A comparison of implant stability between two dental implant design
using two different stability measuring technique

Miss Chanikarn Chaksupa

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By	Miss Chanikarn Chaksupa
Field of Study	Esthetic Restorative and Implant Dentistry
Thesis Advisor	Associate Professor ATIPHAN PIMKHAOKHAM, D.D.S., M.P.A., Ph.D.

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.... Dean of the FACULTY OF
DENTISTRY
(Professor Pornchai Jansisyanont, D.D.S., M.S., Ph.D.)

THESIS COMMITTEE

.... Chairman
(Associate Professor PRAVEJ SERICHETAPHONGSE, D.D.S.,
M.S.)

.... Thesis Advisor
(Associate Professor ATIPHAN PIMKHAOKHAM, D.D.S.,
M.P.A., Ph.D.)

.... Examiner
(WAREERATN CHENGPRAPAKORN, D.D.S., Ph.D.)

.... External Examiner
(Associate Professor Pattapon Asvanund, D.D.S., M.S.D.,
Ph.D.)

ชนิกานต์ จักษุพา : การเปรียบเทียบเสถียรภาพของรากฟันเทียมสองแบบด้วยวิธีวัดเสถียรภาพสองชนิดที่ต่างกัน. (A comparison of implant stability between two dental implant designusing two different stability measuring technique) อ.ที่ปรึกษาหลัก : รศ. ทพ.ดร.อาทิพันธุ์ พิมพ์ขาวขำ

วัตถุประสงค์ เพื่อเปรียบเทียบเสถียรภาพของรากฟันเทียมแบบเกลียวคมและรากฟันเทียมแบบเกลียวไม่คม และหาความสัมพันธ์ระหว่างค่าเสถียรภาพชนิดวิเคราะห์คลื่นความถี่เรโซแนนซ์ (ISQ) และ ชนิดวิเคราะห์ค่าการหน่วง (IST) วิธีการศึกษา รากฟันเทียมชนิดแบบเกลียวคมและรากฟันเทียมชนิดเกลียวไม่คมจำนวนเก้าสิบหกตัว แบ่งเป็นชนิดละสี่สิบแปดตัว ถูกวางแผนด้วยระบบดิจิทัลสามมิติ และฝังลงในแบบจำลองฟันที่มีกระดูกเทียม บริเวณฟันกรามน้อยทั้งฝั่งซ้ายและขวา โดยใช้วิธีคอมพิวเตอร์ช่วยเหลือแบบสถิต สันกระดูกว่างจะถูกแทนที่ด้วยกระดูกเทียมสี่ชนิดที่จัดเรียงกันแบบสุ่ม เพื่อลอกเลียนการผสมของกระดูกเนื้อโปร่งและกระดูกเนื้อแน่นในแบบต่างๆ หลังจากฝังรากเทียมลงในแบบจำลองเสร็จแล้ว ค่าเสถียรภาพชนิดวิเคราะห์คลื่นความถี่เรโซแนนซ์ (ISQ) และ ชนิดวิเคราะห์ค่าการหน่วง (IST) จะถูกวัดและบันทึกทันที โดยใช้เครื่อง Osstell ISQ *และ AnyCheck ตามลำดับ ข้อมูลในแต่ละกลุ่มจะถูกนำมาวิเคราะห์ทางสถิติด้วย* Spearman correlation *และ* Mann-Whitney U test ผลการทดลอง จากการศึกษาพบว่าค่าเฉลี่ยของค่า *ISQ* เท่ากับ *67.87* ในรากฟันเทียมแบบเกลียวคมและ *65.87* ในรากฟันเทียมแบบเกลียวไม่คม ในขณะที่ค่าเฉลี่ยของค่า *IST* เท่ากับ *71.30* ในรากฟันเทียมแบบเกลียวคมและ *69.25* ในรากฟันเทียมแบบเกลียวไม่คม ผลการวิเคราะห์ไม่พบความแตกต่างกันของค่าเสถียรภาพอย่างมีนัยสำคัญทางสถิติระหว่างรากเทียมทั้งสองชนิด อย่างไรก็ตามพบว่ารากฟันเทียมชนิดเกลียวคมมีค่าเสถียรภาพสูงกว่ารากฟันเทียมชนิดเกลียวไม่คม ทั้งค่า *ISQ* และค่า *IST* จากข้อมูลทั้งหมด พบความสัมพันธ์ระหว่างค่า *ISQ* และค่า *IST* สรุป การศึกษานี้พบว่ารากฟันเทียมชนิดเกลียวคมมีค่าเสถียรภาพสูงกว่ารากฟันเทียมชนิดเกลียวไม่คม แต่ไม่พบความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ และพบความสัมพันธ์ระหว่างค่า *ISQ* และค่า *IST*

สาขาวิชา	ทันตกรรมบูรณะเพื่อความสวยงามและทันตกรรมรากเทียม	ลายมือชื่อนิสิต ....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

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KEYWORD: implant stability, Implant Stability Quotient values, Implant stability test values, aggressive thread design implant, non-aggressive thread design implant

Chanikarn Chaksupa : A comparison of implant stability between two dental implant designusing two different stability measuring technique. Advisor: Assoc. Prof. ATIPHAN PIMKHAOKHAM, D.D.S., M.P.A., Ph.D.

Objective To investigate the primary stability of aggressive thread design implant comparing to nonaggressive thread design implant and to evaluate the correlation between ISQ values and IST values. Materials and methods 96 implants were used in this study. 48 BLT Straumann® and 48 BLX Straumann® were used. All implants were digitally planned and placed in 3D printed model using computer assisted guided surgery. The edentulous area at models were packed with randomized pattern of four different kinds of polyurethane blocks to replicate mixed cancellous bone. Postoperative implant stability measurement was performed immediately after implant insertion. Implant stability was measured by Osstell ISQ for ISQ value and AnyCheck for IST value. The data was analyzed using Spearman correlation and Mann-Whitney U test. Results The mean ISQ value was 67.87 and 65.87, for BLX and BLT respectively. While, the mean IST value was 71.30 for BLX and 69.25 for BLT. The primary stability between BLX and BLT found no statistically significant difference in both ISQ value and IST value. There was a significant correlation between ISQ value and IST value. Conclusion The aggressive thread design implant (BLX) and nonaggressive thread design implant (BLT) has no statistically difference in both ISQ and IST groups. Moreover, there was a correlation between ISQ and IST in both implant design.

Field of Study:	Esthetic Restorative and Implant Dentistry	Student's Signature ....
Academic Year:	2021	Advisor's Signature ....

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Chapter I

Introduction

Rationale and significance of the problem

Implant stability is one of the most crucial factors for successful dental implant treatment. The satisfying stability during healing period might prevent an excessive micromovement and disruption of bone formation [6]. Primary stability is the stability of implant at the time of implant placement, which is a critical factor for achieving osseointegration. Several possible aspects that has an influence on primary implant stability are bone-related factors, implant characteristics and surgical technique [7, 33].

Since bone density or bone quality can determine the success in obtaining primary stability. Various bone assessments have been proposed, they were commonly classified into four bone types based on compact bone to trabecular bone ratio [29]. According to Misch [36], bone density categorize into D1 to D4. D1 comprised the majority of dense compact bone, while D2 bone is composed of dense to porous compact cortical bone on the outside and coarse trabecular bone on the inside; D3 bone is composed of porous, thinner cortical bone and fine trabecular bone; and D4 bone is composed of fine trabecular bone with very low density and little or no cortical crestal bone. The volume of available bone and its density are significantly correlated with the surgical intervention and implant type, and these factors are fundamental to the successful outcome of dental implant

surgery. Recently, material which commonly use to replicate jaw bone for a mechanical-test in laboratory experiment is polyurethane foam block (Sawbones®; Pacific Research Laboratories Inc., Washington, USA). Polyurethane foam is generally accepted as the standard for mechanical testing of orthopedic implants. Furthermore, the physical properties of this biomechanical test material are uniform and consistent, preventing the variation which can occur when testing with human cadaver bone [13]. In addition, some in vitro study has been striving to achieve the utmost simulation of the intraoral implant surgery and decrease the limitations. The three-dimensional printing models with edentulous area were used and attached to the phantom head, in purpose of mocking a real intraoral surgery, also position and visualization of the operator. [51, 58]

Regarding surgical technique, optimal implant placement is critical for providing a prosthesis design that is suitable for long-term success and maintenance. Conventional guide technique was obtained an acceptable outcome by using a surgical stent which converted from a radiographic stent with an opaque radiographic marker. The stents enable the surgeon to observe the appropriate prosthesis location intraoperatively. This technique is frequently referred to the free-hand technique. However, the exact implant position is highly dependent on the surgeon's ability and expertise in this technique. Lately, new digital technology called static computer-assisted implant surgery (CAIS) has been used to plan implant position and design surgical guided stent before surgery, considering the bone quality and quantity, the

location of important anatomical structures, soft tissues, and teeth, and the final

prostheses. A 3D-printed surgical guide is used to transfer the planned implant

location to the surgical site. Through a metal sleeve placed in the surgical guide,

guided surgical drills control the angulation and depth of the implant osteotomy.

