Prevalence and Morphometric Analysis of Mandibular Lingual Concavity in Alveolar Ridge with Adequate Dimensions for Standard Implant Placement

Kornkamol Kretapirom[1] and Kavisara Sukumalchitkul[2*]

[1] Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Mahidol University, Ratchathewi District, Bangkok, Thailand
[2] Graduate student, Master of Science program in implant dentistry, Mahidol University, Ratchathewi District, Bangkok, Thailand
[*]Corresponding author, E-mail: skavisara92@gmail.com

Abstract

Objectives: Posterior mandibular lingual concavities are considered to be a predisposing factor for the lingual plate perforation during the implant installation. This rupture can create various complications ranging from hemorrhage to upper airway obstruction. The aim of this study is to determine the prevalence of ridge morphology and the dimension of the lingual concavity in the posterior mandibular region in Thai population and to find the relation between the dimension of undercut with other factors such as age and gender. Methodology: This study evaluated 102 cross sectional images of the mandibular second premolar and the first molar both in dentate and edentulous conditions. The alveolar ridges were classified into 3 types which were U-type, C-type and P-type. Then, the U-type ridges were further determined by measuring the dimensional parameters. Result and discussion: The distribution of U-type, P-type, C-type ridge in the posterior mandibular area was found to be 45.1%, 37.3%, 17.6% respectively on dentate ridge and 37.3%, 21.6%, 41.2% respectively on edentulous ridge. The relationships between the dimensional parameters and other factors, including age, gender, dental status and tooth type, were analyzed. However, there is the only negative correlation that existed between age and the depth of the lingual concavity ($P<0.05$). Conclusion: Lingual concavity is a common anatomy of the posterior mandible. However, even the ridge has adequate dimension, taking the CBCT image prior the implant surgery is recommended.

Keywords: *Mandibular lingual concavity, Lingual undercut, Ridge morphology, Ridge prevalence, Concavity parameter*

1. Introduction

Dental implant treatment is one of the most successful and reliable solutions to help patients with tooth loss nowadays. Due to the recent growth in implant dentistry, the purpose of performing dental implant treatment has changed from fulfilling its functions to aesthetically pleasing for the patients. In order to achieve the successful outcome, a good treatment plan is crucial. Therefore, it is a necessity to obtain precise preoperative examination, which can lead to a proper diagnosis and results in a good treatment plan (Greenstein et al, 2008)

Basically, before starting any treatment, the surgeon has to gather all the necessary information about the planned surgical site both from the clinical assessment and the radiographic image. Through clinical examination, the surgeon can perceive the shape and width of the ridge, while the vertical ridge height and position of the adjacent vital structure can be evaluated by radiographic examination.(Mraiwa, Jacobs, van Steenberghe, & Quirynen, 2003). Panoramic radiograph is the standard application in implant dentistry. The advantage of this application is that it can provide overall visualization of the anatomical structures and initial examination of bone height. However, it still lacks of cross-sectional information (Tal & Moses, 1991; Tyndall & Brooks, 2000). Of all the three-dimensional imaging applications, cone beam computed tomography (CBCT) is the most appropriate radiograph. It can provide information about bone morphology and bone quantity in all directions. The images shown from CBCT has no superimposition and rarely distort. If compared to medical CT, it also takes less scanning time and exposes less radiation dose to the patient (Guerrero et al, 2006; Harris et al, 2012; Suomalainen et al, 2008). The American Academy of Oral and Maxillofacial Radiology (AAOMR) in 2012 suggested the use of CBCT as a current image modality of choice for preoperative cross-sectional imaging of potential implant sites (Tyndall et al, 2012). However, some surgeons may consider to clinically evaluate the bone width, such as by ridge mapping with the caliper device or by palpating in order to avoid the cost and the radiation exposure for the patient.

