evaluate post-prosthetic outcome of both of normal dentition and denture.

CHAPTER III

MATERIALS AND METHODS

Subject

This study had operated under The Project for Celebration of 80th King's Birthday of Faculty of Dentistry, Chulalongkorn University.

All subjects were recruited into this study using the following inclusion criteria:

General Inclusion criteria

- No previous or current radiotherapy or chemotherapy in the head and neck region.
- No smoking or smoking of < 1 pack of cigarettes per day.
- No physical condition contraindicating implant surgery.
- No medication of the bisphosphanate drugs

Dental Inclusion criteria

- They are edentulous patients who had received the conventional complete dentures from Prosthodontics department of Dentistry Faculty of Chulalongkorn University since 2008 to 2010 under academic standard.
- Individuals with acceptable quality of conventional upper and lower dentures, but experienced functional problems with their lower complete denture. (Acceptable quality of denture refer to 1. Denture base was placed in the suitable anatomical landmark 2. No occlusal table wearness that change vertical dimension and/or pattern of occlusal scheme 3. There was sufficient

stability for resist horizontal force tested by press each side at buccal area of lower denture without moving of denture).

- Upper prosthesis can be a conventional complete denture, acrylic removable partial denture and metal removable partial denture.
- Sufficient bone to install implants in the appropriate areas of the mandible.
- At least 6 mm. keratinized mucosa in the implant placement area.

Subjects who did not completely fulfill the above criteria were not recruited into the study.

The Ethics Committee of Chulalongkorn University approved the protocol of this study on 8th April 2010. All potential participants were informed about the treatment and study, as well as the risks and benefits of treatment and allowed subjects to participate the study by voluntary. An information about the study was clearly in an information leaflet and informed consent for participation in the study was obtained from every subjects.

Radiographic examination and classification of mandibular edentulous ridge

Before surgery, all subjects had examined by dental computed tomography with surgical stent and panoramic radiograph for evaluate quality and quantity of their bone site for implants. Using the panoramic radiograph, the least vertical bone height of mandible was measured and recorded. One examiner measured mandibular bone height for all patients. To simplify for this study, all subjects were categorized in to 2 groups as High bone group and Low bone group followed by modification from ACP classification. (High bone group defined as the subjects who was categorized in type I and II of ACP classification: the least vertical bone height > 15 mm and Low bone group defined as the

subjects who was categorized in type III and IV of ACP classification: the least vertical bone height ≤ 15 mm) (40,64)

Surgical and prosthetic procedures

The surgical procedure was done by specialist from Oral and Maxillofacial department and Periodontology department of Dentistry Faculty of Chulalongkorn University. The surgery had operated according to a standardized two-stage Bränemark surgical protocol (41). In the first stage, two standardized of dental implant fixtures (Tapered Screw-Vent® Implant system, Zimmer dental, Carlsbad, CA; diameter 3.7 or 4.7 mm ; length 8,10,11.5 or 13mm) (Fig.1) were placed at lower canine regions of each patient. The suitable diameter and length of implant fixtures were calculated from dental computed tomography followed by the company protocal. Then 3 months later, healing abutments were connected in the second stage and were changed to ball-type attachments after soft tissue healed completely with torque at 30 N. (according to the manufacturer's instructions) (Fig.2). The preexisting lower complete denture was fitted to ball-type attachments by the intra-oral technique. The treatment was completed as an implant-retained lower complete denture (IOD) (Fig.3).

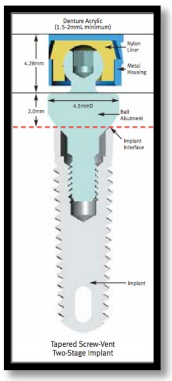
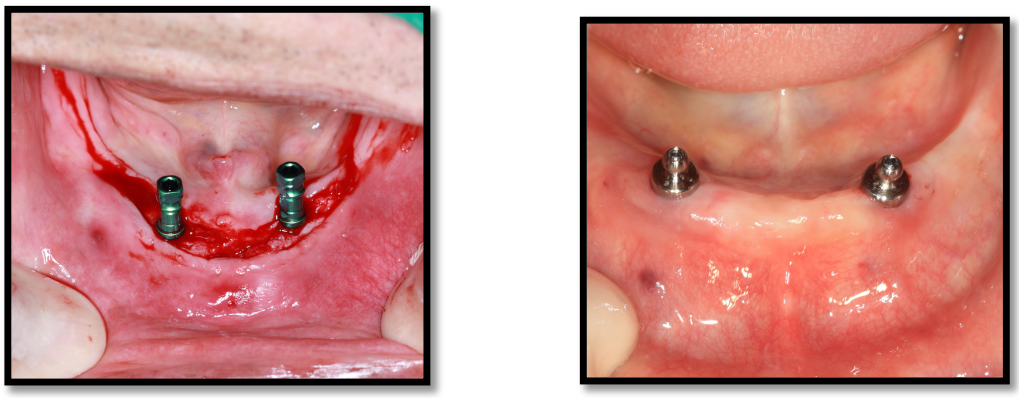


