The relative occlusal force of natural tooth adjacent to distal extension implant support fixed prosthesis using T-scan Analysis: A cross sectional study

Mr. Chin Purintarapiban

A Thesis Submitted in Partial Fulfillment of the Requirements
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การศึกษาการวิเคราะห์ความแรงในการสบฟันของฟันธรรมชาติที่ติดกับรากเทียมในฟันหลังโดยใช้เครื่องวัด T-scan (การศึกษาแบบตัดขวาง)

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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ชิน ปุรินทราภิบาล : การศึกษาการวิเคราะห์ความแรงในการสบฟันของฟันธรรมชาติที่ติดกับรากเทียมในฟันหลังโดยใช้เครื่องวัด T-scan (การศึกษาแบบตัดขวาง). (The relative occlusal force of natural tooth adjacent to distal extension implant support fixed prosthesis using T-scan Analysis: A cross sectional study) อ.ที่ปรึกษาหลัก : รศ. ทพ.ประเวศ เสรีเชษฐพงษ์, อ.ที่ปรึกษาร่วม : อ. ทพญ. ดร.วรีย์รัตน์ เจิ่งประภากร

วัตถุประสงค์: เพื่อเปรียบเทียบแรงกัดสบระหว่างรากเทียมในตำแหน่งท้ายสุดต่อฟันธรรมชาติข้างเคียงในสภาพการกัดสบแน่นสุด

วัสดุและวิธีการทดลอง: การศึกษาแบบตัดขวางโดยการตรวจคนไข้ที่มีรากเทียมในตำแหน่งไกลกลางด้านในสุดโดยใช้แผ่นชิมเป็นตัววัดระยะการสบฟัน การสบฟันในรากเทียมมี 2 แบบคือสบเบาและสบหนัก หากสบฟันแล้วไม่สามารถดึงแผ่นชิมออกได้จะใช้ลักษณะตัวย่อ HB1 (สบหนัก) และ LB1 (สบเบา) หากสบแล้วสามารถลากผ่านได้จะใช้ตัวย่อ HB0 (สบหนัก) และ LB0 (สบเบา) ลักษณะการสบในรากเทียมจะถูกแบ่งเป็น 3 กลุ่มได้แก่ HB1LB0, HB1LB1 และ HB0LB0 แรงกัดสบของรากเทียมและฟันข้างเคียงจะถูกวัดด้วยระบบวิเคราะห์การสบฟันดิจิตอลทีสแกนในแต่ละกลุ่ม

ผลการศึกษา: จากกลุ่มทดลองจำนวน 20 คน และรากเทียมจำนวน 45 ราก เวลาเฉลี่ยในการใช้งานคือ 3.35 ปี การสบฟันในลักษณะ HB1LB1 คิดเป็น 4.44% HB1LB0 คิดเป็น 77.77% และ HB0LB0 คิดเป็น 17.77% ผลการทดลองพบความแตกต่างกันอย่างมีนัยสำคัญของแรงในการกัดสบระหว่างรากเทียม (M = 1.94, SD = 2.36) และฟันข้างเคียง (M = 11.64, SD = 7.54) ในกลุ่ม HB0LB0 ; p = 0.025 และไม่พบความแตกต่างในกลุ่ม HB1LB1 และ HB0LB1

สรุป: ภายใต้ข้อจำกัดของการศึกษาแบบตัดขวาง พบว่ามีความแตกต่างอย่างมีนัยสำคัญของแรงการกัดสบในการสบแน่นระหว่างรากเทียมในกลุ่ม HB0LB0 และฟันข้างเคียง ควรมีการศึกษาแบบไปข้างหน้าหรือการทดลองแบบสุ่มและมีกลุ่มควบคุม เพื่อยืนยันถึงผลกระทบของการสบฟันในรากเทียมไกลกลางด้านในสุดต่อฟันข้างเคียงเพื่อป้องกันภัยตรายต่อทั้งรากเทียมและฟันข้างเคียง

สาขาวิชา	ทันตกรรมบูรณะเพื่อความสวยงามและทันตกรรมรากเทียม	ลายมือชื่อนิสิต ....
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KEYWORD: relative occlusal force, distal end implant, adjacent tooth, implant protected occlusion

Chin Purintarapiban : The relative occlusal force of natural tooth adjacent to distal extension implant support fixed prosthesis using T-scan Analysis: A cross sectional study. Advisor: Assoc. Prof. PRAVEJ SERICHETAPHONGSE, D.D.S., M.S. Co-advisor: WAREERATN CHENGPRAPAKORN, D.D.S., Ph.D.

Objective: This cross-sectional study aimed to compare the relative occlusal force between implant in the distal end and tooth adjacent to implant in maximum intercuspation. *Methodology*: Patients with implant restoration replacing teeth in free end space adjacent to natural tooth were recalled. The occlusion is examined as shim stock passes through the occluded tooth in heavy or light bites. The heavy bite or a light bite with shim stock that cannot pull through is HB1 or LB1. If the shim stock can pull through it is considered HB0 or LB0. The implant is classified into 3 groups, HB1LB0, HB1LB1, and HB0LB0. The T-scan was used to determine the relative occlusal force of the implant and adjacent tooth in each group. Result and Discussion: A total of 20 patients with 45 implants were recalled and examined. The mean duration of the overall functional implant is 3.35 years. The occlusion type of implant with HB1LB1 is 4.44%, HB1LB0 77.77%, and HB0LB0 17.77%. There was a significant different between relative occlusal force of HB0LB0 implant group (M = 1.94, SD = 2.36) and adjacent teeth (M = 11.64, SD = 7.54); p = 0.025. Conclusion: The relative occlusal force of the distal end implant and the adjacent mesial tooth was a statistically significant difference in maximum intercuspation of the HB0LB0 group. Further prospective control or randomized control study should be conducted to find the cause-relationship between the occlusion of the implant distal end and failure of the adjacent tooth to prevent

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

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CHAPTER I INTRODUCTION

Rationale and Significance of the Problem

Many researchers suggest that implant restoration with natural teeth should be loaded with light contact, and natural teeth should protect implant occlusion. This is because the rigidity of the osseointegrated implant that poorly distributes force to the alveolar bone makes the implant vulnerable to normal masticatory force, especially in eccentric force. When the occlusal load is applied to the implant, most force is concentrated in the implant's crestal bone.