In the area of posterior mandible, there are critical anatomies that the clinician has to be cautious of during the implant surgery. The lingual aspect of posterior mandible has so many vital structures since it is a highly vascularized area. The major sources of blood supply are from the submental and sublingual artery. It can be found in 60% of dissections that large submental artery pierced through the mylohyoid muscle and anastomosed with the sublingual artery.(Bavitz, Harn, & J. Homze, 1994) This perforation branch gives rise to the injury risk to submental vessel if the lingual cortical perforation occurs above the mylohyoid muscle. Moreover, there is a depression of submandibular fossa which is normally called lingual concavity (Bavitz, Harn, & J. Homze, 1994; Chan et al, 2011). The deep extension of the concavity can be considered as a potential risk factor for the lingual plate perforation during the drilling osteotomy and implant placement (Quirynen et al, 2003; Parnia et al, 2010). There were incidence reports of the lingual plate perforation from the implant surgery which caused the hemorrhage and hematoma in the area of floor of mouth. It was followed with the tongue elevating and upper airway obstruction (Givol et al, 2000; Wanner, Manegold-Brauer & Brauer, 2013)(Wanner, Manegold-Brauer, & Brauer, 2013). Therefore, a precise evaluation by palpation is hard to obtain due to the attachment of mylohyoid muscle in the lingual depression area. This area cannot be evaluated solely by panoramic radiograph technique therefore three-dimensional imaging technique should be considered (Tyndall et al, 2012).

2. Objectives

To determine the prevalence and dimension of lingual concavity in posterior mandibular region in Thai population

3. Materials and Methods

<u>Patient selection and Image acquisition</u>

The images used in this study acquired from the CBCT database at the Oral and Maxillofacial Radiology Clinic, Faculty of Dentistry, Mahidol University. All the images were taken from the Thai population between January 2017 and December 2018. Patients were taken x-ray with CBCT machine (3D Accuitomo, J. MORITA CORP.) which was set at 90kVp, 5mA. Only the images with FOV 6cm x 6cm were selected and the data was saved in DICOM format. The images were viewed from the liquid crystal display monitor with a resolution of 2560x1440. To measure the parameter of ridge morphology and plan the 3-D position of the implant, the planning software program (coDiagnostiX®) was applied. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (the Institutional Review Board of the Faculty of Dentistry/ Faculty of Pharmacy, Mahidol University) and with Helsinki Declaration of 1975, as revised in 2013.

Inclusion criteria

1. CBCT had to present the area of both mandibular second premolar and first molar.

1.1 In case of the edentulous area of mandibular second premolar or first molar, the adjacent teeth next to the investigated edentulous site had to remain presence and were in normal position (the imaginary line connecting the cusp tip of canine, central groove of premolars, and molars was generally smooth) and in normal occlusion. The cause and duration of tooth loss were not considered because it was beyond the scope of this study. Only the dimension of the residual ridge that was taken into account.

1.2 In case of the presence of mandibular second premolar or first molar, these teeth had to be in normal position (the imaginary line connecting the cusp tip of canine, central groove of premolars, and molars was generally smooth) and in normal occlusion.

2. The investigated site had to have bone height of ≥12mm from alveolar crest to the superior border of inferior alveolar canal (IAC).

3. The edentulous area had to have buccolingual width at crestal level ≥6mm at premolar site or ≥ 7mm at molar site.

4. The edentulous area had to have mesiodistal distance at crestal level ≥7mm at premolar site or ≥ 8mm at molar site.

5. Minimum age of 18 years due to the complete development of jaws

6. The outline of the mandible and inferior alveolar canal had to be easily identified.

7. The opposing maxillary tooth was presented to provide information for implant angulation.

Exclusion criteria

1. Images were unclear or presented artifacts.
2. The bone pathology presented in the posterior mandible region.
3. Images showed grafted alveolar ridge at the investigated site.
4. Images showed the permanent mandibular second premolar or first molar which partial erupted.
5. The implant was placed adjacent to the area of interest.

Image analysis

The evaluation of the ridge morphology was done only on the area above the superior border of IAC 2mm.

1. Classification of ridge morphology

Alveolar ridges were classified into 3 types according to the criteria of Chan et al. (2011)(Chan et al, 2011) and the prevalence of each ridge type was calculated.