Fig.1 Design of dental implant fixture, ball-type attachment, housing and nylon liner



(a) (b)

Fig.2 Surgical procedure

(a) First stage: place 2 fixtures at both side of lower canine area

(b) Second stage: after three months, insert ball-type attachment

Fig.3 Prosthetic procedure; complete treatment as implant-retained lower complete denture with intra-oral technique.

Chewing ability test

To evaluate masticatory efficiency in this study, the subjects had been tested for 3 times: before implantation (Test 1), within 1 week after insert an implant-retained lower complete denture (Test 2) and one month after an implant-retained lower complete

denture (Test 3) by using a 10x10x10 mm two-colored (red/white) wax cube as in previous study (20-22) (Fig4).

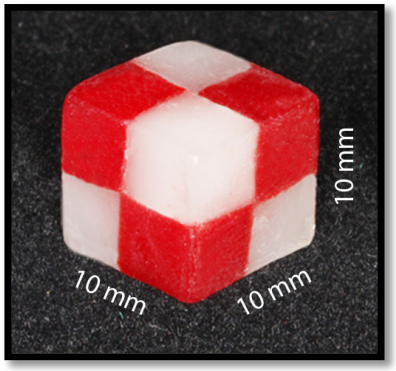


Fig.4 Size and shape of wax cube for chewing ability test

The testing process started by adjusted the dental chair until the subject had sit in an upright position. Lubricant was applied on the occlusal surfaces of the upper and lower dentures. Each test, the subject had chewed one piece of wax cube on the right side for 10 habitual stokes by combined working of denture, muscle of mastication and tongue function then repeat the process again with another wax cube on the same side. After finished two cycles on the right side, repeat all of the above chewing process on the left side. Therefore each subject had 4 pieces of the chewed wax in total per test. At the end of third test, each subject had 12 pieces of chewed wax. A schematic of the methodology of the study was shown in Fig.5.

