Correlation between cortical bone thickness and implant stability

Pobploy Petchmedyai[1], Sirichai Kiattavorncharoen[1], Dutmanee Seriwatanachai[2], Natthamet Wongsirichat[1]

[1] Department of Oral Maxillofacial Surgery, Faculty of Dentistry, Mahidol University.
[2] Department of Oral Biology, Faculty of Dentistry, Mahidol University.

Abstract

Objective: To determine the relationship between cortical bone thickness from CBCT and primary implant stability from RFA measurement.

Material and methods: A total of 12 implants were placed in 8 patients at the posterior mandible sites. The crestal cortical bone thickness, buccolingual bone thickness at 5 mm below the alveolar crest, and bone quality of implant recipient sites were preoperatively recorded using CBCT. RFA measurement (ISQ value) was immediately taken using an Osstell ISQ, after implant placement. The correlation between crestal cortical bone thickness and primary implant stability and correlation between buccolingual bone thickness and primary stability were tested with Pearson's correlation at P value less than 0.05 was considered statistically significant.

Results: Mean crestal cortical bone thickness and buccolingual bone thickness at 5 mm below the alveolar crest were 1.423 ± 0.65 mm and 6.954±1.37 mm, respectively. Bone at the implant sites were mostly classified as type II and III. Mean ISQ values were 73.33 ± 6.14. No significant correlation were found between crestal cortical bone thickness and primary stability (r = 0.171, P > 0.05) or between buccolingual bone thickness and primary stability (r = 0.473, P > 0.05).

Conclusion: With the limitation of this study, crestal cortical bone thickness and buccolingual bone thickness were not correlated with the primary implant stability. It is believed that further research on bone microstructural is necessarily required to predict the primary implant stability.

Key Words: implant stability, cortical bone thickness, resonance frequency analysis

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Corresponding author:
Natthamet Wongsirichat
Department of Oral Maxillofacial Surgery,
Faculty of Dentistry, Mahidol University,
6 Yothi Street,Rachathewee District,
Bangkok 10400, Thailand
Email: natthamet.won@mahidol.ac.th
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Introduction

Nowadays the use of dental implants to restore missing teeth without affecting adjacent teeth has been increasingly accepted as a standard dental treatment. Many clinical studies have revealed favorable outcomes with implant treatment.[1-4] The success of any implant treatment depends on several factors, such as patient-related factor including general health conditions, surgical procedure, dental implant materials[5] and also quality and quantity of available bone.[6,7]

High failure rates for implants placed in maxilla especially posterior maxilla have been observed in several clinical studies[8,9] The primary cause of higher failure rate may be associated with bone quality of maxilla because it has poorer bone quality than the mandible.[10] The success rate of dental implants is thought to be related with the volume and density of the local bone. Therefore, evaluation of quantity and quality of the primary bone bed before implant placement is not neglectable.

Primary stability of dental implant depends on several factors, such as implant design, surgical procedure, quantity and quality of available bone. When predicting implant stability, bone quality is the one of the most important factors to be considered. A good stability favors osseointegration of implant.[11] One of several methods that have been used in research for the last decade to assess the stability of implant is resonance frequency analysis (RFA). It is an objective method to assess implant stability and osseointegration. It is also a non-destructive method that does not destroy the surface between implant and tissue around implant. The measurement unit is the implant stability quotient (ISQ), ranges from 0 to 100 units.

Recently, with development in implant surfaces and clinical techniques, the initial healing time has significantly reduced and an early or even immediate loading of implant is possible. The successful outcome of immediate or early loading concept depends on level of primary stability of implant, which could be an advantage to the clinicians if they can predict the level of primary implant stability before implant placement.[12] Several studies have shown the relationship between primary stability of dental implant and bone quality derived from CT and CBCT[7,13] However, a controversial correlation between CBCT derived gray values and CT-derived gray values was also observed.[14] Therefore, using gray values derived from CBCT to determine bone density may not be sufficient to indicate the actual bone quality. Moreover, there has been only a few studies evaluated bone quality by using cortical bone thickness, and determined primary stability of implants.[13,15]

With this background, the purpose of this study was to find the correlation between cortical bone thickness measured from CBCT, and implant stability measured by RFA.