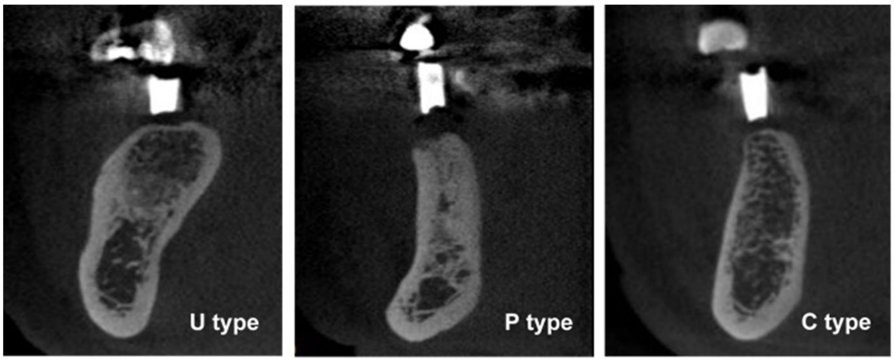

Figure 1 Three types of cross-sectional ridge morphology on edentulous ridge: U, P, C type.

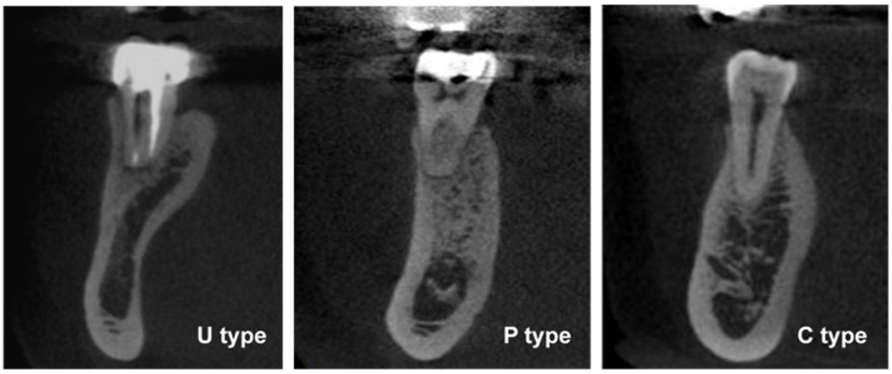

Figure 2 Three types of cross-sectional ridge morphology on dentate ridge: U, P, C type.

- Convergent ridge type (C type): the ridge with the bucco-lingual width reduction from the base to the crest which is absent of undercut
- Parallel ridge type (P type): the ridge with generally buccal and lingual side parallel to each other.
- Undercut ridge type (U type): the ridge with the bucco-lingual width expansion from the base to crest, showing the prominent point on lingual side.

2. Cross-sectional morphology assessment

In this part, only the type U ridges were chosen and the areas above the IAC 2mm were evaluated. The concavity depth (D), the vertical distance from the crest to the deepest point of the lingual concavity (V) and concavity angle (ϴ) were measured. For the edentulous ridge, V was measured from the top of the bone crest to the deepest point of the lingual concavity. If the mandibular second premolar or first molar was presented, V was measured from the top of lingual bone crest instead.

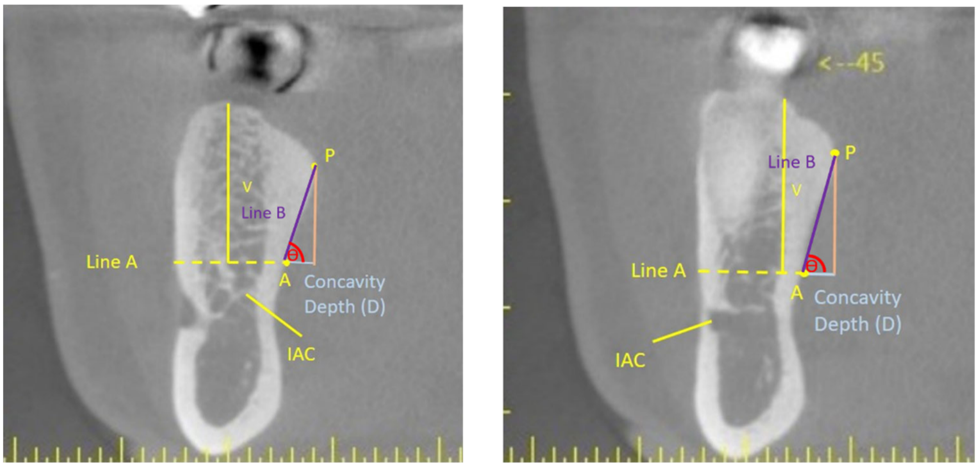

Figure 3 Demonstration of cross-sectional view showing the relevant measurements.