Morover, it has been stated that guided implant surgery has a higher precision and

accuracy than conventional surgical guides or free-hand implant surgery [53, 58]

Another potential factor which can influence the stability of implant and

long-term success rate is implant characteristics. Main features of the implant are

such as implant material, implant micro-design and macro-design [10, 19]. Currently,

new material has been developed which is a hybrid of titanium and zirconia.

According to studies by Kobayashi [26], it provides greater strength and

biocompatibility. As a result, the risk of fracture is reduced, allowing the dentists to

choose a smaller diameter implant in case of anatomical limitations. Moreover, most

implant companies offer taper implants, due to the advantage of lateral compression

in poor bone implant sites and situations with anatomical limitations. Currently, the

aggressive thread design was introduced. This implant design provides special ability

to cut the bone during insertion and obtain better primary stability after implant

placement [21].

To determine or predict the outcome of implants, various technique for

evaluating implant stability have been developed, including invasive and non-

invasive clinical test methods. Insertion torque (IT) is one of the objective and non-

invasive measurement technique. Some studies have previously reported implant stability using IT measurements [3, 38]. Implant stability could be determined by a high torque number (Ncm). However, following implantation, this procedure could not be reproduced. Consequently, Resonance frequency analysis (RFA) was introduced. RFA is a non-invasive electronic instrument that has excellent repeatability and reliability for monitoring changes in implant stability [33]. The implant-bone complex's stiffness was determined and reported as an implant stability quotient (ISQ) value ranging from 1 (least stability) to 100 (highest stability). In the last decade, the RFA has been employed increasingly to provide a quantitative assessment of implant stability. ISQ measurements were taken periodically throughout the healing period to detect changes in implant stability as a result of successful osseointegration [9, 20, 35, 37]. However, in the process of ISQ measurement, the healing abutment must be unscrewed and the transducer of a metal rod (a peg) must connect to the implant. As a result, the routine of unscrewing healing abutment and a peg back and forth may have an effect on implant stability and osteointegration during critical period.

Consequently, implant stability test (IST) device (AnyCheck: Neobiotech, Korea) has been developed to detect the stiffness between alveolar bone and implant by means of slightly tapping at the healing abutment. AnyCheck can also be utilized without having to unscrew the healing abutment. It strikes the healing abutment six times over during three seconds and converts the time into IST values.

As a result, this device provides a safety measure for detecting initial implant stability, however research on AnyCheck is limited, and more studies is needed [27].

However, none of the studies that have assessed primary stability using the ISQ and IST values have investigated the impact of the aggressive thread implant. The advantages of identifying factors affecting implant stability are substantial. It will enable clinicians to select an implant that minimizes or eliminates implant instability during the early stages of bone remodeling, allowing a greater number of cases to meet the criteria for immediate or early loading while maintaining a high degree of predictability and a successful treatment outcome.

Research question

1. Is the primary stability of aggressive thread design implant was superior than non-aggressive thread design implant?

2. Is there the correlation between implant stability quotient (ISQ) values and implant stability test (IST) values?

Objective of the study

1. To investigate the primary stability of aggressive thread design implant (BLX) comparing to nonaggressive thread design implant (BLT)

2. To evaluate the correlation between implant stability quotient (ISQ) values and implant stability test (IST) values.

Statement of hypothesis

Null Hypothesis :

Primary stability of aggressive thread design implant is not superior than non-aggressive thread design implant. There is no correlation between implant stability quotient (ISQ) values and implant stability test (IST) values.

Alternative Hypothesis :

Primary stability of aggressive thread design implant is superior than non-aggressive thread design implant. There is the correlation between implant stability quotient (ISQ) values and implant stability test (IST) values.

Conceptual framework
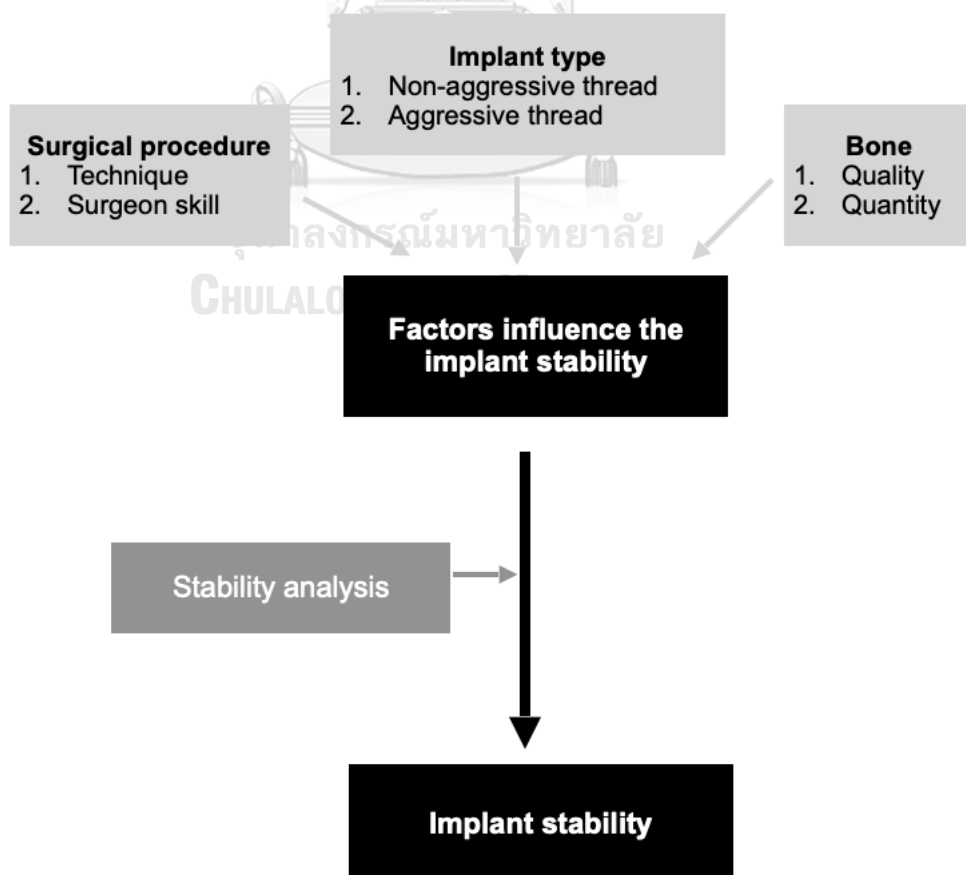
Chapter II

Review of the literatures

1. Implant stability

Since the establishment of the osseointegration idea by Brnemark and colleagues, oral implant-supported dental prostheses have been widely utilized. [12] Osseointegration is described as a direct structural and functional contact between living bone and the surface of a load-bearing implant. Zarb and Albrektsson's clinical definition of osseointegration is "a process by which clinically asymptomatic rigid attachment of alloplastic materials is accomplished and maintained in bone throughout functional loading." [5] Therefore, implant immobility is a clinical sign of osseointegration. Implant rigid fixation or implant stability has been acknowledged as a requirement for osseointegration and is regarded as one of the important keys that influence implant loading and long-term success. When the implant is secure in the bone site, new bone will develop and remodel directly on the implant surface. [4] This new bone will resemble the mature original bone in appearance. In addition, an excessive amount of micromotion during the healing period may impede bone formation on the implant surface and result in fibrous tissue encapsulation rather than osseointegration. [6]

Stability of an implant can be divided into two phases: primary (mechanical) and secondary (biological). During the healing process, the proportion of mechanical and biological stability varies. Implant stability at the moment of implantation relies

only on mechanical retention between the implant and the bone bed. This is often

referred to as "primary stability" or "mechanical stability." Consequently, a lack of

primary stability may result in less bone-to-implant contact than a stable implant.

