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Evaluation of Mandibular Lingual Concavity in Premolar and Molar Region Using Cone-Beam Computed Tomography (CBCT)

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ABSTRACT

Background: Implant therapy has become an integral part of dental practice. However, surgical accidents and complications by placing implants may occur. So knowledge of bone morphology is mandatory for correct implant direction. The aim of this study was to evaluate the morphological parameters of mandibular concavities using Cone-beam Computed Tomography.

Methods: In this study, 100 cone-beam computed tomography images were assessed on cross-sectional view. The mandible morphology 2 mm above the inferior alveolar canal was classified into the convex (C), parallel (P) and undercut (U) type, based on the presence of lingual concavity and the shape of alveolar ridge. The prevalence of each group and the lingual concavity characters, including the depth and the angulation were determined by the measurements of selected anatomic landmarks. Data analysis was performed through SPSS26 and using Pearson correlation, t- test and Chi-Square test. The significance level was set at 0.05.

Results: One hundred subjects (mean age: 38.89± 12.10, range of 19-63 years) were studied. The U type was the most prevalent, accounting for 51% of the study population. The mean undercut depth and angulation at the level 2 mm above the inferior alveolar canal were respectively 3/22 ± 0.92 mm and 50.42 ±4.75 degree. Concavity depth and its angle showed no significant correlation with age, gender, edentulous area and type of ridge.

Conclusion: The anatomic location and the degree of the lingual concavity presented in this article added more information about implant treatment planning at mandibular premolar and molar regions.

Keywords: Anatomy, Dental Implant, Lingual, Mandible

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Introduction

Implant therapy has become a routine dental practice, because of its high success rate. Most implant surgeries, with proper diagnosis and treatment planning can meet functional and aesthetic needs after osseointegration. However, surgical accidents may occur (1).

These complications are usually predictable and treatable. One of these mishaps is bone perforation during implant placement. Bone perforation can damage critical structures (2). Complications such as inflammation, infection and implant loss occur following bone perforation.

In order to avoid these complications, it is necessary to prepare appropriate radiographs to examine the amount and shape of bone, the exact location of vital structures and determine the appropriate size of the implant for surgery (3).

Periapical and panoramic radiographs are two-dimensional and do not provide useful information about the width and shape of the alveolar ridge (4). Cone beam computed tomography (CBCT) is a type of computed tomography (CT) that reconstructs a three-dimensional image and is the superior imaging modality in many cases (5). CBCT images are well for a variety of clinical applications, including implant planning, impacted teeth, localization, maxillofacial surgery, clefts, endodontics (6,7).

Moreover, CBCT is suitable for assessing buccal or lingual mandibular undercuts and preventing cortical perforation and its complications (8, 9). The choice of implant size in the mandible depends on the width and height of the bone and location of the inferior alveolar canal (10,11), and shape of the alveolar ridge. According to ridge morphology, subjects are classified into three types of C (convex), P (parallel) and U (undercut) (12,13).

Undercut or lingual concavity is a common finding in the posterior regions of the mandible that, if ignored, can lead to perforation of the mandibular lingual cortex (14). It can also cause damage to vital structures, nerve damage, and heavy bleeding in the floor of the mouth, which can be life-threatening if the airways become blocked (15). In a study by Nickenig *et al.* (13), the prevalence of lingual undercuts was 68% in molar region, and in the second molar region, it was significantly higher (90%) than that in the first molar region (56%). Also they showed that type U was the most common and accounted for 66% of their study population. Panjnoush *et al*. (12), showed an inverse relationship of depth and concave angle of the mandibular ridge with age. Herranz-Aparicio *et al*. (16) suggested that in mandibular bones with any lingual concavity, there is a possibility of perforation of the cortical bone during implant placement surgery, and three-dimensional imaging, such as CT scans, can describe the anatomy of the submandibular cavity and provide other important information for preoperative evaluation of the posterior mandible in dental implants.