- Point A: The deepest point of the lingual ridge
- Point P: The most prominent point of lingual ridge
- Line A: Imaginary line extended from point A and parallel with inferior border of mandible
- Line B: The connecting line between point A and point P
- D: The horizontal distance in mm from point A to the line drew from point P perpendicularly.
- V: The vertical distance in mm between the bone crest and the deepest point of lingual concavity. In case the tooth was presented, V was measured from the top of the lingual bone crest instead.
- ϴ: The angulation between line A and line B in degrees

To classify each ridge type, all the image analysis were done by oral and maxillofacial radiologists and well-trained examiners. For the inter-examiner agreement, two examiners were calibrated with 30 samples before the study began. After the calibration, two examiners worked separately. If there was any disagreement in image interpretation, it was discussed until the consensus was reached. As for the morphology assessment process, only the well-trained examiner measured all the parameters. For the intra-examiner agreement, 30 images were randomly chosen and all the variables were reexamined within 4-week intervals.

Statistical Analysis

The data were analyzed using SPSS Statistics 21.0 (SPSS Inc., Chicago, IL, USA). To evaluate the difference of prevalence among the ridge morphology, Chi square test was performed. The dimensional parameters (V, D, ϴ) were calculated into mean and standard deviation then compared the quantity among various factors with correlation test and 2-sample T test.

4. Results and Discussion

<u>Result</u> The CBCT images that showed both the second premolar and first molar area were screened. A total of 49 subjects (24 males and 25 female) with average age of 53.58 years (range: 27-69 years), whose both teeth passed the inclusion criteria were selected and included in the study. Each subject was evaluated at least 2 sites, which are the mandibular second premolar and mandibular first molar area on the same quadrant. Of 49 subjects, 102 sites were analyzed because 2 subjects had bilateral ridges that met the inclusion criteria. For the edentulous ridge, C type ridge (41.2%) was the most common ridge morphology, followed by U type ridge (37.3%) and P type ridge (21.6%) respectively (table 1). For the dentate ridge, U type ridge (45.1%) was the most prevalent ridge type. However, when determined each tooth type separately, the results showed dissimilarity. To illustrate, P type ridge (42.3%) was the most common ridge type for second premolar teeth, while U type (52.0%) was the most common ridge for first molar teeth (table 2). The significant differences of the prevalence of lingual undercut between second premolar and first molar area were not presented in both edentulous and dentate ridge ($P>0.05$).

Only the ridges with U type morphology (n=42) were chosen and their concave parameters were further evaluated. The mean value of vertical distance between the top of the crest to the deepest point of lingual concavity (V), the mean value of concavity depth (D) and the concavity angle (ϴ) were shown in the Table 3. The relationships between these dimensional parameters and other factors, including gender, dental status and tooth type, were studied and there are no significant differences found. However, when analyzing its relationship with age, negative correlation existed between age and D ($P<0.05$) (Figure 4).

Table 1 Frequency distribution of ridge morphology on edentulous ridge

Tooth type	Ridge morphology			Total	p-value
	C	**P**	**U**		
Second premolar	9 (36.0%)	8 (32.0%)	8 (32.0%)	25 (100.0%)	0.206
First molar	12 (46.2%)	3 (11.5%)	11 (42.3%)	26 (100.0%)	
total	21 (41.2%)	11 (21.6%)	19 (37.3%)	51 (100.0%)	