The occlusion design, so-called implant-protected occlusion (IPO) proposed by Carl E. Mish, may help prevent the implant from overloading by having non-occlusion at implant and opposing natural teeth when the patient bites lightly and occludes when the patient bite at maximum force. The PDL of another natural tooth may absorb the force and prevent the implant from overloading(1).

However, with distal end implant, especially when the implant is placed to compensate for the loss of molars area. The adjacent tooth in front of the edentulous area may be subjected to greater force when the IPO idea is used to reduce force load to the implant. (2, 3).

From recent observation in the clinic, the teeth in front of distal end edentulous that have been through treatment such as root canal treatment with post-core-crown complex has vertical root fracture and others with tooth mobility. Thus, implant-protected occlusion may hold accountable for overloading in these teeth.

Additionally, a probable vertical root fracture of an endodontically treated tooth next to the implant restoration is reported in a series of 8 instances by Eyal Rosen et al. The probable cause of this event may be from implant-protected occlusion. Since the IPO concept reduces the implant load, it might affect the load on the adjacent tooth(3).

Jae-Hong Lee et al., follow-up clinical and radiographic analysis of 283 patients with premolar adjacent to distal end implant and conclude that there is risk in traumatic occlusion increase for the tooth in front of the edentulous area when the splinted implant is placed in maxillary distal end opposed by the implant. This study also points out the possibility of implant-protected occlusion to play a role in traumatic occlusion in natural teeth(4).

According to Terauchi et alinvestigation .'s into the various occlusal contact sizes between the implant and the neighboring teeth, the periodontal ligament of the neighboring teeth has a higher threshold for tactile and pressure sensitivity. According to this study, the occlusal contact area in an implant support restoration should keep the neighboring tooth for the long term(2).

To the author's knowledge, no clinical study observed and evaluated the occlusion of the tooth adjacent to the distal end implant using T-scan. Therefore, this study compares relative occlusal force between adjacent tooth to distal end implant and contralateral tooth in the same arch.

Research question

Is there any different in relative occlusal force between implant in distal end and natural adjacent tooth?

Research objective

Compare the relative occlusal force between implant in the distal end and tooth adjacent to implant in maximum intercuspation.

Statement of hypothesis

H_0 = There is difference in the relative occlusal force of a distal end implant and an adjacent mesial natural tooth.

H_1 = There is no difference in the relative occlusal force of a distal end implant and an adjacent mesial natural tooth

Conceptual Framework

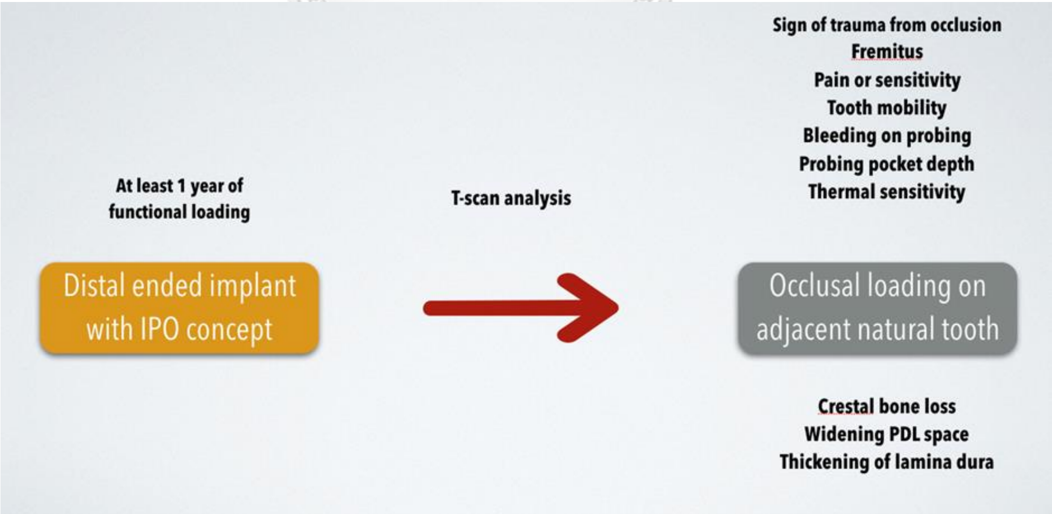


Figure 1 Conceptual framework

Keywords

relative occlusal force, distal end implant, adjacent tooth, vertical root fracture, implant protected occlusion

Ethic consideration

This study was conducted with the approval of the Ethical Committee at the Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand (HREC-DCU 2020-024)

Chapter II REVIEW OF THE LITERATURE

Biophysiological difference between the implant and the natural tooth.

The periodontal ligament (PDL) in the natural tooth is the critical distinction between the implant and the latter. In contrast, the implant has osseointegration, responding to foreign body reactions. When the tooth is forced, the periodontal ligament acts as a shock absorber; the load will be distributed to the apical of the root as tensile strength because the PDL is attached to the bone and the root.

Baggi et al. study the force distribution around implant using finite element analysis. When the lateral load is applied, the force of mastication is centered in the crestal bone area. (5, 6).

