

EVALUATION OF LINGUAL MANDIBULAR DEPRESSION OF SUBMANDIBULAR SALIVARY GLANDS AND ITS RELATION TO INFERIOR ALVEOLAR CANAL USING CONE BEAM COMPUTED TOMOGRAPHY IN MALAYSIAN POPULATION: A CROSS SECTIONAL STUDY

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ABSTRACT

Introduction: In the forensic field, different races or ethnicity present various skeletal status or skull pattern, which aid in racial identification.

Objectives: Our study evaluated the deepest lingual concavity depth in the posterior region of the mandible, and its relation to the inferior alveolar canal using cone beam computed tomography (CBCT), and to associate the findings to different gender, age, and race in Malaysia.

Material and methods: A retrospective analysis of 384 CBCT scans was done on both left and right sides of the mandible. Position of the deepest lingual concavity depth was evaluated in relation to the inferior alveolar canal, and categorized into 3 groups: above the canal, at the same level as the canal, and below the canal. Analysis was carried out for different gender, age groups, and races in Malaysia.

Results: The mean age of the study participants was 36.6 ± 14.6 years, and there was no significant relationship between the deepest lingual concavity depth and age. The mean lingual concavity depth was 2.23 ± 0.76 mm in male subjects, and 1.74 ± 0.61 mm in female subjects. The mean lingual concavity depth was highest in Indian (2.20 ± 0.73 mm), followed by Malay (2.00 ± 0.73 mm), and Chinese (1.80 ± 0.69 mm) populations.

Conclusions: Due to variations in the depth and the risk of penetration, with decision made solely on lingual concavity depth and its relation to the inferior alveolar canal, the assessment of implant fixture site is recommended to be done on a case-by-case basis during pre-operative planning for dental implant surgery.

Key words: dental implants, mandible, salivary glands, inferior alveolar canal, cone beam computed tomography.

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INTRODUCTION

In recent years, dental implants have been widely considered as a viable option to replace missing teeth [1-3]. 76.2% of Malaysian population is aware of dental implants for management of missing teeth [4]. For implants to become successful, proper investigation and treatment planning must be carried out thoroughly, especially on a few important anatomical landmarks, such as lingual concavity and position of inferior alveolar canal, where the inferior alveolar nerve passes through the mandibular foramen into the mandibular bone and exits at the mental foramen [1, 2, 5]. Submandibular gland is found in

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the lingual concavity, between posterior and anterior bellies of digastric muscle, and thus lingual concavity inferior to the mandible is also known as submandibular gland fossa [6]. The lingual concavity and inferior alveolar canal act as a limiting structure in determining the length of dental implant fixture [7, 8].

With lingual concavity being the risk factor, errors made during surgical placement of dental implant can lead to lingual plate perforation, which result in various complications ranging from local edema to life-threatening events. Lingual nerve injury resulting from perforation above mylohyoid muscle can cause loss of general sensation at anterior 2nd/3rd of the tongue. Injury to inferior alveolar canal may cause irreversible neurosensory disturbances, such as loss of vitality of teeth and numbness of the chin in the affected quadrant. Hemorrhage and infection can also occur due to perforation of sub-mylohyoid space, or even parapharyngeal spaces, leading to upper airway obstruction [1, 2, 9].

There are a few methods of assessing surgical sites of the implant, including palpation, diagnostic cast, and osteometry [2, 3]. However, radiographic assessment is still more reliable, as the methods mentioned above are limited to the area above the floor of the mouth, which failed to provide sufficient information on the anatomical variation and morphology of the mandibular bone. Although panoramic radiograph can evaluate the implant length, it cannot provide information on buccolingual dimensions. To minimize complications, three-dimensional radiological techniques are recommended, and various techniques available include computed tomography (CT) and cone beam computed tomography (CBCT). Both CT and CBCT allow cross-sectional analysis and three-dimensional reconstruction; however, CBCT offers lower radiation dose and greater accuracy compared with CT [3, 9, 10]. Furthermore, in the forensic field, different races and ethnicities show different skeletal status or skull pattern, helping racial identification [11, 12]. Mandible is next to pelvis in determination of gender, age, and race [13].