Given that mandibular concavities are clinically common, and have a potential risk when implants are placed in the posterior areas of the mandible, and regarding to the increasing tendency towards implant treatments, it is very important for the surgeon to know the concavities of the ridge by performing accurate radiography as a guide. The aim of this study was to determine lingual concavity in premolar and molar region of mandibular bone through CBCT in patients who are candidate for receiving dental implants in oral and maxillofacial radiology centers in Kerman city.

Materials and Methods

This retrospective and cross-sectional study was approved by the Ethics Committee of Kerman University of Medical Sciences (Code 1399.309IR.KMU.REC). In this study, we evaluated 100 CBCT samples of patients referred to 5 specialized oral and maxillofacial radiology centers in Kerman, which were equipped with CBCT device. By reviewing the archives of the above centers, the CBCT of patients who were candidates for implants in the premolar and molar areas of the mandible were selected. Inclusion criteria were:

1- The minimum bone height (from alveolar crest to superior border of inferior alveolar canal) of 8 mm

2. The minimum bone width of 3.5 mm at the crestal region

3- The minimum age of 18 years (complete development of the mandible is at18 years of age)

We excluded patients with CBCT for pathological reasons and treatments such as bone graft surgery.

Imaging of all samples was performed by Planmeca (Planmeca OY, Helsinki, Finland). Exposure conditions were considered as Current = 8-12 MA, KVP=80-90 and Time = 8s and the thickness of each slice was 0.2 mm and the distance between each slice was 2 mm. CBCT images were analyzed by ROMEXIS 3.4 software and all were performed by a final year student trained by two maxillofacial radiologists. The information obtained was recorded in a checklist.

The following were measured in CBCTs:

1- Mesiodistal width of the edentulous ridge of the mandibular premolars

2- Mesiodistal width of the edentulous ridge of the mandibular molar

3- Buccolingual thickness of the edentulous ridge of the mandibular premolars

4- Buccolingual thickness of the edentulous ridge of the mandibular molar

5- Distance of mandibular alveolar crest to inferior alveolar canal in premolar and molar areas

6- Evaluation of buccal and lingual concavity in mandibular premolar and molar areas

7- Determining the form and amount of undercut in mandibular premolar and molar area

All measurements were performed by computer software (Figure 1).

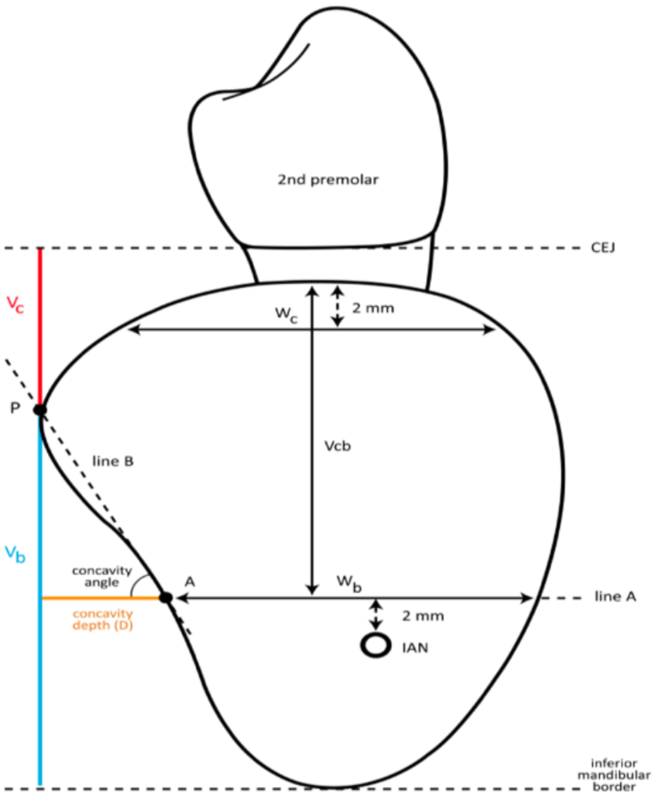

Figure 1. Schematic diagram of the morphology of premolar area of mandible
Line A: a line that is parallel to the horizon surface and passes 2 mm higher than the inferior alveolar canal / point A: the intersection of line A and the lingual surface of the mandible / point P: the most prominent point at the level of the mandibular lingual / line B: The line that connects the two points A and P (1)