[22] Following the occurrence of biological responses such as osteoclastic activity,

remodelling, and new bone formation, secondary bone development replaces

primary intimate bone contact. Due to osteoclastic activity, the primary stability will

diminish over time, but the secondary stability or biological stability will increase, as

illustrated in Figure 1.

Three weeks following the implantation of an implant is considered a vital

period. This timeframe is likely to have the lowest implant stability as a result of the

decreasing of mechanical stability and the lack of biological stability. [41] The

subsequent increase in secondary stability is related to the creation of new bone

upon the implant surface. Lastly, the stability of the osseointegrated implant

depends on the biologic factor. [46, 49] Therefore, the progression of implant

stability throughout most of the healing period must be understood in order to

determine the appropriate healing time prior to functional loading. Non-integrated

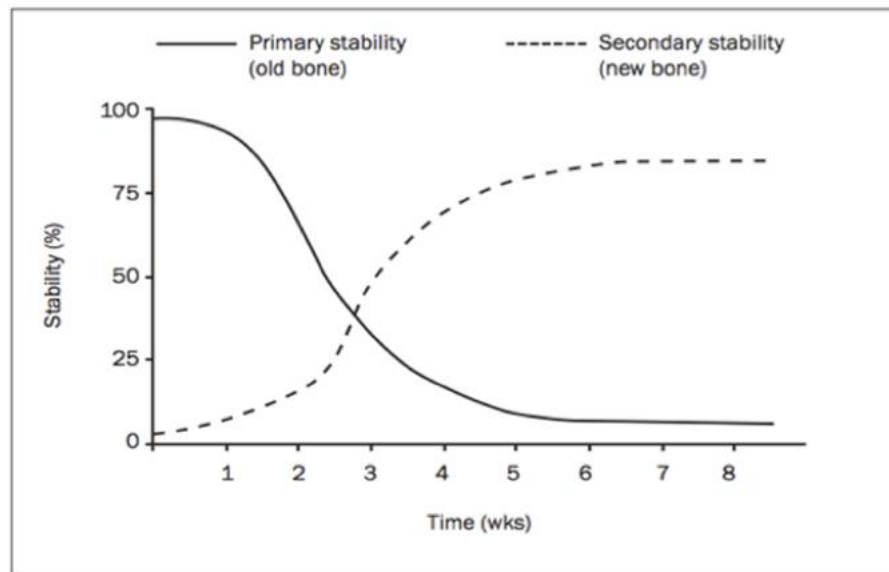implants are characterized by clinically mobile components. [41]

Figure 1 A schematic drawing of the changeover from primary stability to secondary stability by osseointegration in humans [19].

2. <u>Factors affecting implant stability</u>

Implant stability is depended on the bone-related factor, the surgical technique and the implant characteristics [4, 7, 31].

The degree of bone-implant contact is determined by bone quantity, bone quality, and the cortical-to-trabecular bone ratio. Reduction in alveolar ridge width may result in horizontal bone defects at the proposed implant site, such as dehiscence and fenestration defects, which may jeopardize the long-term success rate, the stability of the implant, and the aesthetic outcome of the definitive restoration. Numerous studies have found a correlation between bone quality and implant stability. [16] Previous research has found a link between bone quality and jaw areas. In general, mandibles are denser than maxillae, and both jaws tend to

lose bone quality when positioned posteriorly. Carl E. Misch, Lekholm and Zarb

extended this concept by proposing four bone types based on cortical and

trabecular bone, with D1 containing thick cortical bone which indicated in Hounsfield

scale greater than 1250 HU. On the D2 bone is dense to porous cortical bone and

coarse trabecular bone which represented in 850 to 1250 HU. D3 bone has a porous,

thinner cortical crest and fine trabecular bone which indicated as 350 to 850 HU,

while D4 bone has primarily no crestal cortical bone which equal to 150 to 350 HU.

Various researches have shown that an implant put in thick cortical bone is more

stable than one implanted in an open trabecular network.

Figure 2 Bone density classification scheme

Rigid polyurethane blocks (Sawbones®; Pacific Research Laboratories Inc.,

Washington, USA) were utilized at various densities to represent bone in a laboratory

setting. According to The American Society for Testing Materials recommends using

synthetic polyurethane foams as a standard material for mechanical testing of

orthopedic devices and equipment because they have a density and mechanical

qualities comparable to human bone. The regularity and consistency of rigid

polyurethane foam's standard is designed to create a consistent and homogenous material with qualities similar to human cancellous bone that make it a perfect material for a test medium for various orthopaedic and other medical devices, such as bone screws. Studies have revealed that certain densities of rigid polyurethane foam have a similar closed-cell structure to that of human cancellous bone, as well as mechanical qualities within the same range. Following Misch's classification of bone density, Polyurethane blocks at a density of 40 pounds per cubic foot (pcf) was represented as D1 bone, polyurethane blocks at a density of 30 pcf was represented as D2 bone, polyurethane blocks at a density of 20 pcf was represented as D3 bone, and polyurethane blocks at a density of 10 pcf was represented as D4 bone.

Surgical technique is the second factor related with implant stability. Optimal implant placement is critical for designing a prosthesis that is suitable for long-term success and maintenance. Using a surgical stent converted from a radiographic stent with an opaque radiographic marker, a conventional guide technique yielded an acceptable result. The stents allow the surgeon to see the appropriate prosthesis location during surgery. This technique is also known as the free-hand technique. The precise implant position, however, is highly dependent on the surgeon's ability and expertise in this technique. Static computer-assisted implant surgery (CAIS) is a new digital technology that has recently been used to plan implant position and design surgical guided stents before surgery, taking into account bone quality and quantity, the location of important anatomical structures, soft tissues, and teeth, and the final

prostheses. The planned implant location is transferred to the surgical site using a 3D-printed surgical guide. Guided surgical drills control the angulation and depth of the implant osteotomy via a metal sleeve placed in the surgical guide. Furthermore, guided implant surgery is said to be more precise and accurate than conventional surgical guides or free-hand implant surgery. [53, 58] Moreover, a precise drilling technique is required for a stable implant. Clinicians with insufficient skill may design an implant bed that is improperly sized. A preparation that is too large may result in implant micromotion and non-integration. Undersize preparation, on the other hand, which utilizes a smaller drill than the implant size, might create compression at the implant-bone interface. This compressive force is referred to as "Hoop stresses," which may be advantageous for strengthening the primary implant's stability. [31] However, advancements in cone-beam computed tomography (CT) and intramural scanning have simplified the move from manual impressions and treatment planning to a fully computerized implant approach. Digitally-designed surgical guidance have been promoted as a means of ensuring correct implant placement. [56] Additionally, during implant site preparation, heat is generated by the bone drilling technique, particularly at the site's surface. The increasing temperature during preparation can result in thermal bone damage. Eriksson and colleagues established that the critical temperature of human bone is 47 ℃; when the temperature exceeds 47 ℃ for 1 minute, bone necrosis can occur. [14] To reduce the temperature during the process, saline irrigation is required. [45]

Implant characteristics are the last variable that determine implant stability. During the osseointegration process, the surface of the dental implant also affects the bioadhesion of osteogenic cells. [23] Previous research also indicated that osteoblast proliferation, differentiation, and adhesion were improved on a rough surface, as was the bone-to-implant contact (BIC) percentage. [28]

The SLA® and SLActive® implants (Straumann AG) were developed to shorten the healing time. Sandblasting with large-grit particles and etching with a strong acid were used to prepare the surface of the SLA® implant (Straumann AG) in order to create an active microroughness surface that would promote cell adherence. [1] SLA® implants have been shown to have a more rapid osseointegration as well as an increased bone-to-implant contact (BIC). [50, 57] As a result, the SLA® implant can shorten the amount of time needed for the bone to regenerate, allowing for effective restoration within 6-8 weeks with an acceptable outcome. [11, 42, 50] It was recommended that the SLActive® implants be used not only in early loading implant but also in the region that has a lower than average bone quality. [8]

Moreover, implant macrodesign influences primary implant stability. The implant thread provides various advantages, such as the ability to optimize surface area, distribute the pressure that compresses bone, and provide the primary stability of dental implants. [10, 19] Recently, the concept of double or triple thread has

been established. During insertion, double thread was more rapid and efficient. Also, less heat was generated. [8]

Presently, aggressive thread design implants are capable of severing bone upon insertion. The use of this implant requires specific consideration for bone types 1 and 4. For low-density bone, the cutting capability is excessive, resulting in a complete loss of mechanical interlocking. In contrast, severe pressure to high-density bone causes cell death and compression necrosis. [55]

BLX Straumann® is a recently developed titanium-zirconia implant with SLActive® surface and an aggressive thread design (Straumann AG). This implant is self-drilling and has a soft, rounded tip to preserve anatomical structures such as the inferior alveolar nerve and maxillary sinus. The BLX Straumann® implant is a double-threaded design that expedites insertion. To obtain the highest level of primary stability, the thread is cut on both sides, with progressive spacing and width along the length of the implant.