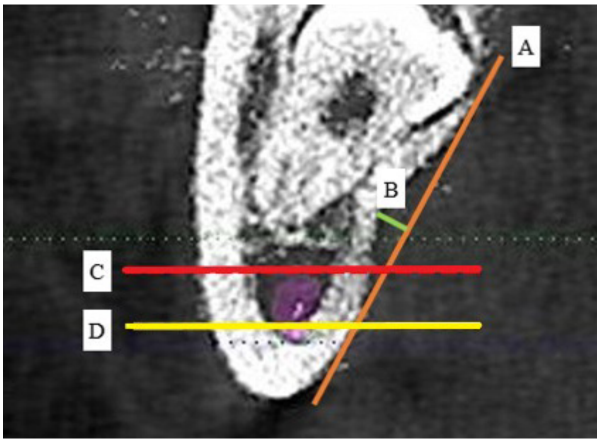

FIGURE 1. Lingual concavity depth measurement on cross-sectional reconstructed images of cone beam computed tomography scans and the level of depth in relation to the level of inferior alveolar canal. Line A – from the upper to lower bony prominences of concavity. Line B – perpendicular to line A from the deepest lingual concavity and distance measured. Lines C and D – superior and inferior borders of the inferior alveolar canal

OBJECTIVES

In the present study, the primary objective was the evaluation of lingual concavity depth in the posterior region of mandible and its relation to inferior alveolar canal as well as variations in Malaysian races, ages, and genders using CBCT scans. Secondary objective was to determine differences between right and left lingual concavity depth of the posterior mandible. Our null hypothesis was: There is no difference in the deepest lingual concavity depth in the posterior mandible in relation to the inferior alveolar canal with respect to different age group, races, and genders in Malaysian population as well as there is no difference between the right and left lingual concavity depth in the posterior mandible.

MATERIAL AND METHODS

A cross-sectional retrospective study was performed on 384 CBCT scans of randomly selected patients, who visited International Medical University, Oral Health Centre (IMU OHC) from 2011 to 2019. CBCT scans were selected by generating random numbers in a spreadsheet (Excel, Microsoft Corp.). Sample size was calculated at 95% confidence interval with power of 80%, and margin of error of 0.05, which closely represented the Malaysian population [14]. Radiographers at IMU OHC anonymized patients details to avoid bias. Both sides of the mandible in each scan was analyzed, resulting in a total of 768 sites. Patients aged from 18 to 80 years, either dentulous or edentulous were selected. However, patients with congenital syndrome, history of trauma and any pathology, exostosis, and surgical intervention in the posterior mandibular area were excluded. Also, CBCT scans, which were not clear and contained implants or other foreign bodies that could produce an artefact were not included. The Joint Committee of Research and Ethics approved the study, with project ID: BDS I-01/2019 (09). Prior to the research, informed consent was acquired from all selected patients.

CBCT images were obtained with KaVo 3D eXam, following strict and standardized exposure, and patient positioning protocol. Exposure parameters were 120 kVp, 26.9 s, 5 mA, voxel size of 0.25 mm, and field-of-view 16 cm x 13 cm. Patients were placed in a horizontal position, and stabilized by chin supporters and custom-made head bands to ensure stable position during scanning procedure.

