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Original Scientific Paper

EVALUATION OF THE SUBMANDIBULAR FOSSA USING CONE BEAM COMPUTED TOMOGRAPHY

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SUMMARY – The purpose of this study was to assess submandibular fossa anatomy using cone beam computed tomography (CBCT) and to determine its relationship with dental status, age, and gender. A total of 230 patients (mean age 43.24±17.70 years; 96 males and 134 females) comprising 101 edentulous and 129 dentate patients were included. CBCT images were utilized to measure depth of the submandibular fossa (SF_{depth}) and distance from its deepest point to the mental foramen ($SF_{distance}$). Radiological characteristics of the submandibular fossa were compared with age, gender, and dental status. Analysis of 460 half-jaw mandibles revealed 239 (52%) type I, 175 (38%) type II, and 46 (10%) type III mandibles. The SF_{depth} of dentate patients (2.21±0.68 mm) was significantly greater compared to edentulous patients (1.80±0.73 mm, $p<0.001$). In both dentate and edentulous patients, the mean SF_{depth} of males (2.42±0.73 mm and 2.03±0.82 mm, respectively) was significantly greater than that of females (2.07±0.61 mm and 1.62±0.59 mm, respectively, $p<0.001$). Among dentate patients, the deepest point of the submandibular fossa was most commonly located at the level of the second molar (79.8%). Submandibular fossa was shallower in edentulous patients compared to dentate patients. SF_{depth} was greater in male patients than in female patients.

Keywords: *Submandibular fossa; Cone beam computed tomography; Mandible; Anatomy*

Introduction

Submandibular fossa is an area of depression located medially to the lower border of the mandible and below the mylohyoid line[1,2]. It contains a portion of the submandibular gland. The posterior region of the mandible, where the submandibular fossa is located, is commonly involved in various surgical interventions such as extraction of molar and premolar teeth, treatment of cyst and tumor, orthognathic surgery, and management of mandibular fractures. Moreover, during implant treatment, this region, which includes the retromolar region and ramus, is often utilized as a suitable source of bone grafts[2]. It is crucial to have knowledge about the anatomical characteristics of the submandibular fossa to avoid damaging vital structures such as the inferior alveolar nerve, as well as the submental and sublingual arteries, during surgical procedures[3].

Radiological methods, including conventional radiography, computed tomography (CT), and cone beam computed tomography (CBCT) are employed

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to assess the bony anatomy of the mandible and its posterior region. Conventional radiographs, such as panoramic radiographs, enable two-dimensional evaluation, whereas CT and CBCT allow three-dimensional evaluation[4,5]. The utilization of CBCT in dentistry is progressively growing for its benefits, such as reduced radiation exposure, being cheaper, and superior geometric resolution compared to conventional CT.

Lingual concavity of the posterior mandible is influenced by anatomical characteristics of the submandibular fossa[6]. The extent of concavity in the submandibular fossa directly correlates with the risk of perforation during tooth extraction or implant socket preparation[2]. Thus, it is crucial to assess anatomical structure of this region using radiological methods before planning surgical interventions involving the submandibular fossa. This step is essential to prevent potential complications.

This study aimed to assess the submandibular fossa anatomy in a specific Turkish population using CBCT and to determine its relationship with age, gender, and dental status of the mandible. The findings of this study provide valuable information that can assist in surgical intervention planning in this region.

Materials and Methods

The study protocol was approved by the institutional review board with a reference number 2019/742. The radiographic database of Ondokuz Mayıs University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, was utilized in this study. The requirement for informed consent was waived as this was a retrospective study.

Study design

The hospital database was retrospectively analyzed to identify patients who had undergone CBCT scans between January 2018 and August 2018 for various reasons, such as implant planning, or evaluation of impacted teeth or jaw lesions. The inclusion criteria for this study were as follows: patients aged 18 years or older; presence of complete first and second premolars and molars in the lower jaw or complete absence of these teeth in the lower jaw; absence of any developmental or pathological conditions (such as tumors, cysts, fractures or malformations) in the posterior region of the mandible; and sufficient diagnostic quality of the CBCT images. A total of 230 patients who met these criteria were included in the study. There were 129 (56.1%) dentate (presence of complete first and second premolars and molars in the lower jaw) and 101 (43.9%) edentulous (lacking first and second premolars and molars in the lower jaw) patients. Evaluation of the lower jaws was conducted separately for the right and left sides, resulting in a total of 460 half-jaws being assessed.