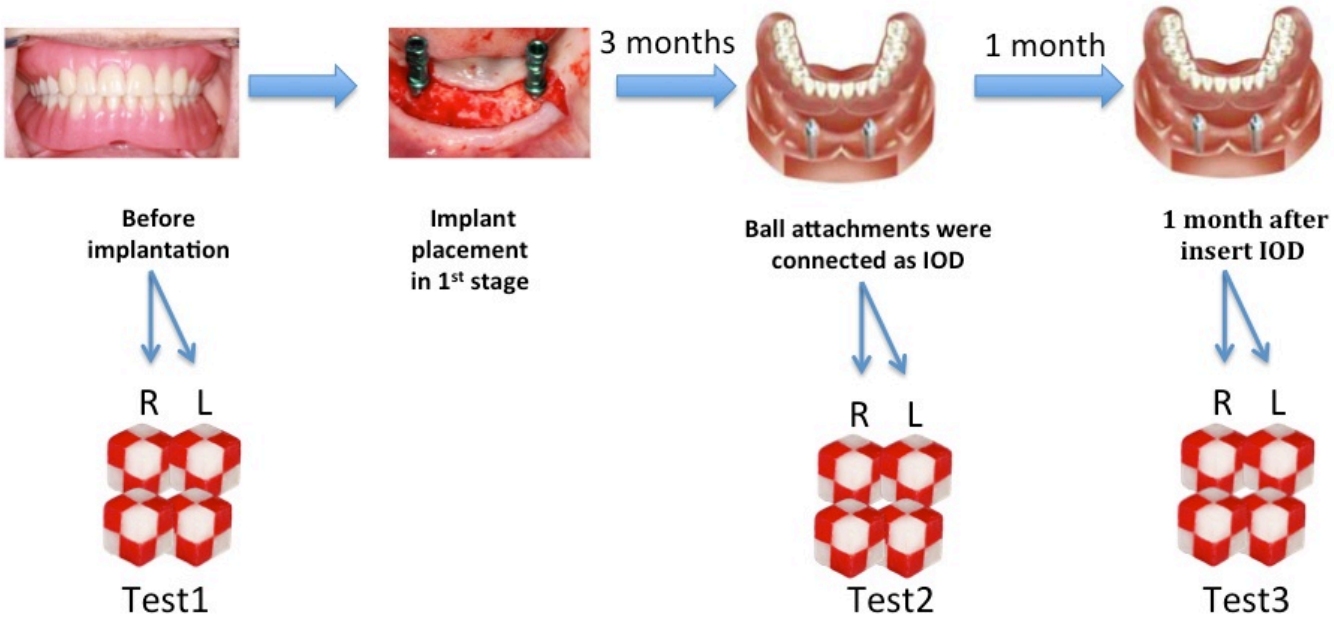


Fig.5 A schematic of the methodology

Chewing ability analysis

Images of both sides of the chewed wax were captured by a digital camera (Canon EOS 450D, Canon, Japan) with a macro lens (Canon macro 100 mm., Canon, Japan). Every picture was taken under the same conditions (a photo stand kit; Copy stand CS920 and Copy light CL-150 with 2 light bulbs; Philips® Cool Daylight 125 Watts, Color temperature 6,500 K and a lux meter; DigiconLX-70, Protonics Inter-trade Co, Ltd., Thailand) All chewed wax picture were analyzed by Image J software (Version 1.42Q, NIH, MD, USA). The process of the wax cube analysis method was demonstrated in Fig.6

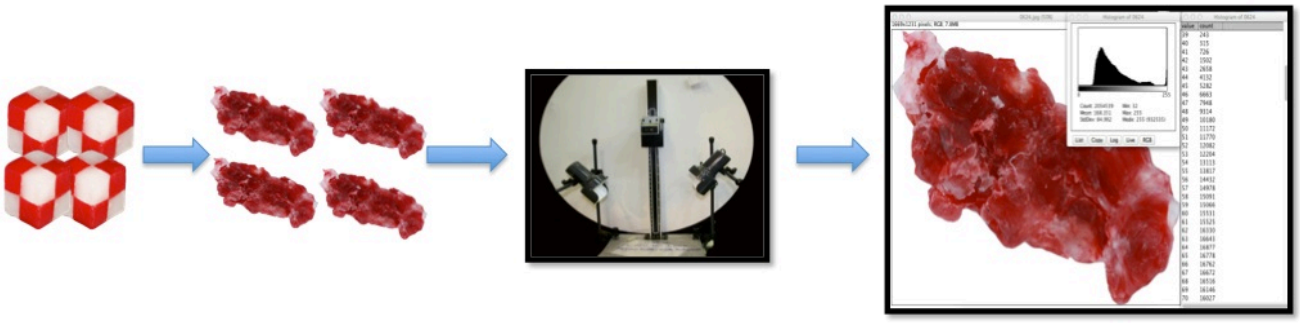


Fig.6 The process of the wax cube analysis method by Image J program

The result of masticatory efficiency was shown in term of “percentage of chewing ability”. The percentage chewing ability based on the chewed wax was computed by the following formula:

$$\text{The percentage of chewing ability} = \frac{\text{Total number of pixels of standard color value} \times 100}{\text{Total number of pixels of the chewed wax}}$$

Each subject generated eight surfaces (from four wax cubes) of the chewed wax in each test, and twenty-four surfaces per person (from twelve wax cubes) at the end of study. Therefore, the average value was calculated in order to determine the average percentage of chewing ability of each subject.