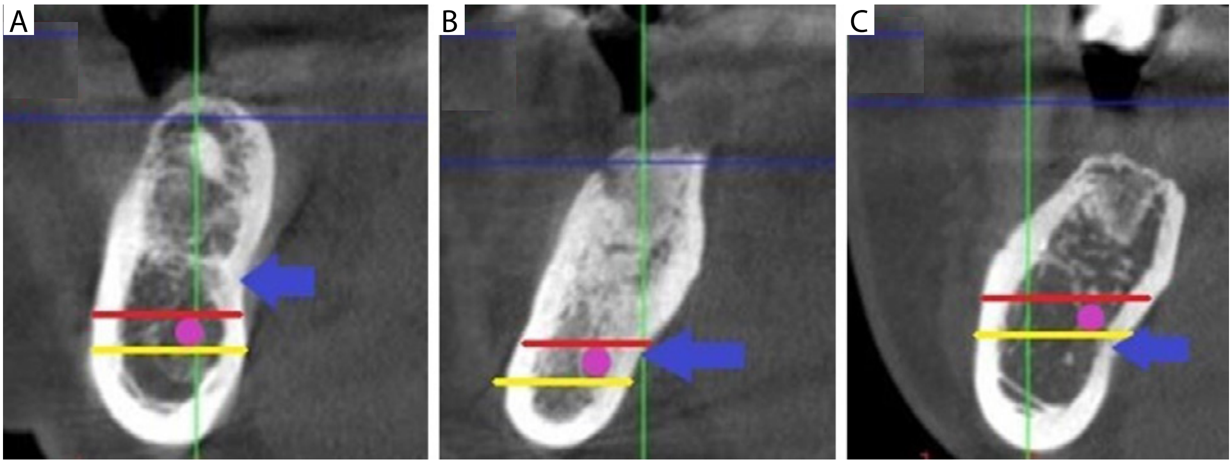

FIGURE 2. Cross-sectional image showing relation of the deepest lingual concavity depth: above inferior alveolar canal (**A** – blue arrow), at the level of inferior alveolar canal (**B** – blue arrow), and below the level of inferior alveolar canal (**C** – blue arrow)

eXamVision software was used to evaluate CBCT images, and all volumes were oriented in a standard way before measurements. Panoramic, sagittal, axial, and cross-sectional images were reconstructed for the mandible. Inferior alveolar canal was identified, and color marked. Measurements were performed in every cross-sectional image between the 1st premolar to 2nd molar region. The scan that portrayed the deepest lingual concavity was measured in cross-sections at 1 mm interval, with 1 mm thickness from mesial of 1st premolar to distal of 2nd molar. Then, a line (line A) was drawn from the upper to lower bony prominences of the concavity, as shown in Figure 1. Another line (line B) was drawn perpendicular to line A from the deepest lingual concavity, and the distance was measured, while lines C and D were drawn to mark the inferior alveolar canal level. The deepest lingual concavity was compared with the color-marked inferior alveolar canal to evaluate its position: above line C (Figure 2A), between lines C and D (Figure 2B), or below line D (Figure 2C). The analysis was carried out for left and right sides of the mandible.

Examiners were calibrated to use only cross-sectional images to measure the deepest lingual concavity and its relation to the inferior alveolar canal. However, they were allowed to freely change between the 1 mm interval of cross-sectional images to measure the deepest lingual concavity. All the data were repeated twice to obtain the mean as the final measurement. The examiners were standardized to identify the lingual concavity and its location in relation to inferior alveolar canal on 10 CBCT scans not included in the study using kappa analysis. The results were compared to ensure kappa value of more than 90% to confirm inter-examiner reliability in obtaining similar depth between the two examiners.

SPSS Statistics software version 27.0 was applied for data analysis. Descriptive statistics were done for each variable, with mean and standard deviation calculated. For comparison between the difference in depth among races and its relation to the inferior alveolar canal, χ^2 test and one-way ANOVA test were performed. To compare differences between our results and results from another studies, one sample *t*-test was also performed.

TABLE 1. Mean lingual concavity depth among different age groups for each side of the mandible

	n	Age group	Mean ± SD (mm)	*p*-value
RCD	176	18-29	2.04 ± 0.74	0.086
	108	30-45	1.99 ± 0.65	
	61	46-60	1.79 ± 0.64	
	39	> 60	2.12 ± 0.85	
LCD	176	18-29	2.03 ± 0.71	0.073
	108	30-45	1.94 ± 0.73	
	61	46-60	1.75 ± 0.70	
	39	> 60	2.02 ± 0.91	

RCD – right concavity depth, LCD – left concavity depth

RESULTS

The study population consisted of 154 Chinese, 115 Malay, and 115 Indian individuals. 51.3% were male and 48.7% were female participants. The population was divided into the following age groups: 18-29 years (45.8%), 30-45 years (28.1%), 46-60 years (15.9%), and above 60 years (10.2%). The mean lingual concavity depth on the right and left sides of the mandible were 1.99 ± 0.72 mm and 1.96 ± 0.74 mm ($p > 0.531$), respectively. The range of intra-examiner agreement for different variables was 0.90-0.92.