Table 2 Frequency distribution of ridge morphology on dentate

Tooth type	Ridge morphology			Total	p-value
	C	**P**	**U**		
Second premolar	5 (19.2%)	11 (42.3%)	10 (38.5%)	26 (100.0%)	0.620
First molar	4 (16.0%)	8 (32.0%)	13 (52.0%)	25 (100.0%)	
total	9 (17.6%)	19 (37.3%)	23 (45.1%)	51 (100.0%)	

Table 3 Dimensional parameters of lingual concavity

Parameters	Second premolar		First molar	
	Dentate ridge (Mean ± SD[1])	**Edentulous ridge (Mean ± SD)**	**Dentate ridge (Mean ± SD)**	**Edentulous ridge (Mean ± SD)**
V [2] (mm)	16.290 ± 2.711	15.837 ± 2.10110	15.554 ± 3.048	15.6364 ± 3.485
D [3] (mm)	2.630 ± 1.051	3.462 ± 1.916	3.092 ± 1.358	3.291 ± 1.083
ϴ [4] (degrees)	80.550 ± 4.522	79.312 ± 4.172	78.665 ± 4.613	77.418 ± 6.682

[1] = standard deviation, [2] = vertical distance between the top of the crest to the deepest point of lingual concavity, [3] = concavity depth, [4] = concavity angle

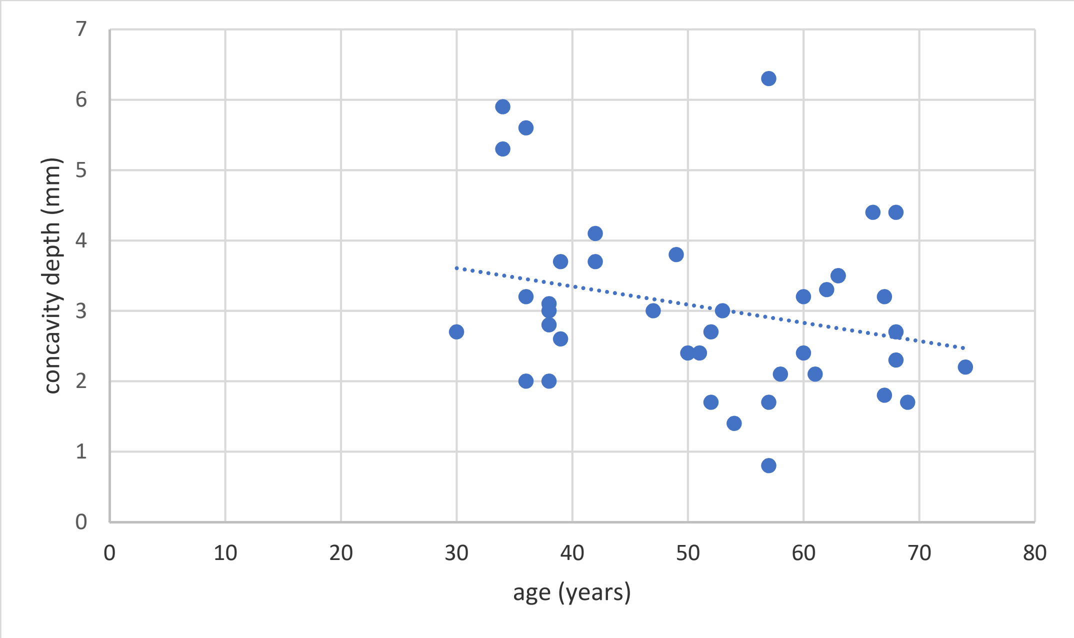

Figure 4 shows the scatterplots of age and the concavity depth.
The negative correlation between them was found (r = -0.2635)

Discussion In the area of the posterior mandible, there are some vital structures to consider before the dental implant surgery. One of them is a lingual concavity, which is a depression at the medial side of the mandible. With the pronounce recession, it was considered to be a potential risk factor of the lingual plate perforation during the implant surgery (Quirynen, Mraiwa, van Steenberghe, & Jacobs, 2003) (Quirynen et al, 2003). If the process of implant bed preparation is not well planned and cautiously performed, the drill may penetrate the lingual cortical bone to the floor of the mouth, which is a highly vascularized area. This could lead to several complications such as infection, bleeding and upper airway obstruction, etc. (Kalpidis & Konstantinidis, 2005; Niamtu, 2001) Therefore, the objective of this study is not only to evaluate the prevalence of the ridge morphology but also the dimension and the position of this concavity in Thai population.