Statistic analysis

One way repeated measures analysis of variance (ANOVA) was used to compared the results of percentage of chewing ability of high and low bone group among three tests ($P<.05$)

CHAPTER IV

RESULTS

The total subjects of this study were 33 denture wearers (15 male and 18 female) aged from 59-78 years old (mean age 67.48 ± 6.17 yrs.). All of them were upper and lower complete denture wearers. Actually total patients who participate in The Project of 2 implant-retained lower complete denture for Celebration of 80th King's Birthday of Dentistry Faculty of Chulalongkorn University were 51 patients. Eighteen patients from this group were excluded from the study because they could not participate according to scheduled time of all 3 tests. So at the end of study, there were remained only 33 subjects. The least vertical bone height of residual mandible of subjects from panoramic radiograph were vary from 9.46 - 27.05 mm (mean 15.52 ± 4.44 mm). The bone height of mandible were classified by The American College of Prosthodontists (ACP) in four types (40) and modified in to two groups as High bone group and Low bone group. The majority of this study participants fit into High bone group (Table I).

The result of this study showed that most of subjects were able to develop their masticatory efficiency after treatment with implant-retained lower complete denture. Statistically analysis showed that the data was in a normal distribution with homogeneity variances. There was a statistically significant difference in the mean values among 3 tests ($P \leq 0.001$). Means of percentage of chewing ability after treatment 1 week was 23.94 ± 6.58 (baseline= 15.43 ± 4.36) and 1 month after loading, it was increased to 28.17 ± 6.16. Multiple comparison procedures (Turkey test) found significant mean differences among each group ($P<0.05$) (Table II). Percentage of chewing ability of all subjects was shown in Fig.7.

Table I Total number of subjects classified by bone height of mandible according to ACP classification and modified group

The least vertical bone height of mandible (mm)	Classification	No. of subject (person)	Modified group	No. of subject (person)
≥ 21 mm	Type I	4	High bone group	18
16-20 mm	Type II	14	> 15 mm	
11-15 mm	Type III	11	Low bone group	15
≤ 10 mm	Type IV	4	≤ 15 mm	

Table II Mean and standard deviations of Percentage of chewing ability of thirty three subjects.

Test*	Mean±SD	
Test 1	15.43 ± 4.36	a
Test 2	23.94 ± 6.58	a
Test 3	28.17 ± 6.16	a

* Test 1:before implantation. Test 2: within 1 week after abutments were connected. Test 3: one month after insert IOD

a: Multiple comparison denotes statistical difference at alpha < 0.001

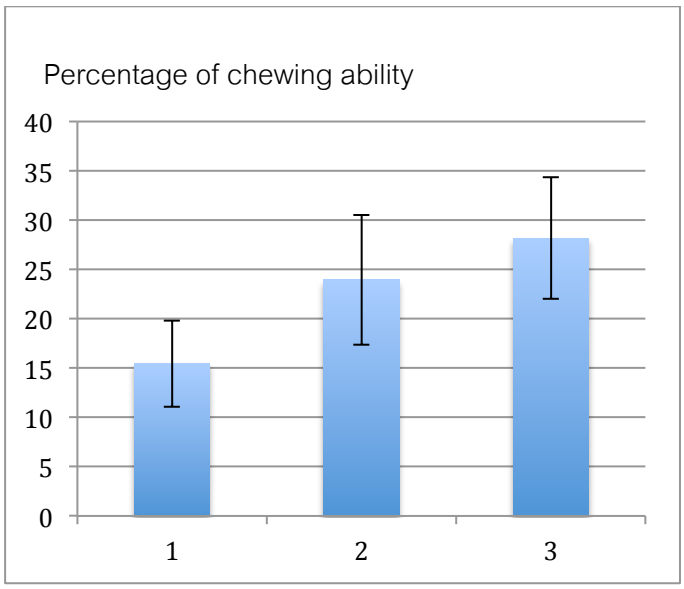


Fig.7 Percentage of chewing ability of three tests of all subjects

Two modified groups as High bone group and Low bone group showed the results in the same way. There was a statistically significant difference in the mean values among 3 tests ($P \leq 0.001$) of both groups. Moreover, the high bone group showed higher mean value of percentage of chewing ability than low bone group statistically significantly ($P < .05$) (Table III). Although the result showed there was a significant effect of time (Test) but it was found that no interaction between bone height and test ($P > .05$). Percentage of chewing ability of high bone group (HBG) and low bone group (LBG) of 3 tests was shown in Fig.8.

Table III Number of subjects, bone height, mean and standard deviations of percentage of chewing ability of high bone group and low bone group.