Table 1 shows the mean lingual concavity depth for each age group, and the comparison among different age groups for each side of the mandible. There was no significant difference in the lingual concavity depth among the age groups for each side of the mandible. There was a significant difference in the lingual concavity depth between males and females for each side of the mandible, as shown in Table 2. The deepest lingual concavity on both sides of the mandible were located above the canal, and no significant difference was found in the level of inferior alveolar canal among the different age groups for each side of the mandible. The mean lingual concavity depth for the Indian population was the highest compared with other races in Malaysia, which was 2.20 ± 0.73 mm (Figure 3A), followed by 2.00 ± 0.73 mm in Malay (Figure 3B) and 1.80 ± 0.69 mm in Chinese individuals (Figure 3C). Table 3 shows the mean depth of the lingual concavity for each side of the mandible according to races in Malaysia. For both sides of the mandible, the mean depth of lingual concavity was found to be significant among races ($p < 0.05$). Therefore, further analysis was performed to compare two races. All combinations were significant, except for Malay and Indian population on the right side of the mandible, as shown in Table 4.

Comparing mean values from other races and nationality using one sample *t*-test, the results demonstrated significant differences, as shown in Tables 5 and 6. Figure 4 and Table 7 demonstrate the relation of the deepest lingual concavity to the location of the inferior alveolar canal for both sides of the mandible in different races.

Most of the subjects had their deepest lingual concavity located above the inferior alveolar canal. The relation of the deepest lingual concavity to the location

TABLE 2. Mean lingual concavity depth in males and females for each side of the mandible

	n	Gender	Mean ± SD (mm)	*p*-value
RCD	186	Male	2.26 ± 0.74	< 0.01*
	198	Female	1.75 ± 0.60	
LCD	186	Male	2.21 ± 0.79	< 0.01*
	198	Female	1.73 ± 0.61	

**Statistical significance, p < 0.05*
RCD – right concavity depth, LCD – left concavity depth

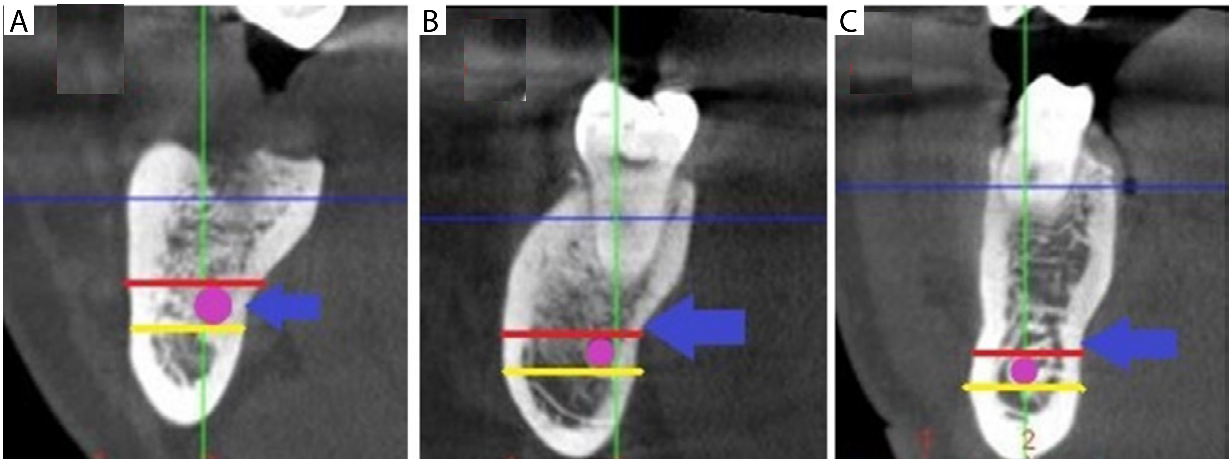

FIGURE 3. Cross-sectional image showing the deepest lingual concavity depth for Indians (**A** – blue arrow), Malays (**B** – blue arrow), and Chinese (**C** – blue arrow)

TABLE 3. Mean of lingual concavity depth in different races and comparison among races for each side of the mandible (one-way ANOVA test)

	n	Race	Mean ± SD (mm)	*p*-value
RCD	154	Chinese	1.83 ± 0.66	< 0.01*
	115	Malay	2.00 ± 0.72	
	115	Indian	2.20 ± 0.75	
LCD	154	Chinese	1.77 ± 0.71	< 0.01*
	115	Malay	2.00 ± 0.75	
	115	Indian	2.20 ± 0.70	