Furthermore, the dynamic chip flutes on the side of the implant aid in the repositioning of the bone during the osteotomy. These lateral channels gather and equally distribute the bone to generate a good implant-to-bone interface. The core of BLX Straumann® is thin and gradually tapers to decrease osteotomy. Additionally, the diameter of the neck is reduced to alleviate stress on the cortical bone.

Additionally, The BLX Straumann® is comprised of a Roxolid® core and SLActive® surface. Roxolid is composed of 15% Zirconia and 85% Titanium and has

superior mechanical properties, including tensile and fatigue strength. Additionally, the SLActive surface has the most remarkable healing capacity.

As mentioned above, for the high performance this BLX implant, it is supposed to use as an implant of choice in clinical practice in any situation and all bone types. Subsequently, to reduce the treatment time, give patients' satisfaction and enhanced implants acceptance.

3. Implant stability evaluation methods

In order to predict the prognosis and define the optimal healing period prior to implant loading, it is essential to assess implant stability continuously from the time of implant placement. Several distinct approaches for measuring implant stability have been developed, including invasive and non-invasive clinical test methods. [31]

Invasive clinical test methods

The histologic and histomorphometric examination is the approach that is considered to be the gold standard for providing information on the percentage of bone to implant contact as well as the amount of bone that is contained within the threads of the implant. However, during this procedure, biopsies will need to be taken of the implant as well as the bone that surrounds it. As a consequence of this, the approach is regarded as destructive, and it does not seem to be applicable in clinical settings.

The reverse torque test involves applying a torque in the anti-clockwise direction to remove an implant. The torque is raised until the critical torque threshold is reached, at which point the bone-implant contact is destroyed. Sullivan and colleagues [52] observed that implant failure occurred in the range of 45 to 48 Ncm, although a reverse torque of no more than 20 Ncm is regarded as appropriate and trustworthy. However, Brånemark found that the reverse torque could cause irreversible plastic deformation and implant failure. [12]

Non-invasive clinical test methods

The metallic instrument percussion test is one of the easiest noninvasive methods for identifying osseointegration. However, this approach is deemed insensitive to detect changes in implant stability as it relies on the clinician's experience.

The radiographic evaluation offers information regarding osseointegration and peri-implant bone density, both of which might impact implant stability. To avoid distortion, precise measuring requires a completely parallel approach, but it is difficult to standardize a reliable and repeatable radiograph. In addition, because radiographs are two-dimensional, changes in facial bone and bone structure are barely discernible. Goodson also observed that the association between disease activity and radiography analyses appeared incapable of detecting early bone mineral alterations. [18]

The cutting torque resistance test evaluates the torque during bone removal during fixture site preparation. To achieve a more objective evaluation, a torque gauge attached to a drilling unit is created. The values of cutting resistance correlated with bone quality, one of the factors influencing implant stability. [17] This approach cannot give a pre-operative assessment of bone quality, nor can serial measurements be performed.

The insertion torque is the torque required to place the implant into the bone location that has been prepared. Johansson and Stride presented an insertion torque technique in which bone quality as a function of density and hardness may be inferred from torque values obtained during implant thread installation. They theorized that the energy necessary to place the implant into the site is a combination of the thread placement force from the instrument's tip and the friction created as the remaining tap or implant penetrates the site. A minimum insertion torque of 20 Ncm was specified for implant insertion and primary stability [40, 54].

Recent non-invasive electronic measurement instruments have been developed to offer objective changes in the stability of implants. Periotest® and resonance frequency analysis (RFA).

Periotest® (Siemen AG, Bensheim, Germany) is designed to measure the periodontal integration of teeth and the implant/bone interface stiffness. The tooth or implant is percussed by an electronic tapping head, and the response is detected by a miniature accelerometer. The contact time between the tapping rod and the

item is recorded and converted into the Periotest values (PTV). The stability of the

tooth and implant allows for brief contact durations, resulting in low Periotest scores.

The typical PTV range for osseointegrated implants is -5 to +5. The values over 10

PTV units are considered insufficient/osseointegration failure. [38] Due to the variable

that affects the accuracy of Periotest®, however, its application is regarded as lacking

in resolution and sensitivity, as well as being subject to operator variables.

4. Resonance frequency analysis

Meredith and colleagues proposed resonance frequency analysis (RFA) in

1996 as a noninvasive electronic instrument for assessing implant stability. [34] The

RFA is designed on the basis of an implant-bone flexure test. Initial components of

the RFA system include an excitation source, a computer analysis, and a transducer.

The transducer consists of a tiny offset cantilever beam to which are attached two

piezo components. One of the piezo components is activated by a sinusoidal signal

from a frequency response analyser, while the other acts as a signal receptor. The

system's resonance frequency is derived from the peak amplitude of the signal,

which varies between 5 and 15 kHz [33].

The resonance frequency analysis depends on three main factors ; the design

of the transducer, the stiffness of the implant-bone junction and the total effective

length [47].

The first factor is the transducer or peg's design. The length, thread type, diameter, and connecting surfaces of the SmartPeg vary to accommodate various implant systems. To obtain an accurate ISQ reading, the peg must be precisely matched with the implant type and screwed in the correct direction.

Second, the stiffness of the implant-bone junction, which is dependent on the stiffness of the implant as a consequence of its features, the stiffness of the surrounding tissue, and the stiffness of the bond between the implant's surface and the surrounding bone.

The properties of an implant include its length, diameter, and general form. According to the investigations of implant length on RFA, implant length had no effect on RFA. [9, 39] However, the majority of research suggested that the diameter of the implant has a substantial effect on RFA measurement, with larger diameters demonstrating greater ISQ values.

The surrounding tissue's rigidity is proportional to the implant's bone density and the ratio of compact to trabecular bone. Previous research has demonstrated a greater ISQ value in denser bone [48]. In general, mandibles displayed a greater ISQ value than maxillas, and the ISQ value of both jaws tends to decrease posteriorly [9]. This variation in ISQ value has been related to differences in bone morphology and the proportion of compact to trabecular bone.

Both in vitro and in vivo investigations have assessed the stiffness of the implant-bone interface. Observations were made of longitudinal variations in the

binding stiffness between the implant surface and the surrounding bone. Meredith

and colleagues conducted an animal investigation to discover a correlation between

bone to implant contact (stiffness) and the changes in resonance frequency because

histology is the gold standard for evaluating osseointegration. According to the

findings of the study, an increase in bone-to-implant area corresponded to an

increase in resonance frequency. [34]

The final aspect influencing the RFA is the overall effective length above the

level of marginal bone. The effective implant length (EIL) is the combined length of a

fixture above a bone and a transducer or abutment. Despite the fact that the length

of the transducer/abutment is fixed, the effective length is dependent on variations

in bone level surrounding the fixture (length of fixture exposed). According to the

results of an experimental study, the resonance frequency of an implant decreases
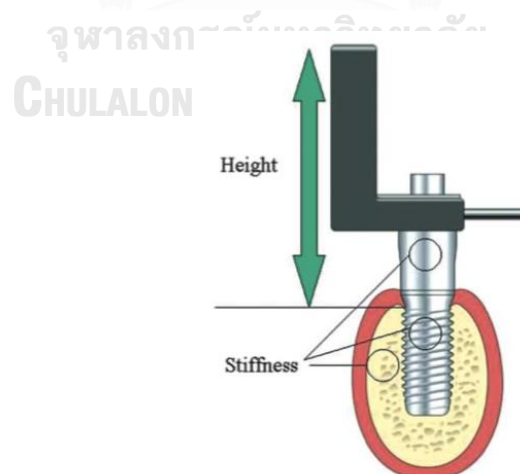
as its height increases. [7, 47]

Figure 3 A schematic showing the factors effect resonance frequency : the design of the transducer, the stiffness of the implant-bone junction, the total effective length above the marginal bone level.