Group	No. of subjects (person)	Bone height (mm)			Mean±SD of Percentage of chewing ability		
		mean±SD	max	min	Test1	Test2	Test3
High bone[a] (>15mm)	18	18.52±3.59	27.05	15.15	18.40±3.47*	25.84±6.39*	30.08±5.87*
Low Bone[a] (≤ 15 mm)	15	11.92±1.97	15	9.46	11.88±2.02*	21.66±6.27*	25.87±5.88*

*Statistical difference at alpha < 0.001

a: Statistical difference between high and low bone group at alpha < 0.05

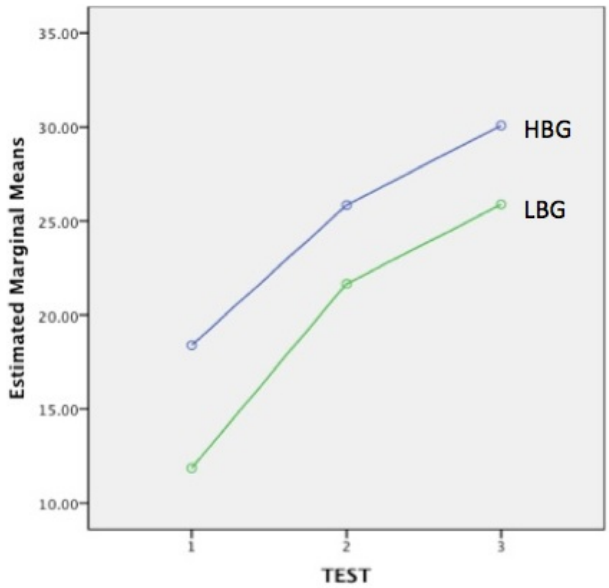


Fig.8 Percentage of chewing ability of 3 tests of high bone group (HBG) and low bone group (LBG)

CHAPTER V

DISCUSSION

The process of this study was started from rehabilitation with conventional complete denture until the third test was completed which spend almost 1 year. There were 18 participants of The Project of 2 implant-retained lower complete denture for Celebration of 80th King's Birthday of Dentistry Faculty of Chulalongkorn University were excluded from this study for many reasons: delay surgical procedure (6 patients), acute systemic disease affected the surgical procedure (3 patients) and can not participate according to scheduled time of the study (9 patients).

Most of the implant fixtures in these participants were successfully integrated with alveolar bone during the study periods. Two implant fixtures from 2 patients were lost at 3 months healing phase and they were excluded from our study because they have to replace new fixtures and could not participate according to scheduled time of the study. By the way, after replaced the new fixtures, they have osseointegrated to their bone finally. After second stage implant, 2 subjects which ACP Type IV had a problem deal with lack of connective tissue attachment around abutment and need soft tissue graft procedure. The problem was solved by replacement of taller abutment instead of surgical procedure because of additional procedure was not supported from the project and the subject refused to pay additional expense. However, the result was quite good with no inflammation around abutment and no complaint from subjects. From this regard, it might be claimed that, aging is not a limitation for implant treatment. Any geriatric patient whose systemic health does not preclude a minor oral surgery procedure is considered as a

candidate for implant placement with favorable outcome of osseointegration. However, long term follow-up will help us to clarify this issue.

From the result, 15 from 33 subjects or about 45.5% were grouped as Low bone group that classified in type III and IV from ACP classification. Indeed, it is very difficult to fabricate a traditional denture for that bone height level with no retention or stability problem. These group need implant treatment for rehabilitation as recommened by ACP.

In agreement with the findings of numerous researchers (17,65-66), this study shows that masticatory efficiency increases significantly during transition from a traditional complete denture to an implant-retained lower complete denture. The result of percent of chewing ability demonstrated that most of subjects were improved their chewing ability since within 1 week after abutments were connected and more after 1 month. When focusing on height of mandible found that both high and low bone group showed results in the same way among 3 tests but high bone group showed superior result. There was statistically significant difference in the mean value between 2 groups but no interaction between bone height and test. This meant that the level of bone could not induce in the participants had a significant effect on their masticatory performance overtime. Recently study showed similar result. They found that mandibular bone height has no effect on patient's satisfaction with the function, chewing ability and comfort of their prostheses. No matter how much bone, they suggested that edentulous elderly will get benefit more from mandibular IOD than from CD (61,67-68). From this reason, the treatment plan for implant-retained lower complete denture in early elderly edentulous patients with uncomplicated systemic disease and high bone level might be better than operate these surgical procedures in late stage with uncontrolled systemic disease and revere resorption of their alveolar bone.