Material and methods

This research is the clinical trial study. A total of eight subjects were eligible as followed the inclusion criteria in this study. The mean age was 53 years. A total of twelve implant sites from eight patients (1 male and 7 female) were enrolled in this study.

Study protocol

The study protocol and consent form were reviewed and approved by the faculty of Dentistry and Pharmacy board ethics committee, Mahidol University. All the participants voluntarily signed consent and participant forms before enrollment. Participants were reviewed and selected according to the inclusion and exclusion criteria as shown in Table 1.

Table 1 The criteria for selecting the patients

Inclusion criteria	Exclusion criteria
1. At least 18 years. 2. Have partially edentulous at posterior mandible area and need implant placement 3. Have adequate bone volume suitable for placing implant 4 mm in diameter and 10 mm in length. 4. Healthy patients with no uncontrolled systemic diseases. 5. Adequate oral hygiene	1. Have inadequate bone height (less than 12 mm from the alveolar crest to the inferior alveolar nerve which evaluated from CBCT preoperatively). 2. Patients with uncontrolled systemic diseases 3. Patients who had previous chemotherapy or radiotherapy 4. Patients who have taken bisphosphanate for more than 3 years 5. Patients who were heavy smoker (more than 10 cigarettes per day) 6. Patients who had tooth extraction in the implant recipient site < 3 months ago 7. Patients who had bone grafting procedures prior or during implant surgery

Preoperative preparation

At the first visit, patients' medical and dental histories were obtained. The inclusion and exclusion criteria were confirmed.

Radiologic evaluation

Panoramic scanning was performed for initial evaluation and the cortical bone thickness of the implant recipient sites was preoperatively estimated using CBCT (3D Accuitomo, J.Morita). In cross sectional image of CBCT under radiographic indicator, cortical bone thickness at the implant at the crestal area was measured. Figure 1 showed buccal, lingual cortical thickness and trabecular thickness were measured at the level of 5 mm below the alveolar crest and each bone area were classified in 4 different bone types (modified from Leckholm & Zarb bone classification) (Table 2.)

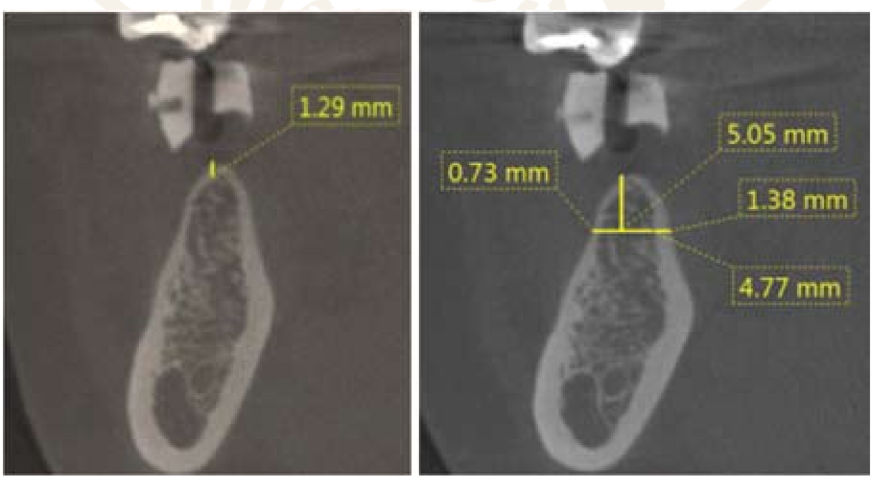

Figure 1 Crestal cortical thickness and buccolingual bone thickness measurement from CBCT

Table 2 The custom bone quality modified from Leckholm & Zarb bone classification