In order to measure the buccolingual thickness in the cross-sectional view, the buccolingual dimension was measured 2 mm higher than the inferior alveolar nerve canal (BL / IAN) and 2 mm inferior than the alveolar crest (BL / Crest), and the mean of these two was considered. Based on the morphology of the ridge, we had 3 types of ridges:

1- Type U (Undercut): The width of the ridge section is less than the crest.

2- Type C (Convex): The width of the ridge section is more than the crest.

3- Type P (Parallel): The width of the ridge section and crest are almost equal.

In type U the ridge has an undercut in the lingual area, but there are no undercut in C and P types.

Also, to determine the degree of concavity, the angle between line A and line B, and to measure the undercut depth in U-type ridges, the horizontal distance between point A and the vertical line passing through point P were calculated (1,10).

In this study, data analysis was performed through SPSS software version 26 and using descriptive statistical methods (calculation of mean and standard deviation for quantitative data). To evaluate the relationship between age and variables including mesiodistal width and buccolingual thickness, crest distance to anatomical points and undercut angle in the studied areas, Pearson correlation was used. Independent t-test was applied to evaluate the relationship between gender and area with other variables, and Chi-Square test used to analyze the association of ridge type with gender and area. The significance level was set at 0.05.

Results

Of the 100 subjects, 45% were males and 55% were females. The mean age of subjects was 38.89± 12.10 years. Forty-two of CBCT samples (42 ٪) were related to the premolar region and 58 ones (58%) to the mandibular molar region. According to mandibular ridge classification, 51% of subjects were included in type U and 49% in type C.

The findings of evaluating the variables are as shown in table 1.

Table 1. Mean, standard deviation, median, minimum and maximum of mesiodistal width, buccolingual thickness, concavity depth, concavity angle and Crest/IAN of mandible

Variables	Mean	Standard deviation	Median	Minimum	Maximum
Mesiodistal width(mm)	19.61	3.31	20.00	8.00	28.00
Buccolingual thickness(mm)	7.35	1.57	7.80	4.20	10.20
Crest/IAN	10.82	1.37	10.80	8.40	15.00
Undercut depth	3.22	0.92	3.16	1.90	5.90
Angle	50.42	4.75	51.00	40.00	59.00

Crest/IAN: alveolar crest to inferior alveolar canal

The results showed that the mesiodistal width and buccolingual thickness were significantly higher in men and in the molar edentulous area. The undercut ridge angle in women was marginally significant higher than men. Also, the buccolingual thickness of the selected areaswas significantly (P <0.05) higher in the U-type ridge (Table 2).

Table 2. The associaton of mesiodistal width, buccolingual thickness, concavity depth, concavity angle and Crest/IAN with gender and edentulous area and the type of ridge

	Gender	Mean	SD	P value	Edentolous area	Mean	SD	P value	Ridge	Mean	SD	P value
Mesiodistal width	Male	20.60	2.53	.006	Premolar	17.56	3.53	.0001	U	20.09	2.81	.156
	Female	18.76	3.67		Molar	21.18	2.05		C	19.13	3.72	
Buccolingual thickness	Male	7.80	1.708	.008	Premolar	5.86	.90	.0001	U	7.81	1.32	.003
	Female	6.97	1.35		Molar	8.45	.89		C	6.87	1.68	
Undercut Depth	Male	3.18	.77	.679	Premolar	3.18	1.05	.728	U	3.36	.91	.115
	Female	3.25	1.03		Molar	3.25	.81		C	3.07	.91	
Angle	Male	49.45	4.55	.065	Premolar	50.43	4.79	.983	U	50.14	4.57	.548
	Female	51.21	4.81		Molar	50.42	4.77		C	50.71	4.97	
Crest/IAN	Male	10.78	1.46	.820	Premolar	10.95	1.11	.390	U	10.71	1.29	.455
	Female	10.84	1.31		Molar	10.72	1.54		C	10.92	1.46	