The most recent commercially available RFA was the Osstell® ISQ (Osstell AB, Integration Diagnosis, Gothenburg, Sweden). The transducer or SmartPeg (SmartPeg, Integration Diagnostics AB) was placed into a fixture and then triggered by magnetic pulses from the Osstell® device. In accordance with the terms of hertz, the result is expressed in implant stability quotient (ISQ) units. ISQ units range from 1 (least stable) to 100 (highest stability). The acceptable range for ISQ is between 55 and 85, with a mean of 70. The ISQ score of less than 55 should be considered a warning indication, and unloading and a period of recovery should be considered.

The Osstell® apparatus has been increasingly performed in clinical research to evaluate the development in implant stability during the healing periods. Thongborisoot in 2012 [43] measured the ISQ values of two different implant characteristics at day 1, day 2 and then at 1, 2, 3 ,4 and 8 weeks. Bischof et al. and Nedir et al. [9, 37] measured the ISQ values at the day of implant placement and at 1, 2, 4, 6, 8, 10 and 12 weeks. The results revealed that the mean ISQ remained stable or increased somewhat over the first 4–6 weeks, then began to climb more visibly, and was considerably higher after 12 weeks. In addition, a review literature of Raghavendra and collaegues [42] determined that the essential time for implant healing in humans would be two to three weeks following osseointegration.

Therefore, it is essential to monitor implant stability during the course of the first two

months in order to assess potential changes in implant stability and decide the

optimal time for implant loading.
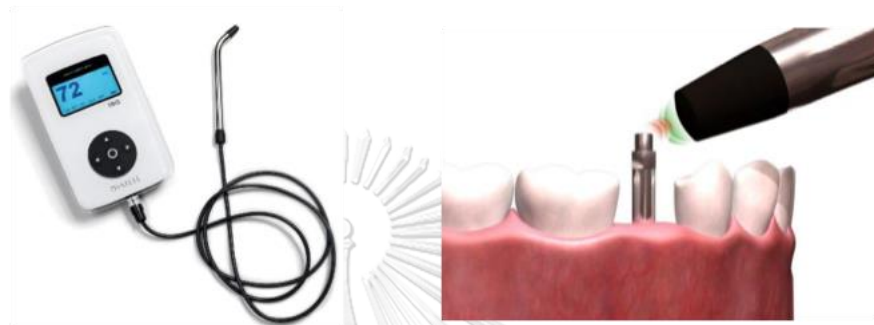
Figure 4 the Osstell® ISQ Reprint from Osstell company Sweden

5. Modified damping capacity analysis (DCA)

The commercially DCA device is the implant stability test (IST) device

(Anycheck: Neobiotech, Korea). The device measures the stiffness of the contact

between the alveolar bone and the implant through the use of a device that taps

the healing abutment approximately six times. The manufacturer claimed that the

tapping force is 30 percent less than the Periotest, and that the device will stop the

second tapping when an IST value of less than 70 is detected. Additionally, the

manufacturer stated that the tapping force is lower than the Periotest. In addition,

the Periotest and the Anycheck can both be utilized without having to unscrew the

healing abutment beforehand. Consequently, this device provides a safety

measurement to detect the initial implant stability, however the research on the

Anycheck is limited and requires expansion.

The IST values must be modified to account for the healing abutment's

height. The usual healing abutment height is 4 mm. The correction appears in the

table below.

Figure 5 AnyCheck Reprint from Neobiotech company, Korea

Table 1 The correction between IST value and the healing abutment's height.

IST level	Healing Abutment height	Final IST value
Standard +3	7 mm	+6 Displayed IST value
Standard +2	6 mm	+4 Displayed IST value
Standard +1	5 mm	+2 Displayed IST value
Standard	4 mm	Displayed IST value
Standard -1	3 mm	-2 Displayed IST value
Standard -2	2 mm	-4 Displayed IST value
Standard -3	1 mm	-6 Displayed IST value

Chapter III

Materials and methods

Materials

Implants

The implant used in this study are BLT Straumann® dental implant system and BLX Straumann® dental implant system (Straumann®, Switzerland). Every single placed implant is Roxolid® with SLActive® surface. All implants were placed by using digital guided surgery, according to a standardized surgical protocol following the manufacturer's instructions.

Implant stability measuring device

Two measuring devices were used for this study. (1) Resonance frequency analysis (RFA) device is Osstell ISQ from Osstell AB, Sweden. A measurement of Osstell is displayed as implant stability quotient (ISQ) from 1 to 100. Its transducer, SmartPeg is fixed to implant fixture. The probe release magnetic resonance frequency which activates magnetic SmartPeg. (2) Implant stability test (IST) device is AnyCheck from Neobiotech, Korea. A measurement of AnyCheck is displayed as Implant stability test (IST). IST scale is similar to ISQ. The measured value display in different color; red – 30-59, orange – 60-64 and green – 65-85.

Methods

Model preparation

The method was adapted from a previously published study by

Sittikornpaiboon et al. (2021); Yeung et al. (2020). This research used a subject with

bilateral edentulous sites at the maxillary first premolar. To create a suitable digital U

shape full-arch model with a bar, an intra-oral scan file (Standard Tessellation

Language; STL) was created and uploaded into Meshmixer software version 3.5.474.

(Autodesk Inc., California). At both edentulous sites, a cylindrical hallow space of 7

mm in diameter and 16 mm in length was designed to conform to the implant

implantation locations. Forty-eight digital models were produced using a 3D printer

(Straumann CARES P30+, Straumann AG, Basel, Switzerland) using a model resin

solution (P Pro Master Model Gray, Straumann AG, Basel, Switzerland) with a layer

thickness of 0.05 mm. Afterward, the models were completely cleaned with

isopropyl alcohol and treated to UV light to cure. To replicate mixed cancellous

bone at the implant insertion site, the hollow area at each site was packed with a

computer-generated randomized pattern of four different kinds of polyurethane

blocks (Sawbones, Washington, United States); each density of polyurethane blocks

was cut into a cylindrical form of 7 mm in diameter and 4 mm in length, according to

total height of the hallow space. Each polyurethane piece was randomly stack up

into four layer, in order to mimic diverse bone density in different area of human

bone jaw. The polyurethane was ensured to fit completely in the hallow space and

secured to the model by using cyanoacrylate glue. A computer-generated

randomization list was carried out by a statistician who was not engaged in implant

planning design or placement and each model was given a number from 1 to 48. All

48 models were chosen into the procedure in order from 1 to 48.

Implant planning procedure

Each implants were digitally plan and create surgical guide on a software

(coDiagnostiX software version 9.7, Dental Wings GmbH, Chemnitz, Germany) using

Digital Imaging and Communications in Medicine (DICOM) file and STL file . To create

DICOM file, all models were taken imaging data using a cone beam CT (CBCT)

machine (X- mind Trium, de Götzen S.r.l.-Acteon Group, Varese, Italy). The CBCT

machine was set to 6 mA, 86 kV, 54 seconds exposure time, 0.15 mm voxel size, and

80 x 80 mm field of view. Moreover, the models were then scanned for 3D file, using

a desktop scanner (Cares 7 SERIES, Dentalwings, Montreal, Quebec, Canada) to create

an STL file. Ninety-six implants were determined a final planned position on the

software. All implants was planned by one investigator. The optimal position placed

at the center of the polyurethane block: 1.5 mm of surrounding area, measured from

implant shoulder to outer margin of the block and 2 mm deeper from the top of the

block. Forty-eight implants for each of the two drilling protocols. Each protocol

specifies the particular surgical kit, the sleeve height, the sleeve location, and the

implant design. All forty-eight surgical guides were designed with an embedded guide

sleeve, with the objective of achieving oprtimal implant position and angulation in all subjects and to control the error from 3D printing process of the model. Additionally, implant diameters varied slightly between two groups, owing to the variance in implant diameter available throughout various systems. The implant length was set to ensure that all groups had the same free-drilling-distance length. As a result, two distinct procedures were used: group A used a 4.1 x 12 mm bone level tapered implant (Straumann AG, Basel, Switzerland), while group B used a 4.0 x 12 mm BLX implant (Straumann AG, Basel, Switzerland).