PDL also provides a stage of mobility, tolerance, and proprioception for excessive force. The osseointegration implant lacks this structure, making it more vulnerable to occlusal overload. The conclusion of the difference between the implant and natural tooth is summarized in table 1.

	Tooth	Implant
Connection	PDL	Osseointegration (Branemark et al. 1977), functional ankylosis (Schroeder et al. 1976) Foreign body reaction (Trindade et al. 2018)
Proprioception	Periodontal	Bone

Table 1 Biophysiological difference between the implant and natural tooth

Neurofeedback and occlusal awareness

PDL in natural tooth also has a neurofeedback receptor which transmits information through nerve and created feedback to the muscle of mastication. The difference between tooth and implant is that implant has a bone receptor with lower sensitivity than nerve fiber in a natural tooth. This is why the tooth has a tactile sense of occlusal interference around 20 microns, and the implant has 48 microns(7). Moreover, Hammerle et al. also report that the tactile sense of the implant is lower than the tooth by 8.75 times(8).

Implant and tooth response to forces

After loading, the movement of the tooth will have the first primary phase, which occurred in PDL space; this phase is non-linear and complex. The second phase is the elasticity of the bone(9). Osseointegrated implant has only one phase, which depends on the elasticity of the bone. Thus, the implant has far less movement when subject to forces. When the tooth is subject to traumatic occlusion, it can increase mobility, dissipate stress and strain, and return to the original condition if the traumatic force subsides. On the contrary, the damage is usually permanent when the implant is subject to traumatic force due to a lack of adaptation and rigidity of implant-osseointegration.

When subjected to lateral force, the natural tooth can be rotated at the apical third (10), and the force is distributed along the root. (figure 2) Implant, on the other hand, has gradual movement and 10-50micron movement in lateral load; forces are not distributed but rather concentrate on crestal bone (figure 3) (6).

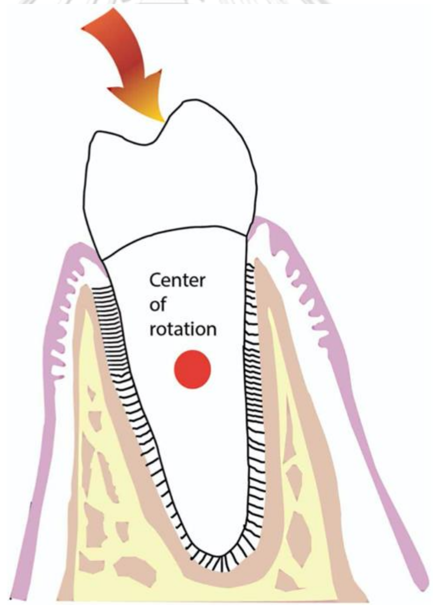


Figure 2 Tooth rotation and force distribution along the root with PDL

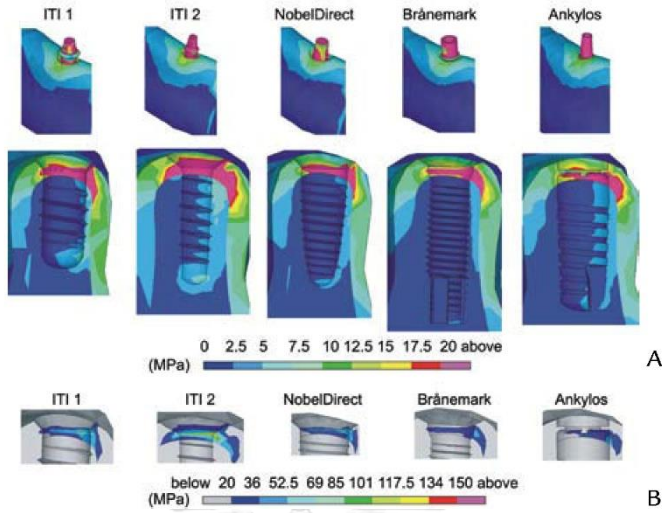
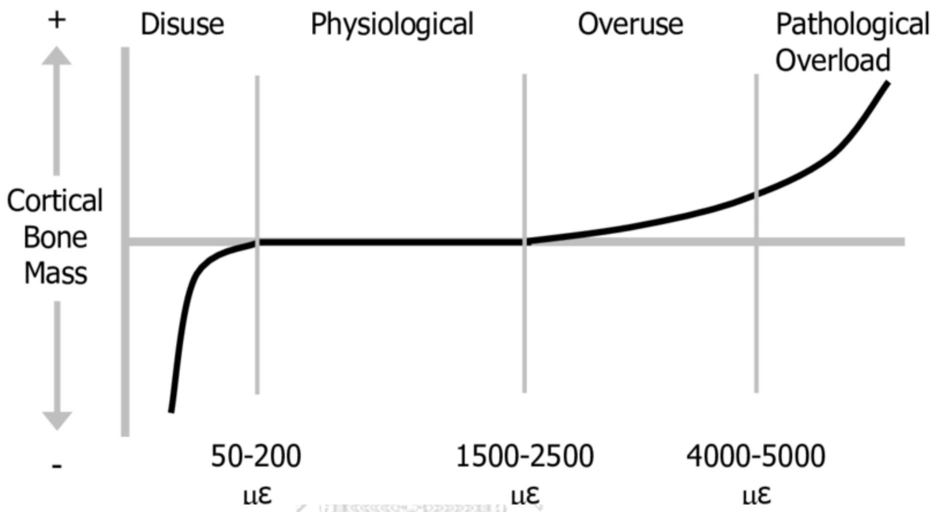


Figure 3 distributed of force concentrated on crestal bone, finite element

Functional Occlusal Loading on the implant

Occlusal loading on the osseointegrated implant is necessary for functional purposes and maintaining alveolar bone. According to Wolff's law combined with Mechanostat theory by Frost (Figure 1)(11), the amount of microstrain in bone (1000 microstrain equal to 0.1% deformation of bone) can dictate bone behavior like the thermostat(11). However, Frost's theory was conducted on long bones. Melsen and Lang(12), experimental in implant load with orthodontic force in an animal model, have adopted this theory and found a correlation. The increasing bone deposition was discovered in 3400-6600 microstrain groups, while bone loss has occurred in over 6700 microstrain groups. Without loading, the bone usually resorbs due to disuse atrophy. But these studies did not answer the loading capacity of implant restoration in terms of occlusion?



