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Investigation the anterior mandibular lingual concavity by using cone-beam computed tomography

Evaluation of lingual concavity on CBCT

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Abstract

Background: In the presence of lingual concavity in the mandible, the cortical perforation and consequently the life-threatening intraoral hemorrhages obstructing the upper respiratory tract may be seen during the surgical intervention. In the present study, it was aimed to determine the prevalence of lingual concavity in the interforaminal region and to determine its relationship with gender and dentate status.

Material and methods: The images of 106 patients undergone cone-beam computed tomography (CBCT) between 2016 and 2017 in Department of Dental and Maxillofacial Radiology Department of Faculty of Dentistry of Ondokuz Mayıs University were retrospectively examined. The images were obtained using a Galileos device (98 kVp, 15-30 mA). The bone height and width in interforaminal region and the frequency of lingual concavity were analyzed.

Results: Of patients involved in the present study, 42.5% were male and 57.5% were female After the examinations performed, the bone was morphologically classified into four classes as Type I lingual concavity, Type II inclined to lingual, Type III enlarging towards labiolingual and Type IV buccal concavity. Type III (77.9%) was the most common type in the anterior region, followed by Type II (16.5%), Type I (4.7%) and Type IV (0.9%). The lingual concavity angle was 76.5 ± 3.69º and the concavity depth was 2.09 ± 0.34 mm.

Conclusions: The lingual concavity can be detected by using the cross-sectional CBCT images and the complications related with lingual cortical perforation can be prevented.

Key words: anterior, concavity, cone beam computed tomography, dental implant, mandible

INTRODUCTION

The use of removable dentures in the mandible with total or partial edentulous is not sufficient comfort, function and aesthetics for the patient. The mandibular two-implant-retained overdenture prosthetic, in case of insufficient stability and retention of complete denture has become a standard treatment protocol [1]. The interforaminal region is considered a reliable area for placing dental implants in the mandible. In this region, there are important neurovascular structures such as lingual foramen, incisive canal, mental foramen, and anterior loop. The sublingual branch of lingual artery, the submental branch of facial artery, and the incisive branch of inferior alveolar artery anastomosis in the anterior mandible [2-4]. This rich vascular plexus courses nearby the lingual cortex in interforaminal region. The perforation in lingual cortex and consequently a vascular damage may develop in this region during dental implant placement or other surgical interventions, especially in presence of concavity. The severe hemorrhage, upper respiratory tract obstruction and hematoma on the mouth floor may develop as a result of the vascular damage [3,5-8]. Up to 24% of hemorrhage complications have been reported after implant placement [9]. Although the minimal perforation developing in lingual cortex has been previously considered to be benign, it has been observed that the hematoma developing on the mouth floor may reach severe levels. Moreover, mycotic pseudoaneurysms, which result in rupture of the internal carotid artery and lingual arteries, are also very rare complications [10,11]. Severe bleeding can occur during the procedure, minutes or 6-7 hours later [2, 12-14].

The clinical palpation of alveolar crest offers limited information in the presence of concavity [15,16]. In examination with intraoral film and panoramic radiography, however, the buccolingual dimension cannot be assessed. It is necessary to use the cross-sectional imaging methods such as cone beam computed tomography (CBCT) in order to obtain detailed information about the volume and morphology of bone and relationship of tooth root with neurovascular structures [3,4,17].
In the present study, it was aimed to determine the prevalence of lingual concavity in interforaminal region and to detect relationship of concavity with gender and dentate status.