SD= Standard Deviation

According to ridge morphology, 51% of subjects were classified into U type (undercut). Other cases (49%) were type C (convex), and there was not the morphology of type P (parallel). As it is shown in figure 2, samples in premolar area were mostly type C (64.3%) and in the molar area, they were mostly U type (62.1%). The results obtained from the Chi-Square test showed that these differences between premolar and molar areas of the mandible were significant (P=0.009). There was not a significant relationship between sex and type of ridge (P=0.98).

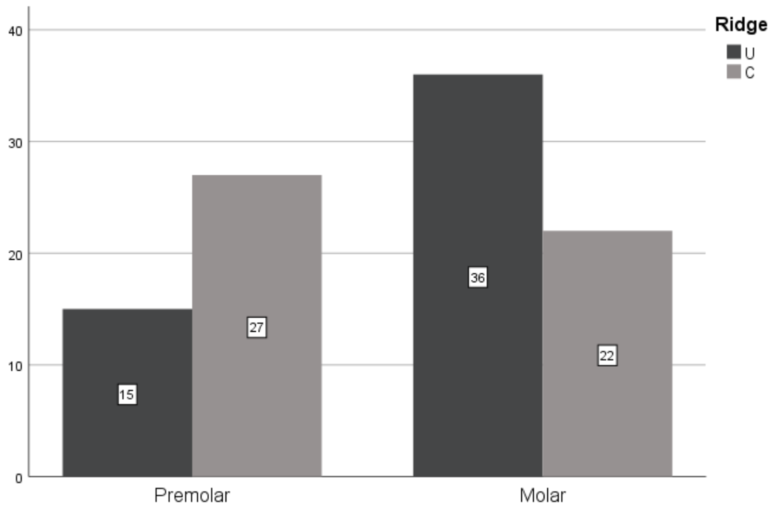

Figure 2. The frequency of U type (undercut) and C type (convex) in premolar and molar edentulous areas of mandible

The results of Pearson correlation coefficient test showed that mesiodistal width and buccolingual thickness of premolar and molar edentulous areas had a significant direct relationships with each other (r=0. 41, P=0.0001). Also, there was a reverse marginal significant association (r=-0.185, P=0.065) between mesiodistal width with angle of ridge (r=-0.183, P=0.072) and Crest/IAN (table 3).

Table 3. The association of mesiodistal width, buccolingual thickness, concavity depth, concavity angle and Crest/IAN with each other and age

Variable		Age	MD	BL	UD	Angle	Crest/IAN
Age	Pearson Correlation	1	.044	-.082	-.048	.044	-.119
	P value		.671	.422	.632	.661	.240
Mesiodistal Width (MD)	Pearson Correlation	.044	1	.408**	.085	-.183	.000
	P value	.671		.000	.409	.072	.998
Buccolingual Thickness (BL)	Pearson Correlation	-.082	.408**	1	.062	-.094	-.039
	P value	.422	.000		.542	.353	.700
Undercut Depth (UD)	Pearson Correlation	-.048	.085	.062	1	-.011	-.028
	P value	.632	.409	.542		.917	.779
Angle	Pearson Correlation	.044	-.183	-.094	-.011	1	-.185
	Sig. (2-tailed)	.661	.072	.353	.917		.065
Crest/IAN	Pearson Correlation	-.119	.000	-.039	-.028	-.185	1
	Sig. (2-tailed)	.240	.998	.700	.779	.065	