Theory of the Frost Mechanostat. Bone's response to mechanical stimulation

Premature occlusal contact in implant

Premature contact will happen when the implant occlusion with the normal tooth due to the differential in movement between the implant and tooth. This makes the implant component more prone to occlusal overload and break. For example, screw loosing, porcelain fracture, abutment fracture, or implant fracture. This failure component or failure of osseointegration is generally due to implant overloading. Miyata et al. observed the premature contact in monkeys and found that after four weeks of 180 microns premature contact, the implant starts to show vertical bone loss occurs around the implant. This event occurs in 4 weeks without inflammation(13). However, it is still unclear how much occlusal force implant can tolerate without complication in humans. Due to the lack of proprioception, Premature contact should be carefully monitored, and the implant should have a lighter contact to minimize the chance of overloading.

Occlusal overloading on implant

Many animal experiments in overloading implant occlusion found a relation between loading force and inflammation(13-22). With the inflammation on progress combined with overloading occlusion, bone loss can progress below the implant neck(18). Without inflammation, a degree of force can increase the bone to implant contact (BIC). However, Miyata et al. suggest that bone around the implant may resorb if the over occlusion height exceeds 180 microns. To this understanding, the load capacity of occlusion force on implant support restoration is still unclear.

Ideally, occlusal loading force on implant should be loaded along the axis of implant fixture, which forces transfer to each component of the implant-restorative complex. Each element of the restoration should be designed to fail before the overloading force reaches the implant fixture and crystal bone. In this situation, monitoring of implant is necessary to repair reversible complications such as dislodgement of restoration, screw loosening, screw fracture. In the case of a tooth-borne problem, the magnitude of the occlusal force on the implant should be light contact. This will prevent the implant from premature contact due to mismatch of implant and tooth movement.

Occlusal overload and peri-implantitis

Occlusal overloading is a multifactorial event in both natural tooth and dental implants. Unfortunately, the implant can’t adapt itself to the overloading; most of the time, when the implant is subject to excessive force, it will present a significant bone loss, and regaining bone loss to the same level is almost impossible. Combining the inflammation with occlusal overload will make peri-implant tissue loss more aggressive.

Recently, the Occlusal overload is "the application of occlusal loading, through function or parafunction, over what the prosthesis, implant component, or osseointegrated interface is capable of withstanding without structural or biologic damage," according to the Glossary of Oral and Maxillofacial Implants(23). We can distribute force into four dimensions (24). First is direction; the implant is susceptible to overloading when loading with lateral or non-axial force. Lateral and non-axial forces will create a concentration of force in crestal bone. Rangers et al. found that implants with more than 15-degree deviation in buccolingual direction will be susceptible to occlusal overloading. (25) In a clinical situation, the eccentric movement of the jaw will create lateral force. The prosthetic part can be redesigned to avoid overloading of occlusion, such as reducing buccolingual width by 30%(26). Also, there should be multiple contact points on the implant crown to increase proprioception and decrease stress in the bone(27). Second, the Magnitude of force can be described by Frost's mechanostat theory and bone strain mentioned above (figure1), which correlates to the type of bone in the implant site. The bone with a more spongy type would create more microstrain than cortical type. The third is the duration of the force that clinically appears as a chewing cycle, and in some cases related to non-parafunctional habit; however, the research for the course of force seems to be limited and needs more investigation—finally, the distribution of force. The implant doesn’t have PDL to distribute force; thus, the prosthesis design, such as lowering the inclination and reducing buccolingual force, and multiple contacts can help distribute forces into the bone(28).

In the animal study model, occlusal overloading and plaque induce peri-implantitis synergistic effects. Miyata et al. found that excess height and hyper occlusion of more than 180 microns will result in significant bone resorption. Moreover, combining hyper occlusion and lack of plaque control will result in apical down growth of epithelium and connective tissue. This condition promoted bacteria invasion and more bone loss related to occlusal overloading(20, 29). Kozlovzsky et al. also state that overloading occlusion aggravated bone loss when peri-implant tissue inflammation is present; however, Bone to implant contact increased but marginal bone level decreased in the dog model with uninflamed peri-implant tissue overloading of occlusion(18).

Osseointegration and occlusal design

Implant osseointegration is a breakthrough discovery that was found by Dr. PI Brånemark back in late 1960(30). The unique characteristic of titanium implants is the ability to have direct contact with the bone and can be loaded with the force of occlusion. Implant, however, has many biological differences to the tooth, and thus the occlusal design for the function is different from the tooth. The implant-protected occlusion by carl E Mish is one of the concepts that has been proposed and widely used among clinicians who place the implant(1, 24, 31-33). The design restoration goal is to minimize the force on the implant and distribute it to a natural tooth, which is practical in tooth-borne situations. However, in a tooth-tissue-borne case such as the free-end edentulous area, the higher force of mastication may distribute to an adjacent natural tooth, especially in a tooth adjacent to the distal end area. This may overload the adaptation capacity in the vulnerable tooth(3).