MATERIALS AND METHODS

The approval for the present study was obtained from the Clinical Research Ethics Committee of Ondokuz Mayıs University (B.30.2.ODM.0.20.08/795-900). In this study, the images of 106 patients undergone CBCT for dental implant or having loss of teeth in mandible between 2016 and 2017 in Department of Dental and Maxillofacial Radiology Department of Faculty of Dentistry of Ondokuz Mayıs University were retrospectively examined. The images containing pathological formations such as cyst, tumor and etc. in interforaminal region were not involved in analyses. All the CBCT images were obtained from Galileos (Sirona Dental Systems, Bensheim, Germany) device with parameters of 98 kVp, 15-30 mA, 15x15 mm image area, 2-5 sec. irradiation and 14 sec. scanning. The synchronous reconstruction was performed by using SIRONA Sidexis XG 2.61 viewer software with isotropic voxels having 12-bit grey-scale depth and 0.25 mm^3 size. All the examinations and measurements were performed using 27” LCD monitor (3.7 MP, 68 cm, 2560 x 1440 resolution)(The RadiForce MX270W, Eizo Nanao Corporation, Ishikawa, Japan) under low level of illumination. In cross-sectional images, the height, width and morphology of the bone were evaluated in the anterior region of the mandible. To standardize the measurements, the region 4-6 mm anterior of the mental foramen was examined. The bone in the anterior region was classified as type I lingual concavity, type II inclined to lingual, type III enlarging towards labiolingual and type IV buccal concavity (Figure 1). The parallel lines were drawn tangentially to the most buccal and most lingual point of the cortical bone. The distance between parallel lines was determined as the maximum bone width. The distance between the tip of alveolar crest and the cortical border of mandibular inferior was recorded as the maximum bone height. The horizontal distance at the deepest point of concavity was noted as concavity depth. The angle between mandibular inferior cortical border and lingual cortex (for type I and type II, the most lingual point was referenced) was determined as lingual slope angle. The slope angle of the lingual concavity was determined as the lingual concavity angle (for type I) (Figure 2).

Statistical analyses

The data obtained from the examined images were analyzed using SPSS 20.0 (Statistical Package for Social Sciences) for Windows. Data were presented as mean ± SD and frequency. The relationship between bone types and age, gender, and dentate status was analyzed using the chi-square test. The paired sample t-test was used for determining the relationship between height and width of bone and age/gender. The p value 0.05 was considered to be statistically significant.

RESULTS

Of the patients, 45 (42.45%) were male and 61(57.55%) were female. The mean age of the patients was 55.7 ± 10.31 years (range, 23–77). In interforaminal region, 37 of the patients were edentulous, 58 were partially edentulous, and 11 were dentate. The shape of the anterior mandible was classified into four types, as shown in Fig 1. Of the patients, 4.7% had type I, 16.5% had type II, 77.9 % had type III and 0.9% had type IV bone morphology. Type III was the most common type in both gender and dentate status. Type I was more common in females and type II was more common in males (Table 1). There was a significant relationship between the bone type and gender (p=0.005). Type I was more common in dentate patients and type II was more common in edentulous patients. There was a significant relationship between the bone type and dentate status (p=0.000; Table 1).

Patients were divided into 3 groups as <40, 40-59 and> 59 according to age. Type I and II were most frequently> 59 years, type III was the 40-59 age. There was a significant relationship between the bone type and age (p=0.019; Graphic 1).

The maximum bone height in male and female ranged from 18.65 to 37.32 mm and from 13.29 to 32.92 mm, respectively. The maximum bone width in male and female ranged from 9.33 to 16.31 mm and 8.60 to 18.47 mm, respectively. The bone height and width in male was significantly greater than in female (p<0.05; Table 2). The bone height in dentate patients was significantly greater than in edentulous patients (p<0.05; Table 2).

Type I and type IV concavity depth were 2.09 ± 0.34 mm and 4.02 ± 1.28 mm, respectively. In type I, the lingual slope angle was 70.59 ± 4.10º and the lingual concavity angle was 76.5 ± 3.69º. In type II, the lingual slope angle was 66.02± 6.58º.

DISCUSSION

The objective of this study is to explain the size and morphology of the mandible in order to guide the surgical interventions by using CBCT data of 106 patients. The interforaminal region is considered as a safe region for placing a dental implant in the mandible. However there are important neurovascular structures and blood vessels, considered to be 1-2 mm in diameter in the region. From these vessels, approximately half a liter of blood can be drained in 30 minutes [18]. Severe postoperative complications were also reported for this region [12,13,19-21].

Although the life-threatening complications were not frequently seen, they should be taken into consideration before the surgical interventions planned for this region [16-22]. Therefore in surgical procedures such as implant placement, the surgeon should have extensive knowledge of the shape and size of the bone.