Bone quality	Details
type 1	buccal and lingual cortical thickness is more than 75% of whole bone thickness.
type 2	buccal and lingual cortical thickness is 50 - 75% of whole bone thickness
type 3	buccal and lingual cortical thickness is 25-50 % of whole bone thickness
type 4	buccal and lingual cortical thickness is less than 25% of whole bone thickness

Implant surgery

A total of 12 Intra-lock implants (Boca Raton, FL, USA, Blossom design) size 4.0x10 mm were inserted. All implants were inserted at the recipient site by one oral surgeon, according to a standard surgical guideline following the manufacturer's instructions by using a non-submerge technique.

After the implant placement, Primary stability as measured by RFA using wiles device- the Osstell (Osstell AB, Integration Diagnosis AB, Gothenburg, Sweden). Only single experienced surgeon was allowed to use the tool for measuring the primary stability. (figure 2)

After measuring, healing abutments were applied to implants and sutures were placed. Antibiotic therapy was given to the patients: amoxicillin 500 mg 3 times per day 5 days. Clindamycin 300 mg 3 times/day 5 days was given to the patients who were allergic to amoxicillin. An analgesic, Ibuprofen 400 mg 3 times per day was prescribed for following 1 week.

Post-operative follow up was done and the sutures were removed on day 7 post-operation surgery. After 2 months, implant supported crowns were constructed.

Figure 2 Primary stability as measured by RFA using wiles device- the Osstell (Osstell AB, Integration Diagnosis AB, Gothenburg, Sweden)

Statistical analysis

Demographic data, the implant stability at the time of implant placement, crestal cortical bone thickness, buccolingual bone thickness at 5 mm below the alveolar crest and bone quality were determined and presented as a mean ± SD, median, percentage or frequency where appropriate for qualitative and quantitative variables.

Kolmogorov-Smirnov test was used to test for normal distribution. The correlation between crestal cortical bone thickness and primary implant stability and correlation between buccolingual bone thickness (cortical and trabaecular bone thickness) and primary stability were tested with Pearson's correlation at P value less than 0.05 was considered statistically significant.

Results

The duration of tooth loss before implant placement was controlled to be more than 3 months, in the range 1-10 years. Twelve implants (Intralock, diameter 4 mm and length 10 mm) were inserted in the posterior mandible area. All restorations were supported crown.

The demographic data of all patients of position and duration follow up dental implant installation were shown in the table 3.

The stability of implants at the time of implant placement

Twelve implants placed at partial edentulous area of posterior mandible were included in statistical analysis of this study. ISQ values of each implant at the time of placement were shown in figure 3. Range, mean ± SD and median ISQ values at the time of implant placement were presented in table 4.

Bone quality, Crestal cortical bone thickness and buccolingual bone thickness

Preoperatively, in cross sectional image of CBCT under radiographic indicator, crestal cortical bone thickness at the implant sites were measured. Buccal, lingual cortical thickness and trabecular thickness were measured at the level of 5 mm below the alveolar crest and each bone area were classified in 4 different bone types according to the detail in table 2. Results were shown in figure 4.

The relationship between crestal cortical bone thickness, buccolingual bone thickness and primary implant stability

Table 5, 6, 7 showed no significant correlation between crestal cortical bone thickness or buccolingual bone thickness with the ISQ value at p value = 0.05

Table 3 Detail of position and duration follow up dental implant installation

Variables	Number	Percentage
Number of implants	12	100
Position of implants		
Premolar	4	33.33
Molar	8	66.67
Duration of tooth loss before implant placement (months)		
< 6 months	-	-
6-12 months	-	-
> 12 months	12	100