The surgical guides were generated identically using the coDiagnostiX program. All 48 surgical guide templates were created with four inspection windows. Between the surgical guide and the tooth, a gap of 0.05 mm was established. All surgical guides were printed using a 3D printer (Straumann CARES P30+, Straumann AG, Basel, Switzerland) with a layer thickness of 0.1 mm from a 2 mm thick medical grade surgical guide resin material (P Pro Surgical Guide, Straumann AG, Basel, Switzerland).

Surgical protocol

The models were attached to a phantom head in a supine position, in order to simulate the real procedure in patient. The operator seated in the right rare position. The surgical guide was placed on a model and evaluated the fitting through the inspection window before the implant placement procedure. All guided implant surgeries were conducted by one operator. The two drilling systems were applied in

this experiment. Same design of implant used the same protocol. The drilling procedure was carried out following with the manufacturer's instructions. Using each system's guided adapter, the implants were inserted fully guided. The BLX was placed at the upper left premolar area while the BLT was placed at the upper right premolar area.

Outcome measurement

All measurements were performed by one trained evaluator. After implants were placed, the final insertion torque value (Ncm) was recorded immediately. Implant stability was measured by an Osstell ISQ. A standardized SmartPeg was hand-screwed into the implant fixture with an amount of 4-5 Ncm of torque which means 'finger tighten' or 'finger torque' as manufacturer's recommendation. The probe of the device was held close as much as possible to the peg in the buccal and mesial direction. The space between the probe's top and the top of the SmartPeg should be a few millimeters without touching. Another measurement of implant stability was used by using AnyCheck IST device with a standard height of healing abutment 4 mm (AnyCheck: Neobiotech, Korea). This device need to maintain the contact angle between 0 to 30 degrees downward based on the ground level (Figure 2). The measurement was performed at buccal and lingual aspects of healing abutment. The ISQ and IST measurement were performed 3 times separately each side.
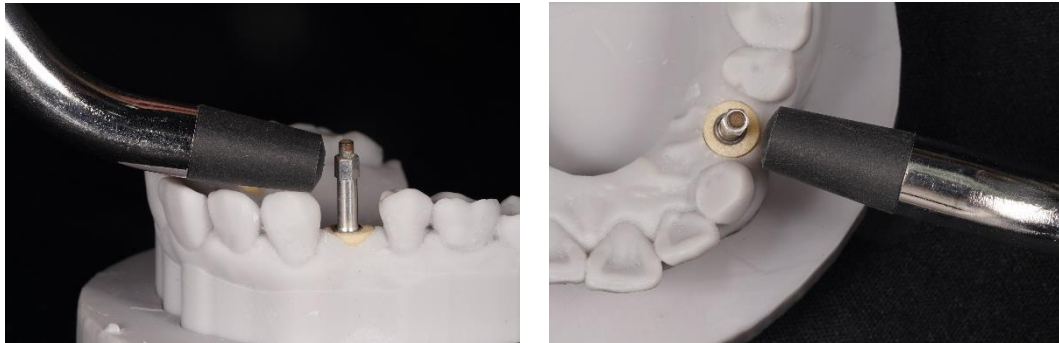
Figure 6 The ISQ value measurement at mesial and buccal using Osstell ISQ
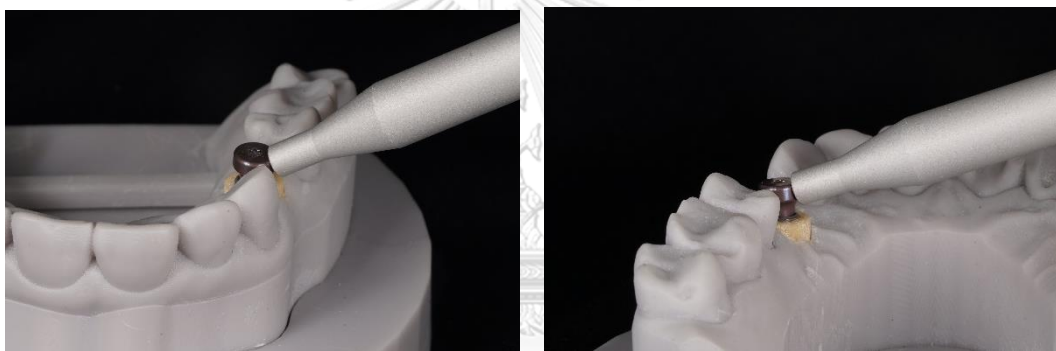
Figure 7 The IST value measurement at buccal and palatal using AnyCheck

Statistical analysis

The data was analyzed with IBM SPSS Statistics software version 22 (SPSS Inc., Chicago, Illinois). Shapiro-Wilk test verified the normality of the data distribution. Thus, Spearman correlation test was used to analyze correlation between the ISQ value and IST value. P values <.05 was set as statistically significant. Independent T test was used to compare the implant stability of BLX and BLT.

Chapter IV

Results

Overall implant stability

A total 96 implant sites in 48 models was included in this study. 48 BLT

Straumann® dental implants and 48 BLX Straumann® dental implants were placed

in each model. The mean implant stability value and standard deviations were

shown in the Table 2. The mean ISQ value was 67.87 (SD: 5.19) and 65.87 (SD: 5.68),

for BLX and BLT respectively. Also, the mean IST value was 71.30 (SD: 5.08) for BLX

and 69.25 (SD: 6.64) for BLT. Shapiro-Wilk test was used to analyze the normality and

we found that all the data were normal distribution (P = <0.001)

Table 2 The implant stability in each group

Group	BLX	BLT	P value*
ISQ			<0.001
Mean	67.87	65.87	
Median	69.50	66.92	
Std. Deviation	5.19	5.68	
Min-Max	43.50-75.00	48.50-73.00	
Range	31.50	24.50	
95% CI	66.36,69.38	64.22,67.52	

IST			<0.001
Mean	71.30	69.25	
Median	71.42	71.84	
Std. Deviation	5.08	6.64	
Min-Max	45.50-79.00	44.50-76.00	
Range	33.50	31.50	
95% CI	69.83,72.77	67.32,71.18	

BLX showed higher stability than BLT in both ISQ value and IST value. However, there was no statistically difference in stability between BLX and BLT.

Additionally, we examine the percentage of prevalence of acceptable stability related to the recommendation value from previous study. It has been shown that, at cut point of 65, BLX has higher rate of prevalence of acceptable cases than BLT. Moreover, analyed by Pearson Chi-square, there was a statistically difference of IST value between both implant design (P= 0.045) while the ISQ has no statistically difference (P= 0.217).

Table 3 Distribution of implants in ISQ value ≥65 and <65

ISQ		BLX	BLT	Total
≥65	Count	40	35	75
	% within IMP	83.3%	72.9%	78.1%
<65	Count	8	13	21
	% within IMP	16.7%	27.1%	21.9%
Total	Count	48	48	96
	% within IMP	100.0%	100.0%	100.0%

Table 4 Distribution of implants in IST value ≥65 and <65

ISQ		BLX	BLT	Total
≥65	Count	46	40	75
	% within IMP	95.8%	83.3%	89.6%
<65	Count	2	8	10
	% within IMP	4.2%	16.7%	10.4%
Total	Count	48	48	96
	% within IMP	100.0%	100.0%	100.0%

Furthermore, regarding the models which have hard bone type (type I,II ;

according to Misch) on top, we found no statistically different of implant stability

between BLX and BLT. Also, there were 100% of cases that have the implant stability

greater than 65. Interestingly, group with hard bone at bottom showed statistically

difference of implant stability between BLX and BLT in both ISQ value and IST value

(P= 0.012,0.007)

Table 5 Distribution of implants in ISQ value ≥65 and <65 of hard bone at bottom

ISQ		BLX	BLT	Total
≥65	Count	6	1	7
	% within IMP	75.0%	12.5%	43.8%
<65	Count	2	7	9
	% within IMP	25.0%	87.5%	56.3%
Total	Count	8	8	16
	% within IMP	100.0%	100.0%	100.0%