The panoramic radiography can be utilized for the preliminary examination in order to obtain information about the bone height and, to a certain extent, the horizontal distance. However, the 2D information provided has specific disadvantages such as distortion and magnification in images [15-23]. In studies comparing the computed tomography (CT) and panoramic radiography, the bone height was statistically significantly greater in panoramic radiography [24-27]. These studies emphasize the importance of 3D imaging methods in accurately measuring the vertical dimension. In many studies, CT or CBCT evaluation has been suggested before implant placement in the interforaminal region [17,28,29]. Also in a study comparing CT and CBCT, reported that the error rate in CT (6.6%, 8.8%) was higher than CBCT (2.3%, 4.7%)[30]. Therefore, evaluation with CBCT can be more reliable.

Quirynen et al. [31] and Watanabe et al. [15] investigated the anterior mandible using CT. Quirynen et al. [31] reported, type III was the most common (69.5%), followed type II (28.1%). They [31] stated that lingual concavity prevalence is 2.4%. Watanabe et al. [15] reported the prevalence of lingual concavity 8% and buccal concavity 74%. In this study, lingual concavity is more common (4.7%) than Quirynen et al. [31], the buccal concavity was less (0.9%) than Watanabe et al. [15].

Nickenig et al. [32] evaluated the bone morphology in the mandibular canine-1. premolar region with CBCT and found a lingual concavity in 14.4%. They [32] stated that the lingual concavity was less frequently in the edentulous mandible. In our study, Nickenig et al. [32] unlike, 70% of the patients with lingual concavity were dentate. However, in some studies declared that the dentate status and bone morphology are not related [33,34]. The differences between the lingual and buccal concavity prevalence values reported in different studies can be explained with the racial and class differences and dentate status.

The risk of lingual perforation is high when placing the implant in case of lingual concavity (type I). Also, if a large diameter (5 mm) implants are placed where bone volume is not sufficient, the risk increases more [22,35]. Therefore, narrow diameter implants, such as 3 mm, is recommended to prevent perforation in the lingual concavity [22,32]. If an implant of less than 3 mm diameter is used, the implant length must be longer to increase the load resistance. However, long implants may increase the possibility of reaching the artery and most cases of hemorrhage have been reported in cases using ≥15 mm implant [2,3,13,36]. For this reason, Givol et al. [37] suggested short implants (14 mm or less) in the mandibular canine region.

There is also a risk of lingual peforation in type II bone morphology and depends on the degree of lingual slope. In cases with buccal concavity perforation may develop while implant placement, as in lingual concavity.

Previous studies reported the prevalence of lingual concavity in the posterior mandible ranged from 32.5% to 80%, higher than the anterior region [16,35,38-40]. Moreover, the risk of lingual perforation also varies in anterior and posterior region. The branches of major arteries in the anterior mandible (submental and sublingual arteries) might be closer to the mouth floor. Since there are no important vital structures in the posterior (submandibular gland and lymph node), immediate severe bleeding and nerve damage are not expected there is a perforation above the mylohyoid ridge [41]. Due to this anatomical difference between the anterior and posterior mandible, the determination of lingual concavity in the anterior is more important. Already severe bleeding has been reported more frequently in the anterior region [4,42].

Nickenig et al. [32] detected minimal bone width in lingual concavity (type I, 7.6 mm). Similarly, the minimum bone width values were observed in lingual concavity (11.2 mm). Quirynen et al. [31] and Nickenig et al. [32] reported the lowest bone height in type of bone enlarging to labiolingual direction (type III, 26.8 mm and 26.9 mm, respectively,). On the contrary with these results, the minimum bone height was observed in type of bones inclined to lingual (type II, 23.5 mm).

The lingual concavity depth was reported 6 mm by Quirynen et al. [31] and 0.8 mm by Nickenig et al. [32]. In our study, this value was 2.09 mm. In cases where the depth of the concavity was more than 2 mm, a high amount of lingual perforation has been reported [32].