The treatment plan for restoring the free-end partial edentulous is predictable using an implant-supported fixed prosthesis. Because these edentulous are lack distal abutment, the implant might be optimal functional treatment.

However, Removi partial denture (RPD) is still a cost-effective way to restore distal end partial edentulous areas. Kapur et al. conclude that both the FPD support implant and the RPD effectively improve chewing function, and treatment success rate over five years is almost the recent. A recent study by Nogawa et al. also states no differences in the masticatory process between the RPD group and the implant support FPD group(34).

In terms of occlusion, the difference between RPD and FPD supported by an implant is the timing of occlusion. The RPD has the timing of occlusion as close as the natural tooth. On the other hand, FPD had to occlude later according to the implant protective concept. This situation may cause problems in the distal end area, where the premolar is the tooth that may be subject to higher occlusal force.

Implant protective occlusion (IPO) concept

This concept is the design of occlusal surface occluding of prosthesis support by the implant, which improves the longevity of implant and prosthesis. In the early time, it was present as medial positioned-lingualized occlusion. The main idea of this concept is to reduce excessive stress to implant and abutment connection using *a specific design such as the timing of occlusal contacts, mutually protected articulation, the axis of implant-crown to occlusal load, prosthesis height, cuspal inclination, cantilever distance, prosthesis contour, protection of weakest component and occlusal material of implant prosthesis(31). The restoration design differs for each patient because of the difference in parafunction, masticatory dynamics, implant position, arch form, and crown height.*

Implant occlusion recommendation
Mutually protected occlusal scheme
Anterior guidance: canine guidance in the lateral excursion with posterior disclusion
Anterior guidance in protrusion
Evenly distribute contacts: Lighter contact in implant than adjacent tooth.
No lateral contact on the implant
Crossbite for palatally positioned implant
Wide freedom is centric in CR and MIP.

Table 2 Modify from Sheridan et al 2016

Occlusion scheme design in implant protected occlusion concept

The occlusal scheme should reduce the horizontal force on the implant. The mutually protected occlusal scheme is often used to protect the posterior implant. The anterior teeth should guide the excursion movement, thus leaving the posterior implant non-contacting. Also, the implant should be lighter in contact or have more occlusal clearance between adjacent teeth. Wide freedom in centric for maximum intercuspation (1-1.5mm) or centric relation is also recommended to prevent occlusal overloading in the implant.(35, 36) The recommendation for occlusal design in tooth-borne implant restoration is listed in table 2.

Timing of occlusal contact in implant

Due to the difference in natural tooth and implant movement, the IPO concept suggests occlusal adjustment divided into the light bite and heavier bite forces. In the initial contact under moderate bite force (patient was asked to bite normally), the implant should barely contact the natural tooth using articulating paper (under 25 microns) as an indicator. After that, the patient was asked to bite heavier, and the implant restoration should contact the natural teeth. This occlusal adjustment also applies when the implant restored all posterior support in the same arch.

Kerstein also applies this principle to minimize the force on the implant using a T-scan (T-Scan III, Software version 9.0.1, Tekscan, Inc., Boston, MA, USA). The occlusal is designed to have natural tooth occluded before implant contact. The time difference is enough for PDL compression in the optimum alveolar bone surrounding tooth resistance. The suggested time delay is 0.4 seconds. If the timing exceeds 0.4 mm, there will be no contact in the implant.

Mesial drifting and loss of proximal contact in the adjacent tooth to the implant

The loss of interproximal contact from mesial drifting is documented and widely accepted among clinicians who place implants in the free end area. A recent retrospective study found that interproximal contact loss was 17% and increased over time by 27%. The most common site is the posterior mandibular site(37). This complication can cause food impaction in the space resulting in periodontal disease peri-implantitis(38). Moreover, because interproximal contact is essential for the tooth to bear loading from occlusion, loss of proximal connection can change the capacity to withstand an occlusal overload of the natural tooth(5).

Sign of trauma from occlusion in tooth adjacent to distal end implant

There are several signs from overloading occlusions, such as the periodontal pocket formation, bone loss, gingival recession, tooth mobility, tooth migration, pain on chewing or percussion test, and signs and symptoms of tenderness in TMJ and muscle present of wear facet enamel fracture and fremitus. There are widening periodontal ligament space widening, disruption of lamina dura, vital tooth apex radiolucency, root resorption for the radiographic sign. These clinical signs may be examined and recorded to help diagnose trauma from occlusion where teeth are adjacent to distal end implant and susceptible to occlusal overloading(39). In this research, we use active signs for trauma from occlusion, which present about periodontal tissue such as a periodontal pocket, tooth mobility, tooth sensitivity.

Vertical root fracture of the tooth adjacent to distal end implant

A probable vertical root fracture of an endodontically treated tooth next to the implant restoration has been reported in a series of 8 cases, according to Eyal

Rosen et al. The probable cause of this event may be from implant-protected occlusion, but more clinical observation and research are needed to confirm this phenomenon.(3) When implant protected occlusion minimized the occlusal force to the implant, it may increase occlusal force in other compartments, especially in adjacent natural teeth.(32)

T-scan, a computer-assisted dental occlusion analyzer method

The drawback of conventional occlusal determination using articulating paper or color foil is the lack of measurement occlusal force and timing of occlusal contact(40). The T-scan system is used for determining the occlusal contact of the tooth in this study to confirm the overloading force on the adjacent tooth to the implant. The resistance in voltage utilized in this manner was converted to a percentage for each bite or timing. The resistance in pressure that occurs when the upper and lower teeth occlude is measured as resistance voltage and converted into information known as relative occlusal force. Each timing depends on the bite force, and each tooth has a different relative occlusal force. This technique is useful for measuring biting force while an implant is functioning and can be assessed in comparison to the neighboring tooth. The result of the T-scan can be described as relative occlusal force distribution among teeth in contact. Much research supports the accuracy of this system and have established themselves as one of the trustworthy techniques for evaluating occlusion analysis.(41-43)

The T-scan system uses the recording sensor, which change the voltage resistance when teeth compress the surface of upper and lower sensors. The digital output voltage is then calculated proportional to the force in occlusion. The higher force results in higher loaded sensor resistance, thus increasing the output voltage. This sensor’s force measure is recorded as raw sum force and organized for display in the same bite pattern to the sensor(44). The digital output can record the data of occlusion in dynamic according to the patient bite; this makes data presenting real-time for occlusion.