CBCT imaging system

The CBCT images were obtained using a dental volumetric imaging system (GALILEOS Comfort Plus, Sirona Dental Systems, Bensheim, Germany) operating at 98 kVp and 15-30 mAs. The CBCT images had a voxel size of 0.3/0.15 mm^3 isotropic, with a scanning time of 14 seconds, irradiation time ranging from 2 to 6 seconds, and a 204° rotation. Simultaneous reconstruction was performed using the SIRONA Sidexis XG 2.61 imager program, with a grayscale depth of 12-bits and 0.25 mm^3 isotropic voxel size. The length angle measurement tool was utilized from the software diagnostic tools, with a measurement accuracy of ±0.15 mm. All examinations and measurements were carried out on a 27-inch color LCD screen (RadiForce MX270W, Eizo Nanao Corporation, Ishikawa, Japan), which had a resolution of 2560 x 1440 pixels and size of 3.7 MP.

Image evaluation

The CBCT images were examined and measurements were conducted by a dentomaxillofacial radiologist under dim light conditions. Reformatted sagittal sections (cross-sectional sections) were utilized for measurements on the right and left half-jaws, specifically in the regions extending from the distal aspect of the mental foramen to the third molar tooth, which corresponds to the submandibular fossa. The following parameters were determined for measurements:

- the deepest value of the submandibular fossa in the posterior region of the mandible (SF_{depth}): a straight line was drawn tangent to the most prominent upper and lower points of the lingual mandible, starting from the distal aspect of the mental foramen and progressing posteriorly by one millimeter for each section. The largest measured value was recorded as the SF_{depth};

- classification of mandible morphology: the submandibular fossa was classified into three different types based on SF_{depth}[7]: type I was defined when SF_{depth} was less than 2 mm; type II when SF_{depth} was 2-3 mm, and type III when SF_{depth} was greater than 3 mm (Figs. 1 and 2);
- distance from the deepest point of the submandibular fossa to the mental foramen ($SF_{distance}$): distance from the distal aspect of the mental foramen to the deepest point of the submandibular fossa was measured by counting the number of slices progressed in sagittal reformat images; and
- tooth number: in dentate patients, the tooth number corresponding to the level of the deepest point of the submandibular fossa was recorded.

After a period of 3 weeks, a subset of 50 CBCT images was reevaluated by the same radiologist to assess the intraobserver reliability.

Statistical analysis

Statistical analysis was conducted using SPSS 15.0 for Windows (Chicago, Illinois, USA). Normal data distribution was assessed using Kolmogorov-Smirnov test. Cross table statistics were performed

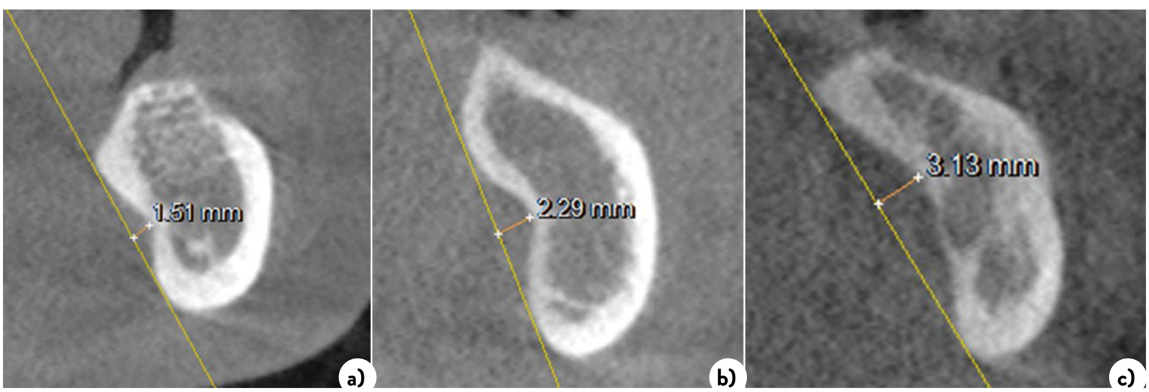

Fig. 1. Measurement of SF_{depth} in type I edentulous (a), type II edentulous (b), and type III edentulous patients (c) in cross-sectional images.