**Statistical significance, p < 0.05.*
RCD – right concavity depth, LCD – left concavity depth

TABLE 4. Mean of lingual concavity depth and its comparison between two races for each side of the mandible (one-way ANOVA test)

	n	Age group	Mean ± SD (mm)	*p*-value
RCD	269	Chinese and Malay	1.90 ± 0.69	0.04*
	269	Chinese and Indian	1.20 ± 0.72	< 0.01*
	130	Malay and Indian	2.10 ± 0.74	0.05
LCD	269	Chinese and Malay	1.86 ± 0.74	0.02*
	269	Chinese and Indian	1.95 ± 0.74	< 0.01*
	130	Malay and Indian	2.09 ± 0.73	0.03*

**Statistical significance, p < 0.05.*
RCD – right concavity depth, LCD – left concavity depth

TABLE 5. Comparison of mean values between Malaysian and population from other countries within the same races (one sample *t*-test)

Race	Mean ± SD (mm)	Population from other studies	Mean ± SD (mm)	*p*-value
Chinese, Malaysia	1.80 ± 0.69	Chinese, Taiwan (Huang *et al.*)	5.4 ± 1.9	< 0.01*
Indian, Malaysia	2.20 ± 0.73	Indian, India (Vhatkar *et al.*)	2.0 ± 2.11	< 0.01*

**Statistical significance, p < 0.05*

TABLE 6. Comparison of mean values in different nationalities: between Malaysian and Caucasian and African-American (one sample *t*-test)

Population	Mean ± SD (mm)	Population from other studies	Mean ± SD (mm)	*p*-value
Malaysia	1.98 ± 0.53	Caucasian and African-American (Chan *et al.*)	2.40 ± 1.10	< 0.01*

**Statistical significance, p < 0.05*

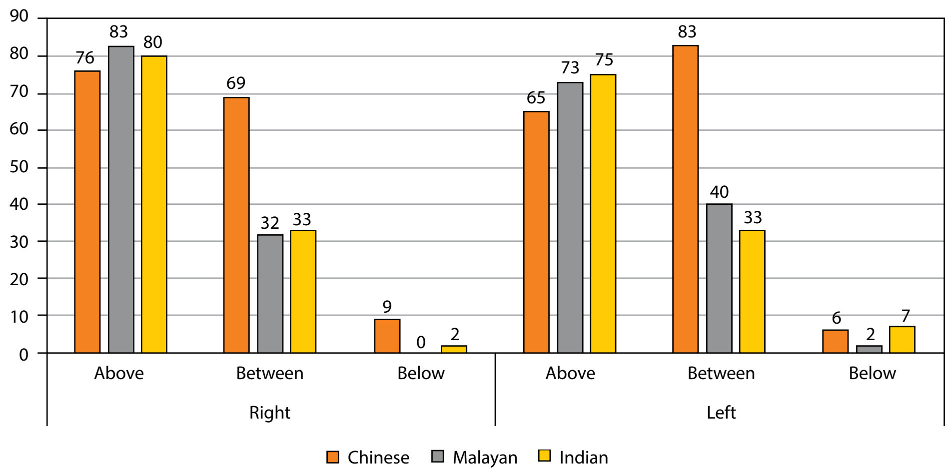

FIGURE 4. Relation of the deepest lingual concavity to the location of inferior alveolar canal in Chinese, Malay, and Indian population in Malaysia (χ^2 test)

of inferior alveolar canal among the three races was again found significant ($p < 0.05$), except for Malays and Indians.

DISCUSSION

Lingual concavity on the posterior mandible and the position of inferior alveolar canal are the limiting structures for determination of the correct dental implant diameter and length. A study conducted on anticipation assessment for simulated implants to cause lingual plate perforation, and results shown that the greater the concavity depth, the greater the probability of lingual plate perforations ($p < 0.001$). It was also observed that a concavity depth of 7.0 ± 1.7 mm caused perforation, whereas a depth of 5.0 ± 1.7 mm did not [15]. In this study, the maximum lingual concavity depth was 5.02 mm, so it could mean that a large part of Malaysian population would be in the safe zone.