The software for T-scan 10 analyzes the occlusion time, disclusion time, and tooth timing. This information is shown in the graph with three non-vertical line for total force (black), right arch (Red), and left arch (Green), and 4 timing points from occlusion time to disclusion time.

Chapter III MATERIAL AND METHOD

Using a T-scan, this cross-sectional investigation measured the relative occlusal force of the tooth in front of the edentulous area. (T-Scan III, Software version 8.0.1, Tekscan, Inc., Boston, MA, USA). The study population is 20 patients treated with implant support fixed prosthesis in unilateral at the dental department clinic, Chulalongkorn University. The implant was functional from January 1, 2010, to January 1, 2020. The study "Association between dental implants in the posterior area and traumatic occlusion in the neighboring premolars: a long-term follow-up clinical and radiographic investigation" was used as a reference to determine the population size using the N4studies tool (Lee et al., 2016). The results of the n4Studies sample size calculation are as follows: For calculating the proportion of an infinite population, Alpha () = 0.05, Error (d) = 0.15, and Z (0.975) = 1.959964 are all proportional values. Sample size is 11 (n). For patients who dropped out, nine more samples were added. With the use of the interclass correlation coefficient, (ICC) the T-dependability scan's was examined.

Inclusion criteria

Patient with implant restoration replacing molars in distal end space in functional contact for at least one year with opposing tooth (natural tooth with or without fixed prosthesis).

Occlusion record

The Occlusal scheme of the patient is recorded on the recall visit as group function or canine guidance. Using an 8-micron shimstock, the occlusal contact was measured in both light- and heavy-bite situations (HB). To assess the clinical occlusion of the implant and surrounding teeth, the occlusal contact using shim stock was recorded. The shimstock was noted as having the following characteristics: LB1 (Light bite- shim stock cannot pull through when biting), LB0 (Light bite- shim stock pull through when biting), and HB1 (Heavy bite- shim stock cannot pull thought when biting), and HB0 (Heavy bite- shim stock pull thought when biting). Also, occlusal contact will be record in adjacent tooth. Any abnormal occlusal contact will be record on recall chart if presented. To verify the clinical scenario for implant protected occlusion at the distal end area, the occlusal contact utilizing shim stock is being recorded.

Occlusion record (T-scan)

Using T-scan, the timing of the occlusal contact and the relative occlusal force were recorded (T-Scan III, Software version 8.0.1, Tekscan, Inc., Boston, MA, USA). The patient is instructed to clench their teeth three times for maximum intercuspation, and the recording is done with them sitting erect in the dental unit. The relative occlusal force records from two randomly chosen patients were compared for dependability after being requested to record the T-scan three times. The data is present in 2D, and 3D view. For relative occlusal force the tooth adjacent to implant area is compared to contra lateral tooth in the same arch using mean value of 3 bite. For analysis, all the data is compiled in a spreadsheet.

Data collection and Statistical analysis

All data are analyzed by statistical software (SPSS). The reliability of T-scan is analyze using the correlation coefficient between classes. The relative occlusal force of the distal end implant and the neighboring tooth were compared using a pair t-test with a dependent sample.

Chapter IV RESULT

The ICC is 0.825 (0.675-0.906) using a definition of agreement and a 95% confidence interval(41). Recalled and examined were 20 patients who had received a total of 45 implants in Kennedy's Class I or Class II edentulous region. Table 1 displays the general features of patients and implants. The typical implant lifespan was 3.35 years. Implant occlusion rates for HB1LB1 are 4.44%, HB1LB0 are 77.77%, and HB0LB0 are 17.77%. Table 2 displays the relative occlusal forces of the implants and the neighboring tooth. Three different occlusion types—HB1LB0, HB1LB1, and HB0LB0—were listed. Fig. 1 provided an illustration of the relative occlusal force of an implant and a neighboring tooth at their maximal intercuspation. According to the Wilcoxon Signed Ranks test, there was a statistically significant difference between the HB0LB0 implant group's relative occlusal force (M = 1.94, SD = 2.36) and that of the teeth next to them (M = 11.64, SD = 7.54); p = 0.025. Between the relative occlusal force of the HB0LB1 implant group (M = 9.27, SD = 7.58) and the neighboring teeth (M = 10.05, SD = 5.71), there was no statistically significant difference; p =

0.758. According to the Paired Sample Test, there was no statistically significant difference between the HB1LB1 implant group's relative occlusal force (M = 16.85, SD = 3.32) and the occlusal forces of the neighboring teeth (M = 3.2, SD = 0); p = 0.109.

***Table* 3 Baseline characteristics of the patients and implants in this study.**

Characteristics	Numbers	Percentage
Patients	20	100
Gender		
Male	5	25.00
Female	15	75.00
Implants	45	100.00
Position		
Maxilla	7	15.55
Mandible	38	84.44
Duration of function Means = 3.35 years.		
1-3 years	24	53.33
4-6 years	20	44.44
7-9 years	1	2.22
Occlusion type		
HB1LB1	2	4.44
HB1LB0	35	77.78
HB0LB0	8	17.78

Table 4 The Relative occlusal force of implants and adjacent teeth.