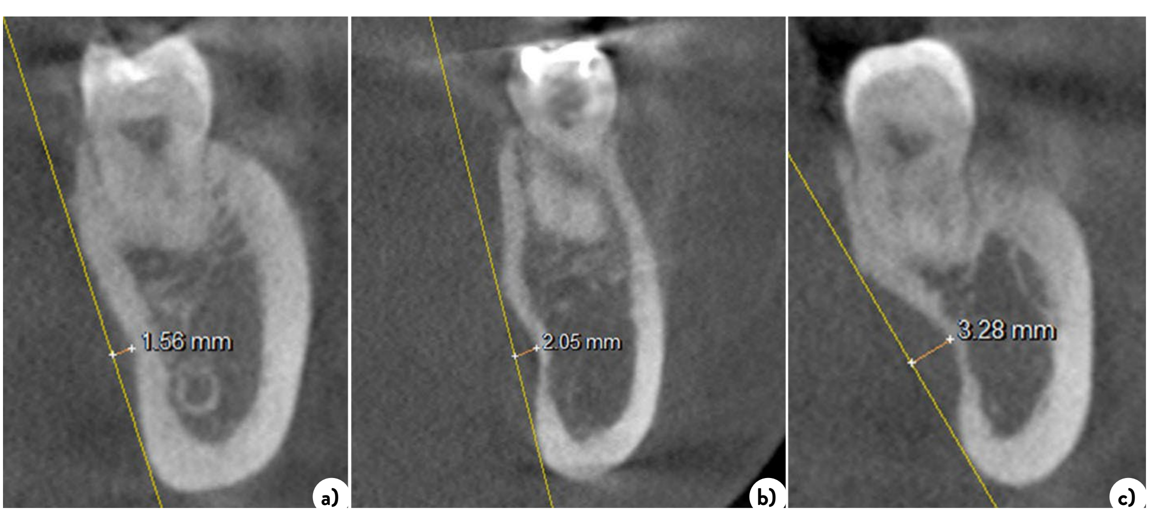

Fig. 2. Measurement of SF_{depth} in type I dentate (a), type II dentate (b), and type III dentate patients (c) in cross-sectional images.

using Pearson's chi-square test and Fisher's exact test. Student's t-test was utilized to compare continuous variables between dentate and edentulous patients. Paired samples t-test was used to compare the left and right hemi-mandibles of the patients. Intraobserver variability was assessed using the intraclass correlation coefficient (ICC). A p-value less than 0.05 was considered statistically significant in all analyses.

Results

Patient demographics

Among the 230 patients included in the study, 96 (41.7%) were male and 134 (58.3%) were female. Out of 129 dentate patients, 51 (39.5%) were male and 78 (60.5%) were female. Among 101 edentulous patients, 45 (44.6%) were male and 56 (55.4%) were female. There was no significant difference between dental status and gender (p=0.444). The mean age of the entire study population was 43.24±17.70 (range 19-99) years. Dentate patients were significantly younger than edentulous patients (mean age 30.98±10.78 years *vs.* 58.9±11.26 years; p <0.001).

A total of 460 lower half-jaws from 230 patients were evaluated using CBCT images. Among them, 258 half-jaws were dentate and 202 half-jaws were edentulous (Table 1). In the entire population, the mean SF_{depth} was 2.03±0.73 (range 0.60-4.61) mm, and mean $SF_{distance}$ was 16.16±4.94 (range 1-25) mm. Out of total half-jaws, 239 were classified as type I (52%), 175 (38%) as type II, and 46 (10%) as type III. The intraobserver agreement for all measurements was excellent, with an ICC ranging from 0.968 to 0.985.

