Effects of Crest Morphology on Lingual Concavity in Mandibular Molar Region: an Observational Study

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ABSTRACT

Objectives: The aim of this radiological study is to evaluate the lingual concavity dimensions and possible implant length in each posterior tooth region according to posterior crest type classification by using cone-beam computed tomography.
Material and Methods: According to inclusion criteria, 836 molar teeth regions from 209 cone-beam computed tomography images were evaluated. Posterior crest type (concave, parallel, or convex), possible implant length, lingual concavity angle, width, and depth were recorded.
Results: In each posterior tooth region, concave (U-type) crest was detected most frequently while convex (C-type) was the lowest. Possible implant length values were higher in second molar regions than first molars. Lingual concavity width and depth were decreasing from second molars to first molars for both sides. Additionally, lingual concavity angle showed higher values in second molar sites than first molars. In all molar teeth regions, lingual concavity width values were the highest in concave (U-type) crest type while they were the lowest in convex (C-type) crest type ($P < 0.05$). Lingual concavity angle values were recorded as the highest in concave (U-type) and the lowest in convex (C-type) crest type at the left first molar and right molars ($P < 0.05$).
Conclusions: The lingual concavity dimensions and possible implant length may vary according to crest type and edentulous tooth region. Due to this effect, the surgeons should examine crest type clinically and radiologically. All parameters in the present study are decreasing while moving from anterior to posterior as well as from concave (U-type) to convex (C-type) morphologies.

Keywords: bone; dental implants; mandible; tomography.

Accepted for publication: 31 March 2023
To cite this article:
Çimen T, Asar NV, Goyushov S, Duruel O, Tözüm TF.
Effects of Crest Morphology on Lingual Concavity in Mandibular Molar Region: an Observational Study
J Oral Maxillofac Res 2023;14(1):e3
URL: http://www.ejomr.org/JOMR/archives/2023/1/e3/v14n1e3.pdf
doi: 10.5037/jomr.2023.14103

INTRODUCTION

For the recent 30 years, dental implant is one of the options that is preferred by the patients for rehabilitation of totally or partially edentulous jaws [1]. Even though patients prefer dental implant therapy frequently, some complications (such as bleeding, paraesthesia, lingual plate perforation, dental implant failure, etc.) may occur after or during dental implant surgeries [2-5]. With detailed evaluation of anatomic structures by cone-beam computed tomography (CBCT), dental implant surgery is safe with less complication risk [6].

Posterior sides of mandible present high complication risk because of proximity to vital anatomic structures like mandibular canal and mental foramen [7,8]. In addition to intra-bony vascular structures, lingual undercut is a common finding and limits the dental implant length especially in molar regions [9]. The surgeons should check the angulation and positioning of the drills to avoid lingual plate perforation because the lingual side of mandible contains submental, sublingual, and mylohyoid arteries [10]. Due to presenting bone concavity and fossa with vascular structures, detailed pre-surgical radiographic evaluation of posterior mandible is highly recommended to avoid complications like lingual plate perforation and damaging blood vessels [11,12].

Radiographic evaluation by orthopantomogram presents the practitioner some information of vital structures and alveolar bone morphologies in two-dimensional manner; however, CBCT evaluation provides us more detailed and accurate information about morphology and dimensions of crest with additional information of bone quality [13-15]. According to pre-surgical evaluation by CBCT, the surgeon determines size, position, and angulation of dental implants before implant surgery to avoid possible complications [1]. Hence, the aims of this radiological study are to evaluate possible dental implant length for molar regions, lingual concavity dimensions and posterior crest type in each molar tooth region, and possible effect of posterior crest type on these linear measurements.

MATERIAL AND METHODS

Study design

This study was performed in two centers (University of Illinois at Chicago and Alanya Alaaddin Keykubat University). Each study centers got their individual Institutional Review Board approval (University of Illinois at Chicago 2019-0432, and Alanya Alaaddin Keykubat University ALKÜ-KAEK 22-36).

The CBCT scan images in the archives of the College of Dentistry at the University of Illinois at Chicago between January 2004 and May 2019, and Alanya Alaadin Keykubat University between December 2018 and August 2020 were used for this retrospective study. Eight-hundred and thirty-six molar teeth regions of 209 CBCT scans were evaluated. Inclusion criteria were as follows:

- Having good quality of CBCT scan.
- No jaw fracture.
- No artifacts caused by movement while image exposure.
- No previous bone grafting in the posterior mandible.

The CBCT mandibular scan was acquired using by KaVo OP™ 3D DVT (KaVo Dental; Biberach, Germany) and i-CAT® Model 17-19 CBCT device (Imaging Sciences International; Hatfield, PA, USA). Operating parameters for the first machine were 90 kV and 9.23 mA, and scan time was 8.14 seconds. For the second machine, images were obtained at 110 mm field of view, 26.9 seconds exposure cycle, 1.4 mA and 120 kV, with a resolution of 0.2 voxels, the thickness of 0.1 mm. Digital Imaging and Communications in Medicine (DICOM) formats were used to save the images. All CBCT scans were taken in a standardized vertical position, in which the heads were stabilized during the scanning with a motionless position.

CBCT image analysis

For visualizing the cases, SimPlant® Pro version 17.01 software (Dentsply Implants NV; Research Campus 10, Hasselt 3500, Belgium) was used by the study centers. The software acquires images in axial and reconstructs in coronal and sagittal views; it also provides at three-dimensional reconstructed model of the area of interest. The brightness and contrast of the images were adjusted, if required, to optimize image quality.

One experienced observer from each center TÇ and NVA made the measurements on the images scanned from CBCTs.

The parameters were recorded from right and left hemi-mandibles for each molar tooth region (Figure 1):

1. Posterior crest type concave (U-type), parallel (P-type), or convex (C-type) modified from Chan HL et al. [9].
2. Possible implant length (distance between the deepest point of lingual concavity and 1 mm apically from crest).

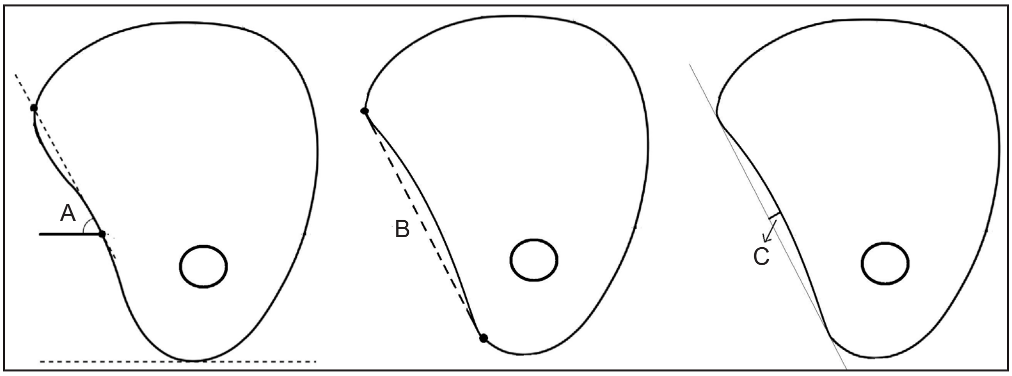

Figure 1. Descriptive illustration of lingual concavity.
A = angle between the plane tangent to the deepest point of the lingual concavity and the ground plane.
B = width - the distance between upper and lower border of the lingual concavity.
C = depth - the distance between the plane passing through the upper and lower border of the lingual concavity and the deepest point of the lingual concavity.

3. Lingual concavity angle, width, and depth.

Intra-observer reliability of the measurements was examined by using inter-class correlation coefficients. Intra-observer coeffecitients values were calculated > 90%.

Statistical analysis

All statistical analyses were performed by using IBM SPSS Statistics for Windows version 24.0 (IBM Corp., Armonk, New York, USA). Mean and standard deviation values were used for descriptive statistics for numeric variables, while number of event and percentage were used for categorical variables. Student t-test was performed for comparison of numeric variables. One-way ANOVA was used while evaluating effect of categorical variables on numeric variables. Parametric data were expressed as mean and standard deviation (M [SD]). Statistical significance level was defined at P = 0.05.

RESULTS

Posterior crest type distribution was presented in Table 1. In each posterior tooth region, concave (U-type) crest was detected most frequently while convex (C-type) was the lowest. Possible implant length values were higher in second molar regions than first molars: right first molar - 14.684 (2.311) mm, right second molar - 15.372 (2.64) mm, left first molar - 14.382 (2.035) mm, and left second molar - 14.596 (2.057) mm. Lingual concavity width: right first molar - 11.99 (1.904) mm, right second molar - 13.308 [2.587]) mm, left first molar - 11.949 (1.759) mm, and left second molar - 12.183 (1.935) mm; and depth: right first molar - 1.58 (0.331) mm, right second molar - 1.713 (0.332) mm, left first molar - 1.479 (0.3) mm, and left second molar - 1.524 (0.305) mm, were decreasing from second molars to first molars for both sides. Additionally, lingual concavity angle showed higher values in second molar sites than first molars: right first molar - 49.96 (7.527), right second molar - 52.302 (7.588), left first molar - 48.983 (6.219), and left second molar - 53.455 (5.565) (Table 2).

Table 1. Posterior crest type distribution according to tooth number

Tooth number	Concave (U-type)	Parallel (P-type)	Convex (C-type)
47	100 (47.85%)	62 (29.66%)	47 (22.49%)
46	103 (49.28%)	61 (29.19%)	45 (21.53%)
36	99 (47.37%)	66 (31.58%)	44 (21.05%)
37	97 (46.41%)	64 (30.62%)	48 (22.97%)

World Dental Federation FDI (French: Fédération Dentaire Internationale) tooth numbering system was used.

Table 2. Overall linear measurements related to lingual concavity for each molar tooth region

Tooth number	Possible implant length (mm)	Lingual concavity width (mm)	Lingual concavity depth (mm)	Lingual concavity angle
47	15.372 (2.64)	13.308 (2.587)	1.713 (0.332)	52.302 (7.588)
46	14.684 (2.311)	11.99 (1.904)	1.58 (0.331)	49.96 (7.527)
36	14.382 (2.035)	11.949 (1.759)	1.479 (0.3)	48.983 (6.219)
37	14.596 (2.057)	12.183 (1.935)	1.524 (0.305)	53.455 (5.565)

World Dental Federation FDI (French: Fédération Dentaire Internationale) tooth numbering system was used.

Table 3. Comparison of linear measurements according to posterior crest type for each molar tooth region

	Concave (U-type)	Parallel (P-type)	Convex (C-type)	P-value
Tooth number 47				
Possible implant length (mm)	15.723 (2.228)	15.32 (1.765)	14.994 (2.407)	0.623
Lingual concavity width (mm)	15.706 (1.974)	13.733 (1.914)	11.909 (2.281)	0.001[a]
Lingual concavity depth (mm)	1.743 (0.331)	1.696 (0.345)	1.674 (0.34)	0.558
Lingual concavity angle	53.559 (7.659)	52.235 (7.944)	51.575 (7.383)	0.039[a]
Tooth number 46				
Possible implant length (mm)	15.235 (2.101)	14.876 (2.404)	14.472 (2.241)	0.513
Lingual concavity width (mm)	12.882 (2.143)	11.91 (1.605)	11.623 (1.842)	0.005[a]
Lingual concavity depth (mm)	1.594 (0.329)	1.547 (0.344)	1.533 (0.326)	0.742
Lingual concavity angle	51.267 (8.303)	50.1 (7.25)	47.007 (5.136)	0.023[a]
Tooth number 36				
Possible implant length (mm)	14.481 (1.683)	14.406 (2.14)	14.266 (2.249)	0.867
Lingual concavity width (mm)	12.632 (1.848)	11.935 (1.78)	11.685 (1.637)	0.034[a]
Lingual concavity depth (mm)	1.49 (0.266)	1.48 (0.356)	1.467 (0.273)	0.929
Lingual concavity angle	49.094 (6.576)	48.131 (6.515)	47.983 (6.219)	0.013[a]
Tooth number 37				
Possible implant length (mm)	14.856 (1.76)	14.702 (1.842)	14.406 (2.306)	0.532
Lingual concavity width (mm)	12.947 (1.754)	12.318 (1.769)	12.021 (2.119)	0.039[a]
Lingual concavity depth (mm)	1.544 (0.277)	1.53 (0.333)	1.482 (0.278)	0.652
Lingual concavity angle	53.929 (6.661)	53.344 (4.461)	53.061 (5.393)	0.73

[a]P < 0.05 significant differences between subgroups according to One-Way ANOVA tests.
World Dental Federation FDI (French: Fédération Dentaire Internationale) tooth numbering system was used.

Comparison of linear measurements according to posterior crest type were presented in Table 3. All linear measurements had a tendency to decrease from concave (U-type) to convex (C-type) posterior crest type. While possible implant length was the highest in concave (U-type) crest type, it was the lowest in convex (C-type) crests. However, the difference was not statistically significant in all molar regions (P > 0.05).

In all molar teeth regions, lingual concavity width values were the highest in concave (U-type) posterior crest type while they were the lowest in convex (C-type) posterior crest type (P < 0.05). Lingual concavity depth in all molar regions showed various values and they were not significant (P > 0.05). Lingual concavity angle values were recorded as the highest in concave (U-type) and the lowest in convex (C-type) posterior crest type at the left first molar and right molars (P < 0.05). There was a tendency to decrease from concave (U-type) to convex (C-type) posterior crest type in left second molar region; however, the difference was not statistically significant (P = 0.73).

DISCUSSION

As complications are prevented, dental implants are predictable options for the treatment of edentulous areas [1,2]. In mandibular posterior region, submandibular fossa and mandibular canal contain vital limiting anatomic structures [2,3]. To overcome complications, detailed evaluation of anatomic structures by CBCT is critical [14]. According to the results of the present study, concave (U-type) crest (right first molar: 49.28%, right second molar: 47.85%, left first molar: 47.37%, and left second molar: 46.41%) was most frequently observed and this finding is compatible with the literature [9,16-18]. The percentage of concave (U-type) crest varies in a wide range in the literature published in English and it may be clarified by the evaluation of various populations.

In the literature, the distance between the deepest point of lingual concavity and alveolar crest has been measured [12]. An additional measurement was done, where the possible implant length (distance between the deepest point of lingual concavity and 1 mm apically from crest) was also measured in this study.

In theory, these parameters give clinicians similar information but there should be about 1 mm difference between them. Parallel to this theory, the possible implant length showed tendency to increase while moving from anterior to posterior sites. In another study, the alveolar crest and the lingual concavity distance showed various values [12].

In this CBCT study, lingual concavity width (right first molar: 11.99 [1.904] mm, right second molar: 13.308 [2.587] mm, left first molar: 11.949 [1.759] mm, and left second molar: 12.183 [1.935] mm) and depth (right first molar: 1.58 [0.331] mm, right second molar: 1.713 [0.332] mm, left first molar: 1.479 [0.3] mm, and left second molar: 1.524 [0.305] mm) values are between the ranges of the literature [9,12,18,19]. Lingual concavity width and depth values decreased from second molars to the first molars in accordance with the literature [12,19]. Lingual concavity angle values also vary in the literature. In a study, it has a tendency of decreasing from anterior to posterior sites [19]. However, in another study lingual concavity angle shows higher values in second molars than first molars in another study which is parallel to the results of the present study (right first molar: 49.96 [7.527], right second molar: 52.302 [7.588], left first molar: 48.983 [6.219], and left second molar: 53.455 [5.565]) [12].

The dimensions of lingual concavity have been evaluated according to sex, age, and edentulous tooth region in the literature [12,20-22]. However, measurements performed in the present study (possible implant length, concavity width, depth and angle) were not evaluated previously according to the crest types in the literature written in English. Therefore, no data can be found to compare with the present study. All measurements have tendency to decrease from concave (U-type) to convex (C-type). Moreover, lingual concavity width and angle show significant difference based on crest type ($P < 0.05$). To interpret the results of the present study, measurements of the lingual concavity and possible implant length may vary according to crest type and edentulous tooth region. Due to this effect, the surgeons should examine crest type clinically and radiologically. Additionally, evaluating crest type and dimensions prior to dental implant surgery are critical to avoid intra- and postoperative complications.

CONCLUSIONS

Concave (U-type) is the most frequent crest type for all mandibular molar teeth regions. All parameters in the present study are decreasing while moving from anterior to posterior as well as from concave (U-type) to convex (C-type) morphologies.

ACKNOWLEDGMENTS AND DISCLOSURE STATEMENTS

The authors report no conflict of interest related to this study.

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To cite this article:
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J Oral Maxillofac Res 2023;14(1):e3
URL: http://www.ejomr.org/JOMR/archives/2023/1/e3/v14n1e3.pdf
doi: 10.5037/jomr.2023.14103