Patient	Implant	Occlusion type	Adjacent tooth ROF	Implant ROF
P1	45	HB1LB0	15.20%	1.67%
	46	HB1LB0		0.60%
	47	HB1LB0		0.70%
P2	46	HB1LB0	11.40%	50.00%
	47	HB1LB0		11.30%
P3	34	HB1LB0	4.40%	4.90%
	35	HB1LB0		2.20%
	36	HB1LB0		4.00%
	37	HB1LB0		2.00%
P4	46	HB1LB0	9.20%	30.65%
	47	HB0LB0*		0.40%
P5	36	HB1LB0	2.60%	11.50%
	37	HB1LB0		28.00%
P6	36	HB1LB0	14.40%	1.20%
	37	HB0LB0*		0.00%
P7	36	HB1LB0	7.40%	6.20%

Patient	Implant	Occlusion type	Adjacent tooth ROF	Implant ROF
	37	HB1LB0		3.00%
P8	46	HB1LB0	4.00%	7.80%
P9	16	HB0LB0*	20.50%	0.20%
	17	HB0LB0*		1.80%
P10	34	HB1LB0	21.40%	11.20%
	35	HB1LB0		5.20%
	36	HB1LB0		6.00%
	37	HB1LB0		0.80%
P11	46	HB1LB1	3.20%	14.50%
	47	HB1LB1		19.20%
P12	36	HB1LB0	8.50%	4.70%
	37	HB1LB0		14.40%
P13	36	HB1LB0	5.90%	11.70%
	37	HB1LB0		12.80%
	38	HB1LB0		23.00%
P14	46	HB0LB0*	16.30%	7.40%
	47	HB1LB0		11.30%
P15	47	HB1LB0	19.60%	6.60%
P16	26	HB0LB0*	9.00%	2.00%

Patient	Implant	Occlusion type	Adjacent tooth ROF	Implant ROF
	27	HB1LB0		11.50%
P17	35	HB0LB0*		1.60%
	36	HB1LB0	2.20%	15.80%
	37	HB1LB0		17.00%
P18	25	HB1LB0		7.80%
	26	HB1LB0	10.00%	9.40%
	27	HB1LB0		15.50%
P19	36	HB1LB0	9.40%	16.00%
	37	HB1LB0		8.80%
P20	47	HB0LB0*	1.00%	2.10%

Chapter V Discussion and Conclusion

Discussion

The definitive occlusal force on the implant is one of unsolved matter, most of the time clinician usually put less load on implant due to physiological limitation of the implant. By using the implant protected occlusion scheme. The implant restorative was designed to not contact in light bite but contact in heavy bite. This can happen because the mandible was flexible. However, in the distal end area, the implant has inevitable responsible to bear loading. The first reason is because the molars help supported the joint and bearing the vertical load on function. If the implant restoration is design to be slightly underload, the load distribution can be concentrated on joints. When patients had unstable joint condition, this causes the patient to have symptomatic joint (45, 46). If the load is concentrated on adjacent tooth, this might cause overloading of occlusion(4). Clarifying the occlusal force on the tooth next to the implant and implant at the distal end was the goal of this cross-sectional investigation. In this investigation, the T-scan system, which delivers the relative force occlusal force value, was used as the occlusion loading assessment. This computer-assisted dental occlusion analyzer approach, which has been extensively employed in dental occlusion analysis research, offers the advantage of recording the percentage of force in each tooth subjectively. But the mapping of force is based on the tooth's input width. despite the software having average tooth widths. For the purpose of accurately calculating the relative occlusal force, each patient's tooth width—including the spacing area—was entered into the software. In order to compare the mark of occlusion in the tooth and software, a photo was also taken with an articulator color on the tooth surface. Due to the patients' varying bite forces, the patient was asked to bite three times with maximum intercuspation in order to assess the correct bite in software. The patient is placed upright when biting the T-scan in order to generate the expected occlusion function.

In this study, there was no significant difference between the HB1LB0 and HB1LB1 groups ($p < 0.05$) at the relative occlusal forces of the implants and the surrounding mesial teeth in maximum intercuspation. This may be the case because, in the majority of patients, the force was distributed equally across teeth and implants during the maximal intercuspation. When verifying with shim stock in this instance, the highest intercuspation force was deemed to be a heavy bite, which typically catches the shim stock when the natural tooth occludes the implant restoration. Additionally, during the functional time, the pressure on the implant may alter. After years of use, the implant's force progressively increases. T-scan research, which assesses the force on the implant prospectively following loading in the final restoration In the first three months, there is a major increase in force (47, 48) This may be the result of the opposing tooth continuing to emerge during the first year of use while the implant remains stationary. Depending on the type of food and the type of restoration occluding with the tooth, the passive eruption of the tooth to meet the occlusal stop occurs. For molar teeth, normal function enamel loses away at a rate of 35,1 2.6 mm per year (Kailas et al., 2015). The eruption may somewhat make up for the wear rate and minor underloading implant. The implant-protected occlusion (HB0LB0) strategy was not followed by all implants. The adjacent tooth and distal end implant in this group had considerably differing relative occlusal forces. This may be the result of excessive occlusion adjustment when utilizing shim stock and articulating paper. While the final implant restoration is typically extremely polished and challenging to alter or locate the occluded spot. When requested to occlude in a mild or heavy bite, the patient's bite can vary. Too much space separates the occlusion for the tooth to emerge into contact. Due to the load being centered on the tooth closest to the implant, this could result in overloading of the tooth adjacent to it (4). The implant could be overloaded and lead to bone loss, though, if it is significantly loaded or occluded before the tooth in the HB1LB1 group.