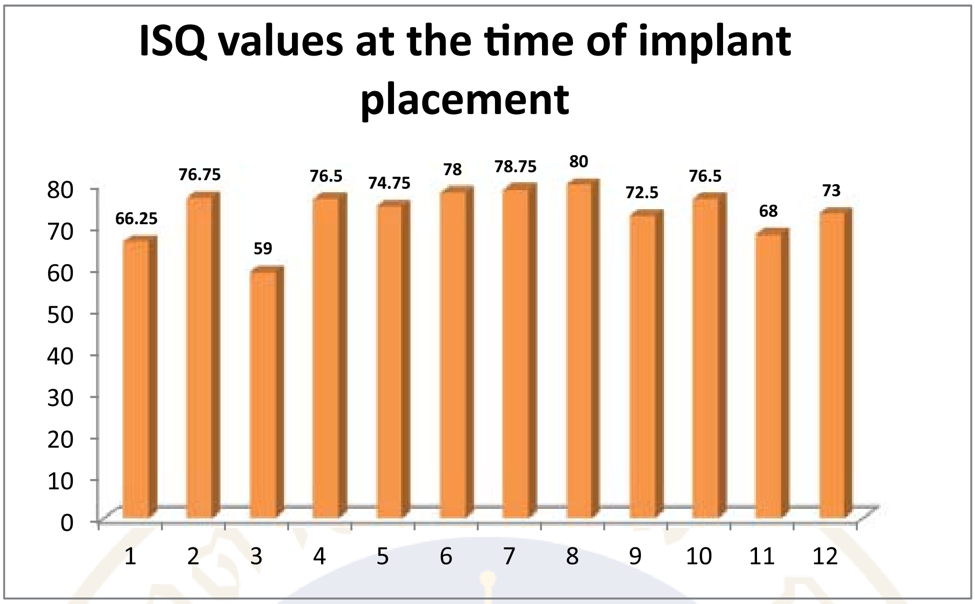

Figure 3 ISQ values of each implants at immediate post-operative dental implant installation

Table 4 Mean±SD, range and median of ISQ values at the time of implant placement

Variables	ISQ values at the time of implant placement
Mean±SD	73.33±6.14
Median	75.63
Range	59-80

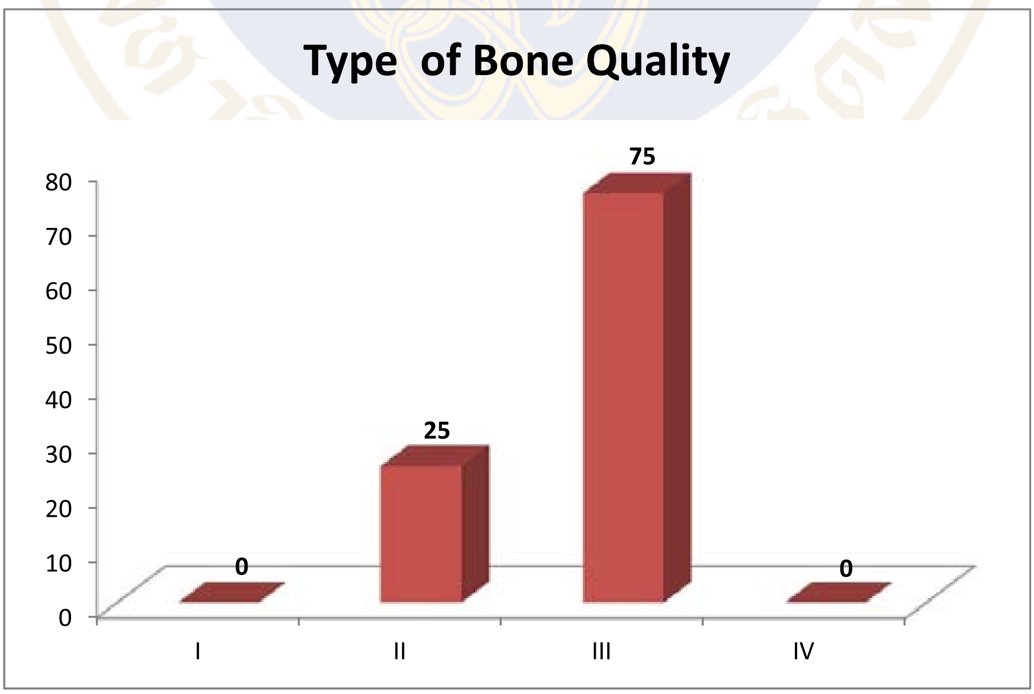

Figure 4 Percentage of bone quality recorded and classified by CT analysis

Table 5 The thickness of cortical bone, trabecular bone and type of bone at the implant sites