In the current study, it was found that there was no relation between age and lingual concavity depth. This indicates that the lingual concavity depth is consistent, and there is no change according to age. Other studies also did not observe any significant differences between age and lingual concavity depth [2, 6, 16]. The mean lingual concavity depth was significantly lower in female subjects than in male subjects in other studies [2, 3, 17]. In the current study, the mean lingual concavity depth was 2.23 ± 0.76 mm in male subjects and 1.74 ± 0.61 mm in female subjects. These results indicate that thickness and width of the bone at the deepest lingual

TABLE 7. Statistical difference of relation of deepest lingual concavity to location of inferior alveolar canal

	p-value	
	Right	Left
Chinese and Malay	< 0.01*	< 0.01*
Chinese and Indian	< 0.01*	< 0.01*
Indian and Malay	0.36	0.18

**Statistical significance, p < 0.05*

concavity were less in male subjects compared with female subjects in Malaysian population. In another group of studies, the mean lingual concavity depth was 2.4 ± 1.1 mm, 2.0 ± 2.11 mm, and 2.73 ± 1.43, respectively, showing no significant difference between gender and lingual concavity depth [5, 6, 18]. The mean lingual concavity depth for this study was 1.98 ± 0.73 mm, and this result was smaller than those of other studies [6, 9]. The difference in the current study could be due to different measurement methods, imaging techniques, racial differences, and presence or absence of the teeth [2, 6, 19, 20]. Moreover, the lingual concavity depth of the posterior mandible was significantly influenced by race ($p < 0.05$). The concavity was the deepest in Indians, followed by Malays and Chinese for both sides of the mandible. This indicates that the width and thickness of the posterior mandibular bone are less in Indians, followed by Malays and Chinese. It could also mean that Indians have the biggest submandibular gland, which is in that fossa. Different races also have different structural variations or facial morphology, as described in previous studies [11, 12, 19].

In comparison with other studies, there were significant differences within the same race between Malaysian Chinese and Taiwanese Chinese [15], and Malaysian Indian and India's Indian [6]. This result could be due to different ethnicity outcomes from globalization and inter-marriages as well as different gender and age.

Furthermore, comparing different nationalities, there is important variation between Malaysian and Caucasian and African-Americans [9]. All these differences may be due to various reasons, including differences in gender, aging effect, and different types of imaging modalities used, for example, utilization of CT scanning [15]. Presence or absence of the teeth in the jaw would also affect the results, as edentulous mandible has a smaller vertical dimension of the bone comparing with dentulous mandible [1].

Regarding the level of the deepest lingual concavity depth in relation to the location of the inferior alveolar canal, results from other studies are consistent with the current study, in which the deepest lingual concavity depth was mostly located above the canal [2]. However, there is no significant difference between Malays and Indians. When dental implant is generally recommended to be placed with at least 1.5 mm above the inferior alveolar canal, optimal anatomical knowledge of the region is essential for prevention of penetration of the lingual plate during implant placement [2, 9].

There were no significant differences observed between left and right sides of the mandible, which was consistent with findings of other studies indicating that right or left side of the mandible has no effects on the discussed variables [2, 3].

Limitation of the study is that all the patients included were healthy. In future studies, concavity measurements can be performed in patients with a history of systemic diseases, such as diabetes mellitus and osteoporosis to measure their impact. Additionally, difference in concavity measurements of edentulous and dentulous patients could be considered as a future point of research.

CONCLUSIONS

Following conclusions were drawn according to the results of the current study. Deepest lingual concavity was located above the inferior alveolar canal on both sides of the mandible, with no significant difference in the level of the inferior alveolar canal among different age groups and gender for each side of the mandible. The deepest concavity was noticed in the second molar area, with significant difference in degree of concavity between the left and right first and second molars and dimensional measurements. There was no significant difference in the degree of concavity; however, there was significant sex- and age- related variations in dimensional measurements of the mandible between left and right sides. To prevent surgical complications in the posterior mandible before implant placement, the lingual concavity depth and inferior alveolar canal should be carefully evaluated with CBCT.

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CONFLICT OF INTERESTS

The authors declare no potential conflicts of interest concerning the research, authorship, and/ or publication of this article.