To categorize ridge morphology, the ridges were divided into 3 groups, which are convergent, parallel and undercut ridge types. On edentulous ridge, the prevalence rate in this study was shown to be 41.2%, 21.6% and 37.3% respectively. The distribution was inconsistent with the result from the study of Chan et al. (2011), although the number and average age of subjects were quite similar to this study (51years, n=103sites). The study of Chan et al. (2011) indicated the prevalence of 13.6%, 20.4% and 66% respectively. However, it must be noted that result was evaluated only in the first molar area. For the dentate ridge, the finding from this study showed that the U type was the most prevalent accounting for 45.1% of study population and followed by P type (37.3%) and C type (17.6%). The result was in accordance with the previous studies (Huang et al, 2015; Lin et al, 2014) which reported that U type is the most common ridge type. This consistent result was due to the similar criteria for recruiting the studied sites such as the ridge height, the alignment of the teeth, etc. The study of Watanabe et al. (2010) classified the mandible shape into 3 types. Type A was the ridge that round on buccal side and concave on the lingual side, Type B was opposite to type A and type C was round on both sides. Conversely, on posterior region, type C (round) (59-61%) was found to be the most common ridge type followed by type A (lingual undercut) (36-39%).

The dimension and position of the lingual concavity were evaluated in this study by analyzing the V, D and ϴ of the concavity. V was referred as the vertical distance between the top of the alveolar crest to the most concave area. This distance was also an important parameter to estimate the length of the implant used. In this study, the Meanto illustrate V on both dentate and edentulous area was found to be 15.55-16.29 mm. This figure exceeds the length of standard implant (10mm). For lingual concavity the results of the depth are diverse because of the various measurement methods, the classification criteria and the subjects 'race. To demonstrate, Chan et al. (2011) studied on the mixed population of Caucasians and Afro-Americans, Huang et al. (2015) studied on the Taiwanese population whereas this study focused on the Thai population. In this study, the mean value of concavity depth was found to be 3.36±1.45mm for edentulous ridge and 2.89±1.23mm for the dentate ridge. The negative correlation between the concavity depth and age was presented. This can be described that along with the aging process, the lingual concavity depth will be decreased. Gender and the presence of the tooth had no effect on the amount of V, D and Ɵ of the concavity. According to the study of Panjnoush et al. (2016), edentulous ridges were assigned into three types, namely type I (less than 2mm), type II (2-3mm) and type III (more than 3mm), depending on the extent of their concavity depth. The result showed that type I and type III were the most and least common ridge type, accounting for 68% and 12% respectively. Chan et al. (2011) demonstrated that mean concavity depth was 2.4±1.1 mm; however, the number was higher in the findings of Nickenig et al. (2015), which reported the depth with 3.7mm. For the dentate ridges, former studies (Huang et al, 2015; Lin et al, 2014) revealed the mean of concavity depth with 4.7±1.70mm and the molars teeth were found to have significantly greater depth than the second premolar tooth.

According to all the studies discussed previously, the lingual mandibular undercut with a variety of dimensions can be found often amongst the population. It can be said that there is a higher risk and more complication which can occur when placing the implant in the posterior mandibular region. Thus, cross-sectional images may be necessary in some situations. It should be justified to analyze each individual condition for the need and benefit of the CBCT images and the clinicians should always be aware of the risk when installing the implant in posterior mandibular area. Future studies should further evaluate the morphology of resorbed ridges and define the risk factors related to the pronounce lingual concavities.

5. Conclusion

The lingual concavity was commonly found on posterior mandibular area which resulted in 37.3% for edentulous ridge and 45.1% for dentate ridge. The concavity depth was found to have negative correlation with age. Therefore, CBCT is still recommended for treatment planning prior to perform the implant surgery even on the alveolar ridge with adequate dimension for standard implant placement

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