In Quirynen et al. [31] and Nickenig et al. [32] study, lingual concavity angle was 84.4º and 84.4º, respectively. However, the angle was lower in this study. (76.5º). When the relationship of lingual concavity angle with gender is evaluated, Herranz-Aparicio et al. [39] found higher values in female (+5º), in contrast, Chan et al.[16] detected higher values in male (+3º). We measured higher in male (+6º), similar to Chan et al. [16].

Quirynen et al. [31] reported the lingual slope angle in type II as 67.6º. Our result were very close to Quirynen et al. [31]. (66.02º) The degree of slope guides the osteotomy before implant placement. Therefore in type II, the risk of perforation is related to the lingual slope angle and when the lingual slope decreases (the smaller slope angle), the risk of perforation increases [31].

CONCLUSIONS

Consequently buccal and lingual concavity may be seen in the interforaminal area. Detecting the concavity in this region is very important to prevent the perforation occurring during the surgical interventions and the consequent neurovascular damage and infection. Considering the risks, CBCT should be used in addition to panoramic radiography in cases of lingual or buccal concavity and lingual inclination.

This cross-sectional study was reviewed and approved by the Ethics Committee for Human Research of the University of 19 Mayıs. (B.30.2.ODM.0.20.08/795-900) mention under heading of ethical approval.

Human rights statements: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Conflict of Interest Mesude ÇITIR, Kaan GUNDUZ and Pelin KASAP declare that they have no conflict of interest.

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Table 1. Distribution of bone types by gender and dentate status

	Male	**Female**	**Dentate**	**Edentulous**
Type I	1.11%	7.38%	5.34%	3.7%
Type II	24.44%	10.65%	4.58%	35.8%
Type III	73.55%	81.15%	88.56%	60.5%
Type IV	0.9%	0.82%	1.52%	-

Table 2. Measurements of mandibular dimension and lingual-buccal concavity

	maximum bone width (mm)	**maximum bone height (mm)**	**lingual slope angle(°)**	**lingual concavity angle (°)**	**concavity depth(mm)**
Type I	11.2±1.55	25.6±3.49	70.59±4.10	76.5±3.69°	2.09±0.34
Type II	13.6±1.42	23.5±4.74	66.02±6.58		
Type III	12±1.57	27.3±3.98			

Type IV	17.19±1.28	31.89±0.37			4.02±1.28
Female	11.72±1.57	26.02±3.77	67.26±7.29	75.98±3.19	2.86±0.47
Male	12.99±1.70	28.19±4.86	66.54±4.75	81.9	6.61±1.81
Dentate	12.06±1.79	28.85±3.40	70.36±3.8	77.88±3.43	3.82±1.77
Edentulous	12.59±1.60	23.86±4.05	65.37±6.29	73.53±0.5	2.54±0.14