Comparison of right and left submandibular fossa

Considering the whole study population, there was no statistically significant difference between the right and left hemi-mandibles in terms of SF_{depth} and $SF_{distance}$ (p=0.567 and p=0.287, respectively). When comparing the right and left SF_{depth} values separately for dentate and edentulous patients, no statistically significant

Table 1. Comparison of the right and left sides of the mandible in study patients

Characteristic		Total hemi-mandibles	Right hemi-mandible	Left hemi-mandible	p[a]
Dental status	Dentate	258	129 (56.1%)	129 (56.1%)	1.00
	Edentulous	202	101 (43.9%)	101 (43.9%)	
Submandibular fossa type	Type I	239	121 (52.6%)	118 (51.3%)	0.577
	Type II	175	87 (37.8%)	88 (38.3%)	
	Type III	46	22 (9.6%)	24 (10.4%)	
Tooth number	5	5	3 (2.3%)	2 (1.6%)	0.625
	6	44	23 (17.8%)	21 (16.3%)	
	7	206	101 (78.3%)	105 (81.4%)	
	8	3	2 (1.6%)	1 (0.8%)	
Whole population	SF_{depth}	2.03±0.73	2.02±0.71	2.04±0.75	0.567
	$SF_{distance}$	16.16±4.94	15.98±5.12	16.34±4.76	0.287
Dentate patients	SF_{depth}	2.21±0.68	2.19±0.65	2.23±0.71	0.462
	$SF_{distance}$	16.12±4.84	16.05±4.97	16.19±4.73	0.755
Edentulous patients	SF_{depth}	1.80±0.73	1.80±0.73	1.80±0.74	0.943
	$SF_{distance}$	16.20±5.07	15.88±5.32	16.52±4.81	0.218

[a]p value was derived from comparison of the right and left hemi-mandibles.

difference was found in either group ($p=0.462$ in dentate patients and $p=0.943$ in edentulous patients). Similarly, there was no statistically significant difference between the right and left $SF_{distance}$ values in either dentate or edentulous patients ($p=0.755$ in dentate patients and $p=0.218$ in edentulous patients).

There was no statistically significant difference between the right and left hemi-mandibles in terms of morphological classification of the mandible (types I, II, and III; $p=0.577$). The deepest point of the submandibular fossa was located at the level of 2nd premolar tooth in 5 hemi-mandibles (1.9%), at the level of 1st molar tooth in 44 hemi-mandibles (17.1%), at the level of 2nd molar tooth in 206 hemi-mandibles (79.8%), and at the level of 3rd molar tooth in 3 hemi-mandibles (1.2%). There was no significant difference between the right and left hemi-mandibles in terms of tooth number ($p=0.625$).

Comparison of submandibular fossa characteristics by gender and age

Comparison of the measured characteristics is shown in Table 2. The mean age of male patients was 46.29±18.28 (range 19-99), while the mean age of female patients was 41.05±16.70 (range 19-87; $p=0.027$). The mean SF_{depth} in male patients was 2.23±0.80 mm, whereas the mean SF_{depth} of female patients was 1.88±0.64 mm. The submandibular fossa was significantly deeper in male patients compared to female patients ($p<0.001$). There was no significant difference in $SF_{distance}$ between male and female patients (16.51±4.96 *vs.* 15.91±4.92; $p=0.196$). A statistically significant difference was observed between the submandibular fossa type and gender ($p<0.001$). Type I and type II fossa were more common in female patients, while type III fossa was more common in male patients.