Table 6 Distribution of implants in IST value ≥65 and <65 of hard bone at bottom

ISQ		BLX	BLT	Total
≥65	Count	8	3	11
	% within IMP	100.0%	37.5%	68.8%
<65	Count	0	5	5
	% within IMP	0.0%	62.5%	31.3%

Total	Count	8	8	16
	% within IMP	100.0%	100.0%	100.0%

Correlation between ISQ value and IST value

A correlation between the ISQ value and IST value was analyzed by Pearson correlation test. A very high correlation was found between ISQ and IST value ($r = 0.859$)
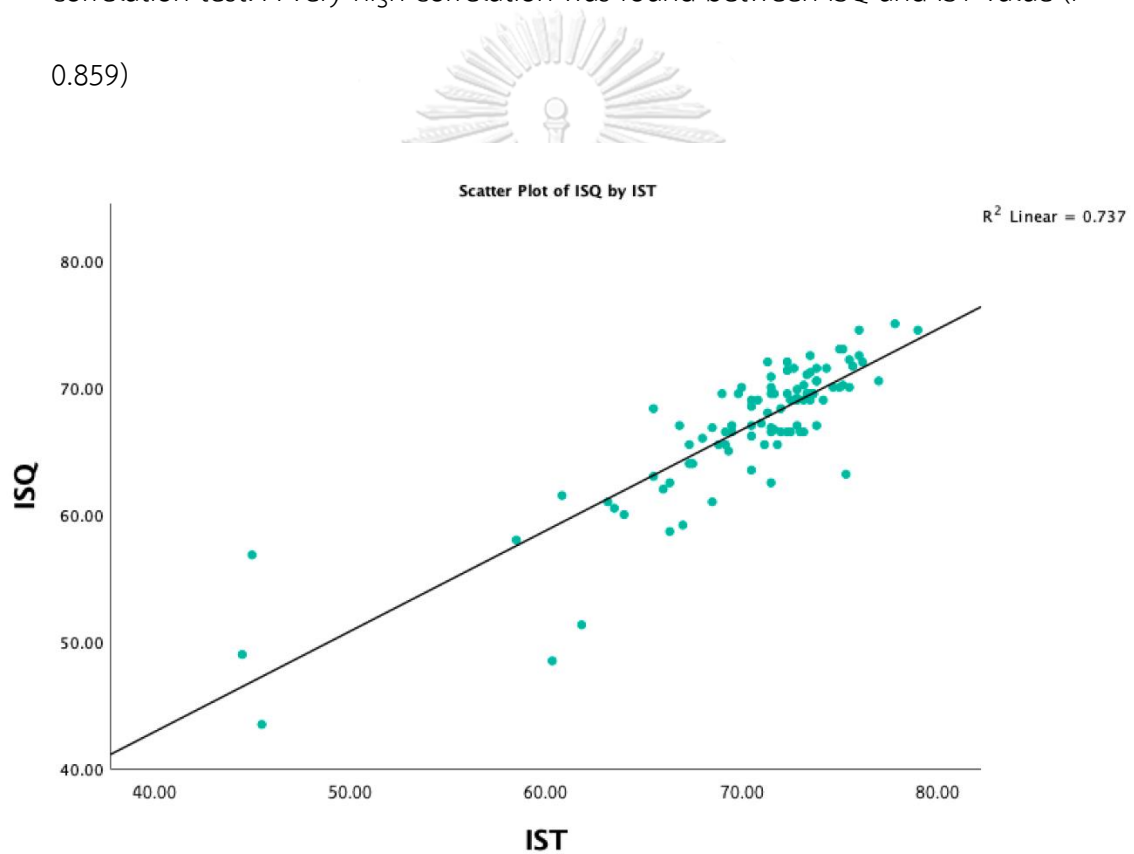
Figure 8 Correlation between ISQ value and IST value

Chapter V

Discussion and conclusion

Discussion

This study aimed to investigate the primary stability of aggressive thread design implant (BLX) comparing to non-aggressive thread design implant (BLT) and evaluate the correlation of implant stability quotient (ISQ) values and implant stability test (IST) values. From the experiment, three interesting observations were found. First, a higher implant stability showed in aggressive thread design implant (BLX). Second, there was a statistical difference of implant stability in subgroup hard bone at bottom. Third, there is a strong correlation between ISQ value and IST value.

Regarding implant design, the BLT has a straight-tapered implant body while the BLX has a fully tapered implant core with sharper and deeper threads. Previous study from Jokstad 2018 reported variations of tapered implant and describe the differences of ISQ value between the tapered versus non-tapered designs up to 10% at baseline. [24] Implant body design and surface modifications have been proposed to increase implant success in low-quality bone by improving anchoring and giving a larger surface area of load to alleviate stress on softer bone types. According to finite element analysis study, the distributions and magnitudes of bone stress might vary depending on the implant geometry. Additionally, threads are employed to optimize initial contact, enhance stability, increase the surface area of the implant, and

facilitate in the absorption of interfacial stress. Moreover, according from Lozano-Carrascal et al. (2016), conical implants achieve higher ISQ value and insertion torque values than cylindrical design implants [30]. Rokn et al. (2011) suggested that tapered implants gain more lateral compressive force on the surrounding bone, thus in area with inadequate bone quality and quantity, the tapered implant is recommended to achieve better primary stability [44].

With regard to implant threads, this present study showed a higher stability in aggressive thread design but there is no statistically significant difference between the two implant design. The aggressive thread design has determined to has a greater ISQ value and IST value which in agreement of the study from McCullough and Klokkevold (2017) [32]. It has been shown that macro-thread design has an effect on implant stability; indicating the novel knife-edge design implant had an overall higher mean ISQ value compared to a standard V-shape design. Moreover, the previous studies reported the highest of ISQ value in NobelActive which interestingly created extensive grooves in the apical part, while the imprint was considerably smaller for BLT and Astra [25]. The aggressive thread design implant presented the advantage in fresh socket extraction of non-molar teeth cases with resulting a very high initial stability [21]. However, it should be kept in mind that other factors, including as implant design, drilling technique, and osteotomy preparation, will affect the primary stability. Large, wide threads surrounding a smaller core of the aggressive thread implants affect BIC in both immediate insertion and healed sites. When a hard bone

drill protocol is used, only the thread tips will make direct contact with surrounding

bone, resulting in a reduced BIC at early healing time points. Also, improper

osteotomy preparation in type I bone could result in an unstable implant and low

ISQ compared to type III bone. This emphasizes the need for well-controlled,

uniform trials with explicit methodologies.

Interestingly, this study shown a significantly higher implant stability of the

aggressive thread design implant in hard bone at bottom models which might refer

to the situation such as immediate and early implant placement. During immediate

insertion, it is believed that the cutting feature of the aggressive implant threads

assists in contacting a greater portion of the palatal wall and a lower amount of the

buccal wall of the socket. However, implants with non-aggressive thread designs

cannot profit from this concept. [2]

In addition, the result showed that there was a significant correlation between

ISQ value and IST value in both BLX group and BLT group. Moreover, a study from D.

H. Lee et al. (2020) has reported similar results, the IST values were strongly

correlated with ISQs, suggesting that the IST values follow the tendency of ISQ values

[28]. In addition, there was no information about appropriate healing abutment

diameter for *in vitro* or clinical setting.

Resonance frequency analysis (RFA) was introduced by Meredith et al. 1996

and it has been commonly used as a non-invasive electronic device that has been

shown to be a reliable and repeatable tool for assessing implant stability during the

healing process [34]. The RFA analyzes the implant-bone complex stiffness and displays it as an implant stability quotient (ISQ) value. The ISQ value is determined by three key factors: the transducer design, the stiffness of the implant-bone junction (implant characteristics, cancellous to cortical bone ratio, and implant-tissue interface stiffness), and the total effective length [47].