Implant No.	Crestal cortical bone thickness	Buccolingual cortical bone thickness At 5 mm below the crest	Buccolingual Trabecular bone Thickness At 5 mm below the crest	Bone type	Buccolingual bone thickness
1.	1.01	2.5	3.67	III	6.17
2.	1.10	2.72	2.57	II	5.29
3.	1.36	2.32	2.81	III	5.13
4.	1.1	2.77	4.01	III	6.78
5.	2.1	3.21	4.31	III	7.52
6.	1.19	3.31	5.32	III	8.63
7.	1.22	3.79	2.32	II	6.11
8.	2.11	4.68	4.23	II	8.91
9.	2.94	2.94	6.36	III	9.30
10.	1.10	2.94	3.65	III	6.59
11.	0.55	1.92	4.22	III	6.14
12.	1.29	2.11	4.77	III	6.88

Table 6 Mean±SD, range and median of crestal cortical bone thickness and buccolingual bone thickness

Variables	Crestal cortical bone thickness (mm)	Buccolingual bone thickness (mm)
Range	0.55-0.94	5.13-9.30
Mean ± SD	1.42±0.65	6.95±1.37
Median	1.21	6.69

Table 7 Correlation between, crestal cortical bone thickness, buccolingual bone thickness and ISQ value

Variables	Crestal cortical bone thickness	Buccolingual bone thickness
ISQ value correlation coefficient	0.171	0.473
ISQ value P-value	P > 0.05	P > 0.05

Discussions

Primary stability is important for successful outcome of implant treatment. Therefore, implant stability measurement may reduce the risk of implant failure. The high implant stability is an indicative for successful treatment outcome.

On the other hand, low implant stability may increase the risk of failure.[12] Moreover, to reduce overall treatment time, the concept of immediate loading has been widely accepted. Primary stability measurement at the time of implant placement such as ISQ value is commonly used as an good indicator for immediate loading, if the clinician was to predict implant stability before implant treatment.[13]

The significant correlation between bone quality and implant stability parameters indicate that the clinician may predict primary stability of implant before implant surgery (from CBCT) and may modify the treatment to achieve a good primary stability of implant such as under preparation, using osteotome and also change of macro-design of implant to wider, longer or taper implant. However, This study demonstrated that the dental implant stability at the time of placement was mildly influenced by cortical bone thickness and buccolingual bone thickness, in contrary with other studies that showed a positive correlation between cortical bone thickness and primary stability.[13,15] Recently, one year-follow up study reported the implant stability not positively correlated with baseline microstructural bone characteristic nor the marginal bone change after loading[17]. The prediction of such stability is clearly inconclusive and needed for further investigation.

The accurate and consistent of CBCT radiological angle while taking an x-ray could also affect the measurement of cortical bone thickness at the implant sites.[13] In the present study, cortical bone thickness was preoperatively measured from CBCT, which may turn to be inaccurate position of cortical bone that engaged by the implant.

Other limitation of this study was the number of the sample size, to achieve a significant correlation, increasing number of sample sized may be required. Further research is required to confirm the outcome, and to compare the primary stability of implant by using RFA with other methods such as cutting torque resistance. Regarding bone quality, bone density measurement with CBCT should be assessed in other areas of jawbone.

In conclusion, with the limitations of this study, crestal cortical bone thickness and buccolingual bone thickness at the implant recipient sites were not correlated with the primary implant stability as measured by RFA at the immediate implant loading.

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