The occlusion on the implant is typically more difficult to correct when both molars and premolars are being replaced, as in the case of patients P3 and P10. This is because anterior teeth shouldn't be loaded with severe occlusion. In a heavy bite, the relative occlusal force ought to be dispersed along the arch. To ensure that there is no overloading occlusion in this case, the dentist should thoroughly examine the occlusion in both the implant and the natural tooth.

Utilizing the implant-protected occlusion technique, the implant that replaces the molar in posterior teeth should be loaded with mastication force (Kim et al., 2005). Using articulating paper and shimstock to match the height of occlusal contact to the opposing occlude tooth is one way to measure occlusal force. There are some issues with this method's subjective interpretation, absence of masticatory force measurement, and timing of occlusion, though. In contrast, occlusion checking using a digital technique offers a more measured, interpretable force. This can help the implant and neighboring teeth fit together better, especially at the distal end. The advantages of digital scanners and computer-assisted dental occlusion analyzer technologies can now be realized as dentistry enters the digital era.

The relative occlusal of tooth and implant in maximum intercuspation did not replicate the function of the masticatory system, which is the study's limitation. When the teeth occlude in maximum intercuspation, the load distribution is already dispersed to other compartment such as joint or other adjacent tooth which did not represent the normal function of the patients. The time/force graph can be used in further study to evaluate the completed cycle of function and habitual contact. Which give the idea of how occlusion in function works and load distribution in implant or adjacent tooth. Despite the fact that this study inputs a parameter into the software and assesses the tooth's width. For force mapping, using a digital scanner to create a 3D file may be more precise. Finally, a larger sample size randomized control or prospective control trial is required to establish the cause-relationship between neighboring tooth complications and distal end implant occlusion. In conclusion, the relative occlusal force of implant in distal end area and adjacent mesial tooth are different in maximum intercuspation in the HB0LB0 group. In the HB1LB1 and HB1LB0 groups, the relative occlusal force is the same. For more precise occlusion data in the distal end implant and neighboring teeth, more information about force and occlusion time should be explored. To determine the causal association between occlusal overload on both the implant and the neighboring tooth, a prospective control study or randomized control research should be carried out.

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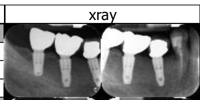
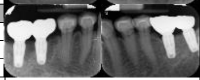
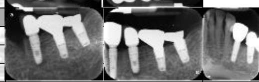
No.	Implant	Occlusal Clinical	T-scan Graph	xray	Implant failure	Adjacent tooth condition
1	45	HB1LB0	under loading			44 RCT.Direct.Composite
	46	HB1LB0	under loading			45 Vital.Indirect.Ceramic
	47	HB1LB0	under loading			
2	36	HB1LB0	under loading			35 Vital.Indirect.Ceramic
	37	HB1LB0	under loading			
	46	HB1LB0	under loading			
	47	HB1LB0	reach maximum before tooth			
3	34	HB1LB0	early loading		34 bone loss	33 Vital.direct.composite
	35	HB1LB0	time delay			
	36	HB1LB0	time delay			
	37	HB1LB0	under loading			
4	46	HB1LB0	early loading			45 Vital.Direct.Amalgam
	47	HB0LB0	early loading			
	26	HB1LB1	reach maximum before tooth		26 bone loss	25 sound tooth
	27	HB1LB1	time delay			
5	36	HB1LB0	time delay			35 Vital.Indirect.Ceramic
	37	HB1LB0	reach maximum before tooth			
6	36	HB1LB0	underloading			35.vital.direct.composite
	37	HB0LB0	not occlued			
7	36	HB1LB0	time delay			35.RCT.Indirect.PFM
	37	HB1LB0	underloading			

No.	Implant	Occlusal Clinical	T-scan Graph	xray	Implant failure	Adjacent tooth condition
8	46	HB1LB0	time delay			45 vital.direct.composite
9	16	HB0LB0	underloading			15 nonvital.indirect.ceramic
	17	HB0LB0	underloading			
10	34	HB1LB0	time delay			33 Vital.direct.composite
	35	HB1LB0	time delay			
	36	HB1LB0	time delay			
	37	HB1LB0	underloading			
11	46	HB1LB1	time delay			45 Vital.Indirect.PFM
	47	HB1LB1	early loading			
12	36	HB1LB0	underloading			35 Vital.Indirect.PFM
	37	HB1LB0	time delay			
13	36	HB1LB0	time delay			35 Vital.caries
	37	HB1LB0	time delay			
	38	HB1LB0	reach maximum before tooth		38 bone loss at distal	
14	46	HB0LB0	time delay			45 Vital.Indirect.PFM
	47	HB1LB0	reach maximum before tooth			
15	47	HB1LB0	time delay			46 vital. Direct. Composite

No.	Implant	Occlusal Clinical	T-scan Graph	xray	Implant failure	Adjacent tooth condition
16	26	HB0LB0	underloading			25 sound tooth
	27	HB1LB0	reach maximum before tooth			
17	35	HB0LB0	underloading			34 vital.indirect.PFM
	36	HB1LB0	time delay		36 bone loss	
	37	HB1LB0	time delay			
18	25	HB1LB0	time delay			25 nonvital.indirect.PFM
	26	HB1LB0	time delay			
	27	HB1LB0	reach maximum before tooth			
19	36	HB1LB0	time delay			35 vital.indirect.PFM
	37	HB1LB0	time delay			
20	47	HB0LB0	early loading			46 vital. Direct. Composite

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PLACE OF BIRTH	thailand
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