** Correlation is significant at the 0.01 level (2-tailed).

Discussion

In various studies, serious complications have been reported after implant placement that may cause long-term and sometimes even permanent neurological problems (17). Therefore, careful clinical examination of the shape and dimensions of the edentulous ridge should be done before planning treatment. The choice of implant size in the mandible depends on the width and height of the bone and the location of the inferior alveolar canal (10, 11, 18). Also, ridge angle is one of the other important factors that should be considered in implant placement (12). In this study, the prevalence of undercut (U type) was 51% in the study population, mean mandibular lingual concavity depth was 3.22 ± 0.92 mm, and mean angle of undercut was 50.42±4.75 degree.

In the present study, the prevalence rate of undercut (51%) was lower compared to two studies conducted in Iran by Parnia *et al.* (80%) and Panjnoush *et al.* (56%) (11, 12) and studies performed in other countries including Chen *et al.* study in USA (66%) and Nickenig *et al.* study in

Germany (68%) (4, 13). While, it was more than the prevalence rates of undercut type found in studies by Watanabe *et al.* in Japan (36-39%) and Braut *et al.* in Switzerland (38.93%) (18, 19).

In the present study, the mean mandibular lingual concavity depth (3.22 ± 0.92 mm) was more than the same values in Panjnoush *et al*. study (1.3 ± 1.54 mm) (10), Parnia *et al*. research (2.6±0.85 mm) (9), and Chan *et al*. study (2.4± 1.1mm) (17). While, the mean angle of undercut in present study (50.42±4.75) was less than that in the study by Chan *et al*. (59.3± 7.3) (4).

Most studies, such as the present study, have shown high prevalence of undercuts. But, differences in the measured indexes can be explained by differences in race, methods of measurement, the presence or absence of teeth, and types of imaging modalities (CT, CBCT).

CT and CBCT help the surgeon to obtain more information by creating three-dimensional images (20). Some of researchers such as Quirynen *et al.* (3), Tepper *et al.* (21), and Parnia *et al.* (11) have evaluated ridge concavity by CT. However, the dose of CT radiation, and it costs for the patients are relatively high. CBCT is a recent imaging technique, with image acquisition time ranging from 10 to 40 seconds. In addition, the resolution of CBCT is theoretically higher than the resolution of CT and the radiation dose is clearly lower than that of multislice CT (22). Therefore, it seems that the ability of providing cross-sectional views with accuracy and high resolution, makes CBCT images a good tool for assessing the cross-sectional morphology of the posterior mandible, especially for detecting lingual concavity.

In our study, the relationship between gender and concavity depth was not significant. In Parnia *et al.*, Panjnoush *et al.*, Quirynen *et a.l,* and Rajput *et al.* studies (3,11,12,23), there has been no relationship between gender and variables of the depth and angle of lingual concavity in the mandible. However, in the present study, mesiodistal width and buccolingual thickness were significantly greater in men than women and in molar areas than in premolar areas. Also, the angle of undercut was greater in women than men and this difference was marginally significant.

The findings of the present study showed that the relationship between age and the measured indexes was not significant. These results are similar with the results of Parnia *et al*. study (9). But, Panjnoush *et al*. have reported that mandibular lingual concavity depth and angle decrease with aging process (10).

In our study, the prevalence of undercut (type U) was significantly higher in the molar than premolar areas.

In order to examine the ridge in detail, the buccal and lingual anatomy of the ridge must be carefully evaluated. One of the limitations of this research was that only 6 cases of buccal concavity were observed, but due to the postoperative defects such as trauma and cyst, these cases were not included in the study. Therefore, it is suggested that further studies be performed with a larger sample size.

Conclusion

This study showed that the prevalence of undercuts is relatively high. The anatomic location and the degree of the lingual concavity presented in this research add more information in implant treatment planning in the mandibular premolar and molar edentulous region.

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