The improvement of percentage of chewing ability from this study could imply that the subjects had more variety for food selection chance after implantation. Some studies comfirmed that those who received implant overdentures had significantly increased their intake of hard and coarse foods such as fruits, vegetables and meats which are typically major sources of vitamins, minerals, proteins and fiber that are difficult to chew with conventional denture (69,70). These suggested that providing edentulous patients with only 2 implant-retained lower complete denture improve their dietary intake and nutritional state including quality of their life. In the aspect of nutrition, the studies reported in another way. They found that although the CD wearers reported having more difficulty in chewing hard food, both CD and IOD wearers appeared to have a similar nutritional status (70,71). To clarify this issue, we need effective methodology for further study.

Notwithstanding, implant-retained lower complete dentures have shown superiority over conventional complete dentures in several ways (72,73), but there are many aspects that should concern before treatment plan. One is the financial condition that obstruct many edentulous patients to reach this service. They have to pay 6-7 times more expensive than conventional complete denture for 2 implant-retained lower complete denture in private dental clinic and need maintenance appointments throughout the lifespan. The other is home care after treatment was important. We need to follow up more frequency at prior after treatment for repeatedly motivation about how to clean up their implants and denture by themselves. Routine recall and follow up evaluation is necessary. Only well-cooperated patients are suitable for this treatment. The last one is considerations on the effects of two implant mandibular overdenture on the opposite maxillary complete denture. At the end of this study, there were about 10 % of subjects perceived a decrease of maxillary denture stability after inserted implant-retained lower

complete denture for 6 months and need reline denture base. There are many study reported the response of supporting soft tissue for implant overdentures and opposing prostheses (74-76). Some authors contend that may cause by the prosthesis-tissue interface that are similar to found in combination syndrome. On the other hand, some studies reported long term follow up that patients rehabilitated with implant-retained mandibular overdentures are not subjected to more residual ridge resorption in the anterior maxilla when compared to patients wearing a conventional full denture (77-79). They documented that a more stable occlusion provides a better distribution of occlusal forces and protects the maxillary anterior edentulous ridge. These suggested that should long term routine follow up our subjects by panoramic radiograph examination and prosthesis reline to maintain proper occlusal relationships.

CHAPTER VI

CONCLUSIONS

From the results of the present study, it can be concluded that

1. By the wax cube analysis method, it find that conventional complete denture wearers can improve their chewing ability statistically significant by implant-retained lower complete denture treatment.
2. Patients with high mandibular bone show percentage of chewing ability superior than patients with low mandibular bone statistically significantly.
3. Mandibular bone height has no interaction effect on masticatory performance of implant-retained lower complete denture wearer.

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APPENDIX

Descriptive statistic analysis in percentage of chewing ability of all subjects

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum
	Statistic	Statistic	Statistic	Statistic	Statistic
before implantation-all	33	17.55	9.00	26.55	509.33
1 week-all	33	26.54	12.99	39.53	790.08
1 month-all	33	26.42	18.50	44.92	929.48
Valid N (listwise)	33				

Descriptive Statistics

	Mean		Std. Deviation	Variance	Skewness	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
before implantation-all	15.4342	.75952	4.36308	19.037	.699	.409
1 week-all	23.9418	1.14561	6.58106	43.310	.231	.409
1 month-all	28.1661	1.07232	6.15999	37.945	.635	.409

Descriptive Statistics

	Kurtosis	
	Statistic	Std. Error
before implantation-all	.316	.798
1 week-all	-.507	.798
1 month-all	.530	.798

Normality Test (Kolmogorov-Smirnov)

TEST1:	K-S Dist. = 0.128	P = 0.182	Passed
TEST2:	K-S Dist. = 0.121	P > 0.200	Passed
TEST3:	K-S Dist. = 0.100	P > 0.200	Passed

Descriptive statistic in percentage of chewing ability of high bone group

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum
	Statistic	Statistic	Statistic	Statistic	Statistic
before implant-high	18	11.40	15.15	26.55	331.14
1 week-high	18	23.78	15.75	39.53	465.10
1 month-high	18	23.47	21.45	44.92	541.40
Valid N (listwise)	18				