Graphic 1. Distribution of bone types by age

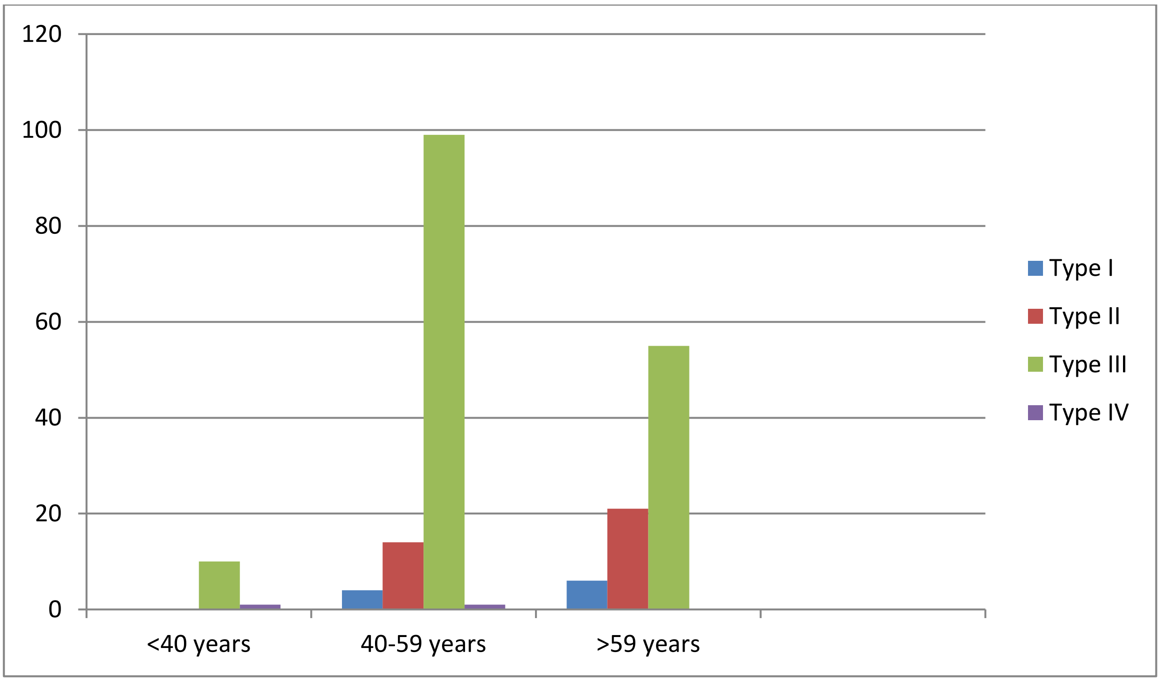
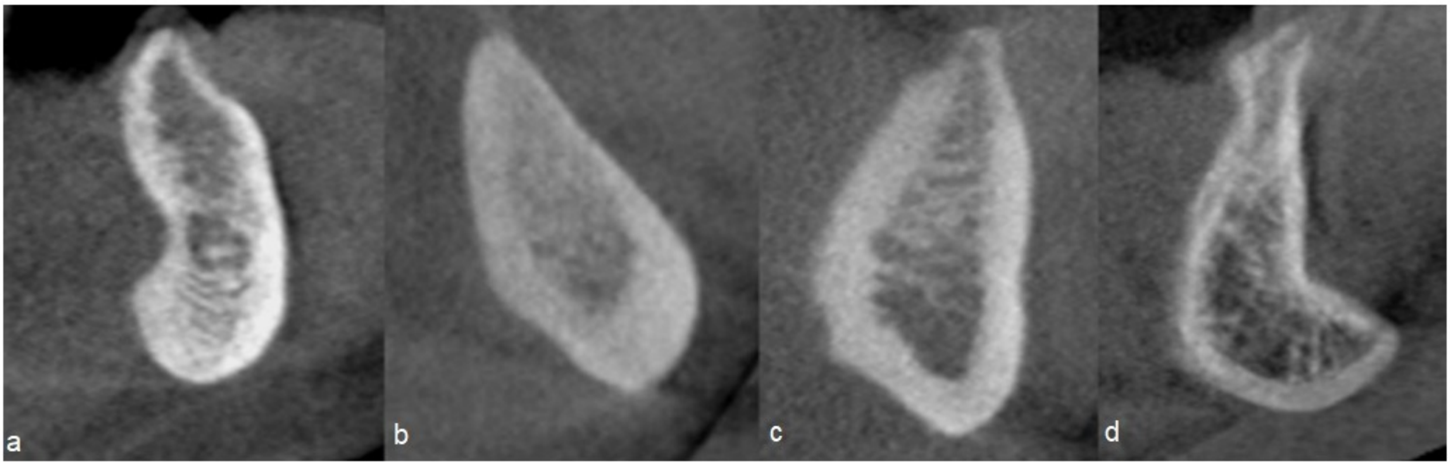


Figure 1. Cross-sectional CBCT images representing the mandible shapes: (a) type I lingual concavity (b) type II inclined to lingual (c) type III enlarging towards labiolingual (d) type IV buccal concavity.

Figure 2. Schematic representation of the CBCT images for the measurement of bone type I, II, III and IV, recpectively.


a
b
c
d


width
height
concavity depth
slope angle
concavity angle
A
width
height
slope angle
B
width
height
C
width
height
concavity depth
D