References

1. Nickenig HJ, Wichmann M, Eitner S, Zöller JE, Kreppel M. Lingual concavities in the mandible: a morphological study using cross-sectional analysis determined by CBCT. J Craniomaxillofac Surg 2015; 43: 254-259.
2. Haghanifar S, Arbabzadegan N, Moudi E, Bijani A, Nozari F. Evaluation of lingual mandibular depression of the submandibular salivary glands using cone-beam computed tomography. J Res Med Dent Sci 2018; 6: 563-567.
3. Parnia F, Fard EM, Mahboub F, Hafezeqoran A, Gavgani FE. Tomographic volume evaluation of submandibular fossa in patients requiring dental implants. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010; 109: e32-e36.
4. Kohli S, Bhatia S, Kaur A, Rathakrishnan T. Public knowledge and acceptance of dental implant treatment in Malaysian population. J Interdiscip Dentistry 2014; 4: 76-80.
5. Velasco-Torres M, Padial-Molina M, Avila-Ortiz G, García-Delgado R, Catena A, Galindo-Moreno P. Inferior alveolar nerve

trajectory, mental foramen location and incidence of mental nerve anterior loop. Med Oral Patol Oral Cir Bucal 2017; 22: e630-e635. DOI: 10.4317/medoral.21905.
6. Vhatkar BS, Shetty NK, Waghmare MS, Pagare SS, Vahanwala SP, Santosh V. Submandibular gland fossa assessment with cone beam computed tomography. Int J Sci Stud 2019; 7: 53-57.
7. Rahpeyma A, Khajehahmadi S. Submandibular fossa augmentation in implant dentistry. J Indian Soc Periodontol 2017; 21: 207-209.
8. Salemi F, Shokri A, Forouzandeh M, Karami M, Khalili Z. Mandibular lingual concavity: a cross-sectional analysis using cone beam computed tomography. J Clin Diagn Res 2018; 12: ZC37-ZC41. DOI: https://doi.org/10.7860/JCDR/2018/35850.12190.
9. Chan HL, Brooks SL, Fu JH, Yeh CY, Rudek I, Wang HL. Cross-sectional analysis of the mandibular lingual concavity using cone beam computed tomography. Clin Oral Implants Res 2011; 22: 201-206.
10. Panjnoush M, Norouzi H, Kheirandish Y, Shamshiri AR, Mofidi N. Evaluation of morphology and anatomical measurement of nasopalatine canal using cone beam computed tomography. J Dent (Tehran) 2016; 13: 287-294.
11. Looker AC. The skeleton, race, and ethnicity. J Clin Endocrinol Metab 2002; 87: 3047-3050.
12. Krishan K, Kanchan T, Garg AK. Dental evidence in forensic identification – an overview, methodology and present status. Open Dent J 2015; 9: 250-256.
13. Thakur KC, Choudhary AK, Jain SK, Kumar L. Racial architecture of human mandible – an anthropological study. J Evol Med Dent Sci 2013; 2: 4177-4188.
14. Daniel WW. Biostatistics: A Foundation for Analysis in the Health Sciences. 7th edition. New York: John Wiley & Sons; 1999.
15. Huang RY, Cochran DL, Cheng WC, et al. Risk of lingual plate perforation for virtual immediate implant placement in the posterior mandible: a computer simulation study. J Am Dent Assoc 2015; 146: 735-742.
16. Herranz-Aparicio J, Marques J, Almendros-Marqués N, Gay-Escoda C. Retrospective study of the bone morphology in the posterior mandibular region. Evaluation of the prevalence and the degree of lingual concavity and their possible complications. Med Oral Patol Oral Cir Bucal 2016; 21: e731-e736. DOI: 10.4317/medoral.21256.
17. Magat G. Radiomorphometric analysis of edentulous posterior mandibular ridges in the first molar region: a cone-beam computed tomography study. J Periodontal Implant Sci 2019; 50: 28-37.
18. Alqahtani NM, Ajmal M, Chaturvedi S, Shariff M, Addas MK, Assiri H. Radio-morphometric analysis of lingual concavity for dental implant placement using cone beam computed tomography. Ann Med Health Sci Res 2021; 11: 1439-1444.
19. Lin MH, Mau LP, Cochran DL, Shieh YS, Huang PH, Huang RY. Risk assessment of inferior alveolar nerve injury for immediate implant placement in the posterior mandible: a virtual implant placement study. J Dent 2014; 42: 263-270.
20. Watanabe H, Mohammad Abdul M, Kurabayashi T, Aoki H. Mandible size and morphology determined with CT on a premise of dental implant operation. Surg Radiol Anat 2010; 32: 343-349.