Currently, The Osstell ISQ device has been increasingly performed in clinical research to evaluate the development in implant stability during the healing periods. The ISQ tends to vary when the bone-implant contact is not strong or certain. On the other hand, when an implant has attained osseointegration and the bone-implant contact is firm, this device seems to be rather reliable. Furthermore, while assessing implant stability with the Osstell ISQ, the uppermost part of the fixture (cover screw or healing abutment) must be removed and the SmartPeg connected, which may create difficulty and limitations [17, 37]. However, since the AnyCheck does not require unscrewing the healing abutment, the procedure is less difficult than with the Osstell ISQ. Also, the measurements of the newly built AnyCheck device were consistent with ISQ values, the AnyCheck device values range from 1 to 99. Moreover, the tapping motion was optimized by using shorter tapping intervals and applying less force to the implant, resulting in a more secure method of determining implant stability.

In addition, the computer-assisted implant surgery (CAIS) were utilized in this study for controlling the position of implant in every model and guaranteed that all

implant would be placed in the cylindrical polyurethane block. According to Smitkarn et al. (2019), the static CAIS showed significantly less deviation than free-hand surgery in all parameters. Six out of nine measurements were shown remarkably higher accuracy in CAIS group [53]. Moreover, in a split-mouth study by Farley et al. (2013), inserted implants using CAIS technique were found to be more accurate in all dimensions compared to implants placed conventionally [15]. However, the authors stated that a limitation of the research was the fit of the CAD/CAM guides, some of which required relining with transparent acrylic resin prior to surgery. Therefore, in this study, the surgical guide was individually created and confirmed fitting in advance of the procedure in order to eliminate instability of the guide.

The limitation of this in vitro study was the research design of this in vitro investigation did not allow for comparison of the devices in osseointegrated implants, and more in vivo studies are necessary before the devices may be used in clinical settings. The correlation between the devices may reflect tendencies toward implant stability, but it cannot provide precise numbers indicating implant prognosis since the devices are not connected. Further research is needed to determine the reliability of the AnyCheck device in clinical settings.

Conclusion

1. Primary stability of aggressive thread design implant has no significant difference from non-aggressive thread design implant.

2. There is the correlation between implant stability quotient (ISQ) values and implant stability test (IST) values.

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Model	BLX				BLT			
	ISQ		IST		ISQ		IST	
	B	M	B	Pa	B	M	B	Pa
1	66	68	72	71	73	72	75	77
	65	68	72	71	73	72	75	77
	66	68	72	71	73	72	75	77
2	70	70	71	72	65	68	72	74
	70	70	71	72	65	68	72	74
	70	70	71	72	65	68	72	74
3	69	68	69	64	70	69	72	69
	69	67	69	61	70	69	71	68
	69	68	69	61	70	69	71	68
4	70	70	70	70	71	72	75	77
	70	70	70	70	71	72	74	77
	70	70	70	70	72	72	74	77
5	71	69	73	73	70	69	72	75
	70	71	73	73	70	69	72	75
	71	69	73	74	70	69	72	75
6	44	43	46	45	65	67	71	70
	44	43	46	45	66	67	71	70
	44	43	46	45	65	67	71	70
7	69	68	71	70	72	74	75	76
	69	68	71	70	72	74	75	75
	69	68	71	70	72	74	75	75
8	71	72	73	75	71	70	73	75
	71	72	73	76	71	70	73	74
	71	72	73	76	71	70	73	75
9	70	71	76	78	70	69	72	73
	70	71	76	78	69	69	72	74
	70	71	76	78	69	69	72	74

10	70	69	69	69	72	72	73	70
	70	69	69	69	72	72	73	70
	70	69	69	69	72	72	72	70
11	60	59	67	67	63	60	60	62
	59	59	67	67	63	60	60	62
	59	59	67	67	63	60	60	61
12	72	72	73	74	66	67	72	74
	73	72	73	74	66	67	71	73
	74	72	73	74	66	67	71	73
13	75	74	78	80	70	68	73	74
	75	74	78	80	70	68	73	74
	75	74	78	80	70	68	73	74
14	67	64	67	68	60	60	65	63
	67	64	67	68	60	60	65	63
	67	64	66	68	60	60	65	63
15	70	69	72	73	65	65	69	69
	70	69	72	73	65	65	70	69
	70	69	72	72	65	65	70	69
16	70	70	74	76	70	68	71	74
	70	70	74	75	70	68	71	74
	70	70	74	75	70	68	71	74
17	75	74	75	77	70	68	74	72
	75	74	75	77	70	68	74	72
	75	74	75	77	70	68	73	72
18	69	69	74	75	70	68	69	72
	69	69	73	75	70	68	69	72
	69	69	73	75	70	68	69	72
19	66	65	68	69	69	72	72	71
	66	65	69	69	70	72	72	71
	66	65	69	69	70	72	72	71

20	59	56	67	65	49	49	45	44
	59	56	68	65	49	49	45	44
	59	63	68	65	49	49	45	44
21	62	63	67	66	49	48	58	62
	62	63	67	65	49	48	59	62
	62	63	67	66	49	48	59	62
22	72	70	73	74	65	66	72	71
	72	70	73	74	65	66	71	71
	73	70	73	74	65	66	71	71
23	71	70	74	76	71	73	73	72
	70	70	74	76	71	73	73	72
	70	70	74	77	71	73	72	72
24	67	67	72	72	62	62	65	67
	66	67	71	72	62	62	65	67
	66	67	71	72	62	62	65	67
25	62	64	74	76	51	51	64	60
	63	64	75	76	52	51	63	60
	62	64	75	76	52	51	64	60
26	58	63	65	63	66	68	71	70
	58	63	64	63	66	68	71	70
	58	63	64	62	66	68	71	70
27	66	67	72	74	61	61	69	68
	66	67	72	75	61	61	69	68
	66	67	72	74	61	61	69	68
28	70	70	74	77	70	69	73	73
	70	70	74	77	70	69	74	73
	70	70	74	77	70	69	74	73
29	69	67	71	72	65	63	67	67
	69	67	70	72	65	63	68	67
	69	67	71	72	65	63	68	67

30	75	75	78	78	66	67	72	72
	75	75	78	78	66	67	72	72
	75	75	77	78	66	67	72	72
31	73	70	73	73	66	67	72	71
	73	70	72	73	66	67	72	71
	73	70	72	73	66	67	71	72
32	67	67	71	71	68	66	67	67
	67	67	71	71	68	66	67	67
	68	67	71	71	68	66	66	67
33	64	64	67	68	67	66	71	68
	64	64	67	68	67	66	71	68
	64	64	67	68	67	66	71	68
34	61	64	72	71	63	63	66	65
	61	64	72	71	63	63	66	65
	61	64	72	71	63	63	66	65
35	65	67	68	68	67	67	68	68
	65	67	68	68	67	67	69	69
	65	67	68	68	66	67	69	68
36	72	72	75	77	67	67	72	73
	72	72	75	77	67	67	73	73
	72	72	76	77	67	67	72	74
37	72	70	73	73	67	66	72	73
	72	70	73	74	67	66	72	73
	72	70	73	74	67	66	72	73
38	69	70	72	75	67	67	73	74
	69	70	73	75	67	67	74	74
	69	70	72	75	67	67	73	75
39	73	73	74	75	72	72	76	74
	73	73	74	76	73	71	77	75
	73	73	75	76	73	72	77	74

40	70	69	72	72	70	70	75	74
	70	69	71	72	70	70	75	75
	70	69	72	71	70	70	75	76
41	72	71	72	72	65	66	72	72
	71	71	72	73	65	66	72	72
	72	71	72	73	65	66	71	72
42	67	67	69	69	62	60	65	62
	67	67	70	70	62	60	65	61
	67	67	70	69	62	60	65	61
43	66	67	69	70	56	58	45	45
	66	67	67	69	56	58	45	45
	66	67	70	70	56	57	45	45
44	70	71	73	74	70	68	71	75
	70	71	74	74	70	68	72	75
	70	71	73	75	70	68	72	74
45	65	66	68	69	63	64	70	71
	65	66	70	70	63	64	70	71
	65	66	68	70	63	64	70	71
46	70	66	71	72	57	59	61	60
	70	67	71	74	57	59	61	59
	70	67	71	73	57	59	60	50
47	69	71	71	72	69	69	71	71
	68	70	71	72	69	69	71	71
	68	71	71	72	69	69	70	71
48	71	72	72	74	70	68	74	72
	71	72	73	75	70	70	74	72
	71	72	74	75	70	71	73	72

VITA

NAME	Chanikarn Chaksupa
DATE OF BIRTH	30 November 1993
PLACE OF BIRTH	Bangkok

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY