

Is panoramic radiograph really safe in the posterior mandibular region for dental implant placement?

Is panoramic radiograph safety for dental implant applications?

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Abstract

Aim: The aim of the study was to investigate the probable planning differences in the vertical bone measurements required for dental implant application between panoramic radiographs and the cone-beam computed tomography (CBCT) images due to the posterior mandible lingual concavities.

Material and Methods: Using a retrospective study design, the authors enrolled a cohort of patients who underwent dental implant surgery. The implant platforms placed based on the panoramic image were simultaneously examined in the coronal sections of the CBCT images in the same section. The sizes of the implants placed perpendicularly to the horizontal axis in the alveolar bones with an undercut were remeasured through careful examination of the undercut anatomy.

Results: A total of 202 regions in the posterior mandible were analyzed in 101 patients (47 males and 54 females). The incidence of an undercut in the posterior edentulous areas of the lower jaw was 27.72% in the first molar region and 60.39% in the second molar region ($P < 0.001$). Implants placed in coronal sections based on CBCT images in both regions were shorter than dental implant platforms placed based on panoramic images in the same section, and this difference was statistically significant in the second molar region (PFM: 0.142, PSM < 0.001).

Discussion: According to the present study, when the second molar region could not be examined preoperatively via CBCT, the clinician should use a shorter implant than planned based on panoramic radiography to reduce the risk of lingual bone perforation.

Keywords

Dental implants; Lingual concavity; CBCT; Posterior mandibula; Submandibular fossa

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Introduction

Implant treatment has become an indispensable method in treating edentulous areas. Implant surgery enables the patient to regain function and esthetics through successful osseointegration [1]. The bone structure in which the implant is placed is an important factor that affects osseointegration. Therefore, it is important to evaluate the bone structure in 3 dimensions. Bone examination, palpation of the bone ridge, and precise evaluation of the bone size and morphology in the implant region are necessary for preoperative planning of mandibular implant placement [2–4]. Moreover, the size of the selected implant depends on the height and width of the available bone and the location of the mandibular canal. The concavity of the mandibular canal and submandibular fossa in the posterior region may lead to potential complications by restricting the available bone [2]. The submandibular fossa is a concavity on the medial surface of the mandible inferior to the mylohyoid line and contains the submandibular gland. The sublingual gland is also located in the sublingual fossa. This fossa is a shallow concavity on the medial surface of the mandible on both sides of the mental spin and above the mylohyoid line. Submandibular and sublingual fossae should be palpated before osteotomy [5]. However, it is difficult and time-consuming for the surgeon to check the angle of the ridge during implant placement. Although various anatomical regions can be analyzed using osteometry, diagnostic castings, etc., to evaluate the alveolar ridge, these techniques are not as effective in certain areas of the posterior mandible since the myeloid muscle prevents the correct evaluation of this area [1]. Mandibular posterior lingual concavity (LC) is a prevalent clinical finding, and the risk of perforation is high, particularly when the fossa is too deep [6,7]. Bone perforations are mainly observed in the posterior region, including the inferior alveolar nerve and the submandibular fossa. The posterior region is a high-risk area during implant placement owing to the risk of injuring the neurovascular bundle and perforating the lingual cortex. Perforation of the lingual cortex can lead to both implant failure and arterial trauma with hematoma [8]. For this reason, the morphology and size of the submandibular fossa constitute the data that should be reviewed in the preoperative evaluation. Periapical and panoramic radiographs can be used to evaluate the edentulous areas in the posterior mandible. On the other hand, these are particularly inadequate in showing the relevant anatomy in the buccolingual or horizontal dimensions (that is, to visualize thickness). Possible measurements in the posterior mandibular region, especially on panoramic radiographs, provides information about the vertical length of the alveolar bone. However, the actual height of the implant may differ in some cases because the aforementioned LC cannot be determined in panoramic radiographs. In addition, cone-beam computed tomography allows for better visualization of the anatomy and morphology of the surgical field. Such diagnostic imaging provides the clinician to better understand intraoral anatomical structures [9,10].

The disadvantages are the additional costs required for CBCT and exposing the patient to more radiation than is needed for panoramic radiographs, although the radiation amount to which the patient is exposed has decreased recently. In the

present study, primary aims were to evaluate the differences in using panoramic radiography and CBCT images to determine the vertical size of the implant in the 1st and 2nd molar regions of the edentulous mandible and to research the necessity of CBCT applications to evaluate the size of the implant in this region. The second aim of the present study was to evaluate the frequency of submandibular concavity in patients in the 1st and 2nd molar regions.

Material and Methods

Study Design

Using a retrospective study design, the authors enrolled a cohort of patients with CBCT scans who underwent dental implant surgery with local anesthesia. Partially or completely lower edentulous patients who were admitted to Adnan Menderes University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery between January 2017 and January 2019 participated in this study. The study protocol was approved by the Adnan Menderes University Human Research Ethics Committee. In the present study, 1098 CBCT images were evaluated. The study included healthy patients of both sexes aged over 18 years with lower posterior edentulous areas. Patients under 18 years of age were excluded from the study. Patients without preoperative records or CBCT images and patients with less than 3.5 mm alveolar bone thickness on the coronal side and vertical bone height less than 6 mm according to the inferior alveolar nerve to the coronal side were also excluded from the study. Demographic measures were age and sex. Anatomical parameters were measured using preoperative CBCT with NewTom 5G Cone Beam 3D Imaging, Verona, Italy. Dental volumetric computed tomography scans were obtained with a 0.25-mm slice thickness. All scanning procedures were performed using a standard exposure and patient positioning protocol.

DICOM files of dynamic volume computed tomography images were imported into NNT Viewer software (NewTom, Verona, Italy). Panoramic images and CBCT coronal sections were created from the same DICOM data. The mandibular posterior edentulous areas were carefully detected and drawn on the cross-sectional images after the segmentation procedure. The presence of LC in the lower regions of the first and second molars of the enrolled patients was determined according to the method in the study by Hsun-Liang Chan et al. in 2010 [6]. LC was evaluated in the posterior mandibular region on the basis of the shape of the alveolar ridge of the mandibular bone 2 mm above the mandibular canal. First and second lower molar regions were specified. Based on the panoramic images, the implant platform was placed in a coronal-apical direction with respect to the alveolar crest, perpendicular to the horizontal axis, and 2 mm in the coronal direction from the mandibular canal (Figure 1a, 2a). In the present study, the same implant platform design was used in both panoramic and coronal section views. The implant platforms placed based on the panoramic image were simultaneously examined on the coronal sections of the CBCT images in the same section (Figure 1b, 2b). The size of the implant platforms placed perpendicularly to the horizontal axis in the alveolar bones with LC was remeasured by carefully examining the undercut anatomy (Figure 3a, 3b). All

morphological assessments were conducted, and measurements were repeated three times by the same clinician.

Statistical analysis

Data normality was assessed using histograms, q-q plots and the Shapiro-Wilk test. Variance homogeneity was examined using Levene’s test. To compare the differences among groups, two independent samples (Wilcoxon test) were applied for quantitative data. Pearson’s chi-square analysis was used to compare categorical data. Data are expressed as means ± standard deviations or as frequencies (percentages). Coefficient of variation (CV) and intraclass correlation coefficient (ICC) were used for intraexaminer reliability. CVs ranged between 3.7% and 4.4%, while ICCs ranged between 0.96 and 0.97, showing excellent agreement. Analyses were conducted using TURCOSA (Turcosa Analytics Ltd. Co., Turkey). A p-value less than 0.05 was considered statistically significant.

Results

The study included 101 patients who met the inclusion criteria. A total of 202 regions in the posterior mandibula were analyzed in 101 patients (47 males and 54 females) enrolled in this study. The average age of the patients included in the study was 53.8 years. In the radiographic images, first molar and second molar regions were evaluated separately with 101 implant platforms. The incidence of an undercut in the posterior edentulous areas of the lower jaw was 27.72% in the first molar region and 60.39% in the second molar region. There were no significant differences in the edentulous mandible in terms of the posterior lingual undercut by age or sex (Page: 0.088, Psex: 0.115). The undercut frequency in the second molar region was found to be significantly higher than the undercut frequency in the first molar region (P<0.001) (Table 1).

Table 1. Summary of Study Variables

Demographic Variables		P Value	
Sample size, N	101		
Gender (Male/%)	47 (46,53)		0.115y
Age (years)	53.8 ± 12.88		0.088†
Variables		Groups	
Number of Region (n=202)	First Molar Region (N=101)	Second Molar Region (N=101)	P Value
Undercut, N (%)	28(27,72)	61(60,39)	<0.001y

Note: Data are presented as number (percentage) or mean ± standard deviation.
 y: Pearson chi Square
 †: T-test

Table 2. Measurements of Dental Implant Platforms

Implant Regions	Groups		P Value
	Panoramic Measurements	CT Measurements	
All Implants			
First Molar	10.68 ± 2.47	10.16 ± 2.54	0.142y
Second Molar	9.49 ± 2.57	8.29 ± 2.29	<0.001y
<10mm Implants			
First Molar	8.13 ± 1.31	7.62 ± 1.36	0.128y
Second Molar	7.18 ± 1.40	6.34 ± 1.21	0.015y
≥10mm Implants			
First Molar	11.81 ± 1.04	11.29 ± 1.09	0.134y
Second Molar	11.25 ± 1.10	10.21 ± 1.82	<0.001y

Note: Data are presented as number mean ± standard deviation.
 y: T-test

It was revealed that the implant platforms placed in coronal sections based on CBCT images in both regions were shorter than dental implant platforms placed based on panoramic images in the same section, and this difference was statistically significant in the second molar region (PFM: 0.142, PSM< 0.001) (Table 2).

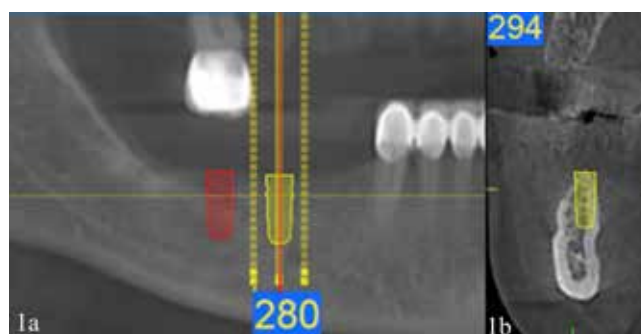


Figure 1. View of a dental implant platform placed in the first molar region in the panoramic image (1a) and in simultaneous CBCT coronal sections (1b).

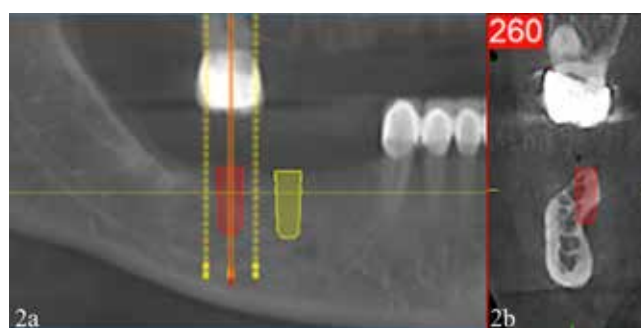


Figure 2. View of a dental implant platform placed in the second molar region in the panoramic image (2a) and in simultaneous CBCT coronal sections (2b).

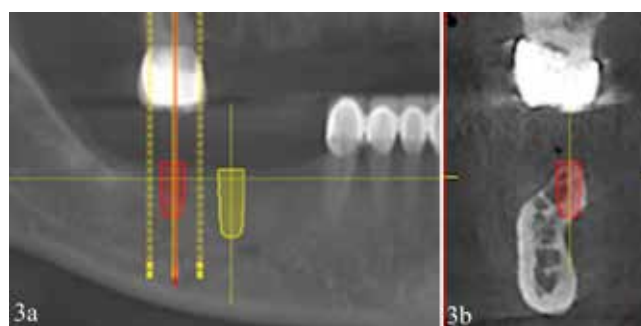


Figure 3. View of the dental implant platform, which was placed according to the undercut anatomy in CBCT coronal sections, in panoramic (3a) and coronal sections (3b).

Discussion

Today, dental implants have become the most popular treatment method in cases of tooth loss and are widely used. Therefore, accurate clinical and radiographic evaluations are very important for preventing complications, increasing the success rate, and boosting patient satisfaction. The size of the bone and the location of the anatomical structures where the implant will be placed can be assessed using 2D radiographs such as panoramic or periapical radiographs. In addition, a cross-sectional examination of the anatomical location where the implant will be placed is also very important [11], since

it enables the angle, width and height of the implant to be determined more accurately.

The oral surgeon should know the size and shape of the jawbone in order to select the appropriate implant size and prevent complications. To prevent lingual or buccal bone perforation during drilling, the implant should be placed according to the shape of the jaw bone [3]. One of the areas that may challenge the clinician during drilling or where the anatomy cannot be seen is the mandibular posterior region. The submandibular fossa in this region leads to a concave bone margin in the lingual side of the alveolar bone, and this causes undesired bone perforations during drilling. In a study conducted in 2011, the perforation rate of the lingual cortex (LCP) was reported as 7% in the second premolar teeth, 9% in the first molar teeth, and 31% in the second molar teeth during the placement of an implant with a diameter of 4 mm [2].

Froum et al. [2] and Chan et al. [6] researched the risk of LCP in implant treatment in the posterior mandibular region. Both used CBCT, computed tomography (CT), and software allowing for virtual placement of the implants with a diameter of 4-5 mm of different lengths (depending on the height of the alveolar crest). These authors concluded that the risk of bone perforation during implant surgery was higher in patients with an apparent LC. Froum et al. [2] suggested computed tomography before the operation to assess the risk of alveolar inferior nerve injury and LCP for immediate implant placement in the posterior mandible to evaluate other options, such as a delayed protocol.

In the lower posterior region, LCP can lead to various complications. The position of the lingual nerve should also be taken into consideration for implant placement in the posterior mandible. The lingual nerve is a branch of the posterior body of the mandibular nerve, delivered in the infratemporal fossa, close to the lingual direction of the mandible in the third molar region [12]. Due to the changing course of the lingual nerve, LCP can lead to nerve dysfunction during the placement of the implant.

If LCP is left undetected and an implant is placed, then the implant can be lost or cause permanent inflammation or infection. This can potentially cause the spread of infection and significant problems. Because of the location of the LC, infection in this area can easily spread to the parapharyngeal and retropharyngeal cavities, which can cause more serious complications such as mediastinitis, pulmonary embolism or upper airway obstruction and internal jugular vein thrombosis [12].

In the literature, various classifications of lingual ridge types have been suggested. Chan et al. [5] classified the ridge types as P (parallel), C (thickening towards the apical) and U (LC). Watanabe et al. [3] classified the types as A (LC), B (parallel) and C (thickening towards the apical). In his study, Magat observed type P as the most common ridge (37.4%), followed by type U (LC) ridges (32.5%) and type C ridges (30.1%). The reported prevalence of type U ridges in the literature varies between 36-66% [6,11,13]. Watanabe et al. [3] evaluated the lower posterior LC in a Japanese population in 2010. Based on their study, they reported that approximately 36% to 39% of all patients had LC. In addition, Chan et al. evaluated multiple CBCT scans for the presence of LC in the lower posterior region

[6]. Their results demonstrated that 66% of subjects presented posterior mandibular LC. These studies are consistent with the results of the present study, suggesting that 60% of the posterior mandibles exhibit LC. The probability of a concavity rises posteriorly in the jaw. Nickenig et al. [13] revealed that the prevalence of LC was higher in the second molar region. In accordance with the literature, mandibular LC was found to be significantly higher in the 2nd molar region than in the 1st molar region in the current study. In the current study, the presence of concavity in the lingual area was separately evaluated in the 1st and 2nd molar regions. Also, the type U bone incidence, which clinically concerns the clinician, was investigated; although it was seen in both regions, this incidence was observed to increase gradually in the 2nd molar region. Unlike other studies in the literature, the current study investigated the accuracy of planning the vertical length of the implant using panoramic films due to the presence of LC.

Panoramic radiography can be considered as a primary evaluation to obtain information about bone height and, to some extent, to acquire information about the horizontal distances [14]. However, panoramic radiographs provide information only in two dimensions and have various disadvantages, such as distortion and magnifications, which provide incorrect information [3,14]. In the current study, although LC was observed by 27% of the cases in the 1st molar region on panoramic radiographs, no significant difference could be detected between the planned implant length using the panoramic radiograph and the planned implant lengths using the CBCT image; the measurements complied with each other. However, it was observed that the bone LC increased in the 2nd molar region, and the planned implant lengths using CBCT were shorter than the implant lengths that could be placed using panoramic radiography during the planning stage; a significant difference was found. This shows that clinicians need to pay more attention to bone concavities in the 2nd molar region, and when required, CBCT should be applied preoperatively. On the other hand, some authors, such as Kalpidis and Konstantinidis, suggest that routine preoperative CT or CBCT screening is not necessary [15]. Alternatively, implant treatment planning and careful preoperative palpation of the lingual mandibular surface in the posterior mandible during surgery can facilitate sufficient reflection of the lingual mucoperiosteal flap and complete viewing of the lingual cortex [6,15]. As mentioned previously, differences in implant length between the two imaging methods may not always result in LCP. Weaknesses of the study include the limited study example and the lack of evaluation of the effects of angled implant placement. Experienced clinicians who do not evaluate the morphology of the region using CBCT preoperatively can understand that the drill is approaching the lingual border during the surgery, the implant length can be placed shorter than planned, or the implant can be placed in the buccal lingual direction to avoid concavity.

Conclusion

The present study reviewed the differences when planning the length of the implant for the mandibular posterior region using panoramic radiography and CBCT imaging. Panoramic radiographs gave results compatible with CBCT in the 1st molar region. However, although there was no significant

difference, there were a low number of cases where the implant length differed. In the 2nd molar region, significant differences were observed between panoramic radiography and CBCT measurements, and bone concavities were observed more frequently in this region. Our study included 101 patients and derived some statistical results using the data acquired from these patients. Nevertheless, each patient should be evaluated alone. If CBCT imaging is not the preferred technique of choice, the clinician should always consider the possibility of reaching the lingual cortical border before the planned drill length and change the planning strategy (implant length or implant angle) in these regions during the surgery.

Our study was retrospective and evaluated the clinical significance of the presence of concavity in this region using the measurements from the images, as well as the differences in panoramic radiographs and CBCT images. This retrospective radiographic study can be used as a model for prospective studies that examine lingual concavities in a larger population. In addition, prospective studies can be planned to evaluate the relationship between the angular differences of placed implants and the frequency of LCP.

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Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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