Descriptive Statistics

	Mean		Std. Deviation	Variance	Skewness	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
before implant-high	18.3967	.81764	3.46894	12.034	1.147	.536
1 week-high	25.8389	1.50539	6.38683	40.792	.351	.536
1 month-high	30.0778	1.38394	5.87155	34.475	1.156	.536

Descriptive Statistics

	Kurtosis	
	Statistic	Std. Error
before implant-high	.556	1.038
1 week-high	-.423	1.038
1 month-high	1.481	1.038

Normality Test (Kolmogorov-Smirnov)

TEST1:	K-S Dist. = 0.175	P = 0.153	Passed
TEST2:	K-S Dist. = 0.185	P = 0.104	Passed
TEST3:	K-S Dist. = 0.191	P = 0.082	Passed

Descriptive statistic in percentage of chewing ability of low bone group

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum
	Statistic	Statistic	Statistic	Statistic	Statistic
before implantation-low	15	6.00	9.00	15.00	178.19
1 week-low	15	19.27	12.99	32.26	324.98
1 month-low	15	17.17	18.50	35.67	388.08
Valid N (listwise)	15				

Descriptive Statistics

	Mean		Std. Deviation	Variance	Skewness	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
before implantation-low	11.8793	.52131	2.01902	4.076	.178	.580
1 week-low	21.6653	1.61828	6.26759	39.283	.156	.580
1 month-low	25.8720	1.51729	5.87643	34.532	.386	.580

Descriptive Statistics

	Kurtosis	
	Statistic	Std. Error
before implantation-low	-1.228	1.121
1 week-low	-1.144	1.121
1 month-low	-1.275	1.121

Normality Test (Kolmogorov-Smirnov)

TEST1:	K-S Dist. = 0.120	P > 0.200	Passed
TEST2:	K-S Dist. = 0.102	P > 0.200	Passed
TEST3:	K-S Dist. = 0.143	P > 0.200	Passed

Statistical analysis of percentage of chewing ability of all subjects

One Way Repeated Measures Analysis of Variance

Normality Test: Passed (P = 0.128)

Equal Variance Test: Passed (P = 0.150)

Treatment Name	N	Missing	Mean	Std Dev	SEM
TEST1	33	0	15.434	4.363	0.760
TEST2	33	0	23.942	6.581	1.146
TEST3	33	0	28.166	6.160	1.072

Source of Variation	DF	SS	MS	F	P
Between Subjects	32	2153.460	67.296		
Between Treatments	2	2775.545	1387.772	84.116	<0.001
Residual	64	1055.893	16.498		
Total	98	5984.898			

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001). To isolate the group or groups that differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.050: 1.000

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
TEST1 vs. TEST2	8.508	3	12.032	<0.001	Yes
TEST1 vs. TEST3	12.732	3	18.006	<0.001	Yes
TEST2 vs. TEST3	4.224	3	5.974	<0.001	Yes

Statistical analysis of percentage of chewing ability of high bone group

One Way Repeated Measures Analysis of Variance

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.487)

Treatment Name	N	Missing	Mean	Std Dev	SEM
TEST1	18	0	18.397	3.469	0.818
TEST2	18	0	25.839	6.387	1.505
TEST3	18	0	30.078	5.872	1.384

Source of Variation	DF	SS	MS	F	P
Between Subjects	17	875.290	51.488		
Between Treatments	2	1258.819	629.410	35.150	<0.001
Residual	34	608.813	17.906		
Total	53	2742.922			

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001). To isolate the group or groups that differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.050: 1.000

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
TEST1 vs. TEST2	7.442	3	7.462	<0.001	Yes
TEST1 vs. TEST3	11.681	3	11.712	<0.001	Yes
TEST2 vs. TEST3	4.239	3	4.250	0.013	Yes

Statistical analysis of percentage of chewing ability of low bone group

One Way Repeated Measures Analysis of Variance

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.225)

Treatment Name	N	Missing	Mean	Std Dev	SEM
TEST1	15	0	11.879	2.019	0.521
TEST2	15	0	21.665	6.268	1.618
TEST3	15	0	25.872	5.876	1.517

Source of Variation	DF	SS	MS	F	P
Between Subjects	14	672.959	48.068		
Between Treatments	2	1546.283	773.141	51.849	<0.001
Residual	28	417.523	14.912		
Total	44	2636.765			

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001). To isolate the group or groups that differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.050: 1.000

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.05
TEST1 vs. TEST2	9.786	3	9.815	<0.001	Yes
TEST1 vs. TEST3	13.993	3	14.034	<0.001	Yes
TEST2 vs. TEST3	4.207	3	4.219	0.016	Yes

Statistical analysis of percentage of chewing ability between High bone group and Low bone group

Within-Subjects Factors

Measure: MEASURE_1

TEST	Dependent Variable
1	Test1
2	Test2
3	Test3

Between-Subjects Factors

		N
1=high group,2=low group	1	18
	2	15

Box's Test of Equality of Covariance Matrices[a]

Box's M	5.618
F	.836
df1	6
df2	6318.516
Sig.	.542

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.[a]

a. Design: Intercept + boneheight

Within Subjects Design: TEST

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
TEST	Pillai's Trace	.815	66.277[b]	2.000	30.000	.000
	Wilks' Lambda	.185	66.277[b]	2.000	30.000	.000
	Hotelling's Trace	4.418	66.277[b]	2.000	30.000	.000
	Roy's Largest Root	4.418	66.277[b]	2.000	30.000	.000
TEST * boneheight	Pillai's Trace	.039	.610[b]	2.000	30.000	.550
	Wilks' Lambda	.961	.610[b]	2.000	30.000	.550
	Hotelling's Trace	.041	.610[b]	2.000	30.000	.550
	Roy's Largest Root	.041	.610[b]	2.000	30.000	.550

a. Design: Intercept + boneheight
Within Subjects Design: TEST

b. Exact statistic

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
TEST	.826	5.747	2	.057	.852	.925	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.[a]

a. Design: Intercept + boneheight
Within Subjects Design: TEST

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed i the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
TEST	Sphericity Assumed	2801.678	2	1400.839	84.623	.000
	Greenhouse-Geisser	2801.678	1.703	1645.039	84.623	.000
	Huynh-Feldt	2801.678	1.850	1514.329	84.623	.000
	Lower-bound	2801.678	1.000	2801.678	84.623	.000
TEST * boneheight	Sphericity Assumed	29.557	2	14.779	.893	.415
	Greenhouse-Geisser	29.557	1.703	17.355	.893	.401
	Huynh-Feldt	29.557	1.850	15.976	.893	.408
	Lower-bound	29.557	1.000	29.557	.893	.352
Error(TEST)	Sphericity Assumed	1026.335	62	16.554		
	Greenhouse-Geisser	1026.335	52.796	19.440		
	Huynh-Feldt	1026.335	57.353	17.895		
	Lower-bound	1026.335	31.000	33.108		

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TEST	Type III Sum of Squares	df	Mean Square	F	Sig.
TEST	Linear	2696.494	1	2696.494	134.567	.000
	Quadratic	105.184	1	105.184	8.048	.008
TEST * boneheight	Linear	21.859	1	21.859	1.091	.304
	Quadratic	7.698	1	7.698	.589	.449
Error(TEST)	Linear	621.186	31	20.038		
	Quadratic	405.150	31	13.069		

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
before implantation	3.239	1	31	.082
1 week after loading	.001	1	31	.977
1 month after loading	.446	1	31	.509

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.[a]

a. Design: Intercept + boneheight

Within Subjects Design: TEST

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	48773.762	1	48773.762	976.578	.000
boneheight	605.211	1	605.211	12.118	.002
Error	1548.249	31	49.944		

BIOGRAPHY

NAME	Miss Nuntaporn Chokpreecha
DATE OF BIRTH	7 February 1983
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Chulalongkorn University, 2001 – 2007: Doctor of Dental Surgery Chulalongkorn University, 2009 – 2012: Master of Science (Prosthodontics)
WORK EXPERIENCE	2007 – 2009, Bayabansathanprabarame Hospital Kanchanaburi, Thailand Position: Dentist
PUBLISHED JOURNAL	-
RESEARCH GRANT	The Excellent Center for Oral and Maxillofacial Reconstruct Project, Chulalongkorn University
CONTACT ADDRESS	89/91 Charansanitwong 13 Rd. Thapra, Bangkokyai, Bangkok 10700, Thailand E-mail: la_belle_lo@hotmail.com