Table 2. Comparison of age, SF_{depth}, $SF_{distance}$ and submandibular fossa types according to gender

Variable		**Male (N=96)**	**Female (N=134)**	**p**
Age		46.29±18.28	41.05±16.70	0.027
SF_{depth}		2.23±0.80	1.88±0.64	<0.001
$SF_{distance}$		16.51±4.96	15.91±4.92	0.196
Submandibular fossa type	Type I	82 (34.3%)	157 (65.7%)	
	Type II	75 (42.9%)	100 (57.1%)	
	Type III	35 (76.1%)	11 (23.9%)	

Table 3. Comparison of age, gender, SF_{depth}, $SF_{distance}$ and submandibular fossa type according to dental status

Variable		**Dentate patients**	**Edentulous patients**	**p**
Age		30.98±10.78	58.9±11.26	<0.001
Gender:	Male	102 (53.1%)	90 (46.9%)	0.444
	Female	156 (58.2%)	112 (41.8%)	
SF_{depth}		2.21±0.68	1.80±0.73	<0.001
$SF_{distance}$		16.12±4.84	16.20±5.07	0.865
Submandibular fossa type	Type I	105 (43.9%)	134 (56.1%)	<0.001
	Type II	119 (68.0%)	56 (32.0%)	
	Type III	34 (73.9%)	12 (26.1%)	

Table 4. Comparison of SF_{depth} and $SF_{distance}$ according to dental status and gender

	Dentate hemi-mandible			Edentulous hemi-mandible			p^c	p^d
	Male	**Female**	p^a	**Male**	**Female**	p^b		
SF_{depth}	2.42±0.73	2.07±0.61	**<0.001**	2.03±0.82	1.62±0.59	**<0.001**	**0.001**	**<0.001**
$SF_{distance}$	16.55±4.98	15.85±4.74	0.255	16.47±4.96	15.99±5.17	0.509	0.909	0.812

[a]derived from comparison of dentate male and dentate female patients; [b]derived from comparison of edentulous male and edentulous female patients; [c]derived from comparison of dentate male and edentulous male patients; [d]derived from comparison of dentate female and edentulous female patients.

Comparison of age, gender, and submandibular fossa characteristics according to dental status

Table 3 displays comparison of age, gender, fossa type, SF_{depth}, and $SF_{distance}$ based on tooth condition. Edentulous patients were found to be statistically significantly older than dentate patients (p<0.001).

Dentate patients exhibited a mean SF_{depth} of 2.21±0.68 mm, whereas edentulous patients had a mean SF_{depth} of 1.80±0.73 mm. The SF_{depth} in dentate patients was significantly greater compared to edentulous patients (p<0.001). However, there was no statistically significant difference between dentate and edentulous patients in terms of $SF_{distance}$ (p=0.865).

A statistically significant difference was found between morphological type of the mandible and tooth condition (p<0.001). Type I fossa was more frequently observed in edentulous patients, whereas type II and type III fossa were prevalent in dentate patients.

Table 4 presents comparison of SF_{depth} and $SF_{distance}$ based on dental status separately for male and female patients. In dentate patients, the mean SF_{depth} was 2.42±0.73 mm for males and 2.07±0.61 mm for females. The submandibular fossa of dentate males was significantly deeper than that of females (p<0.001). Regarding edentulous patients, the mean SF_{depth} was 2.03±0.82 mm for males and 1.62±0.59 mm for females. The submandibular fossa of edentulous males was significantly deeper than that of females (p<0.001). In terms of $SF_{distance}$, there was no statistically significant difference between male and female patients in either dentate or edentulous populations (p=0.255 *vs.* p=0.509).

Discussion

The evaluation of mandibular morphology, precise localization of important anatomical structures, assessment of bone quality and quantity are vital for ensuring successful implant placement and long-term maintenance of the implant. In this regard, pre-treatment evaluation using CBCT is widely accepted as the gold standard technique[8]. CBCT provides an effective imaging modality for treatment planning prior to implant surgery, allowing for minimization of complications and achievement of more successful outcomes[9]. Other methods, such as measuring mucosal thickness, using an osteometer, palpating the jawbone, employing various implant placement techniques, or relying on radiographs, are insufficient for accurately determining the size and location of the submandibular fossa[3,7].

Sumer *et al.* evaluated the submandibular fossa depth in CT scans of 86 partially or completely edentulous patients[10]. They found that the prevalence of type I, type II, and type III fossa was 55.2%, 28.5%, and 16.3%, respectively. They also observed that the depth of the submandibular fossa was more than 2 mm in 45% of patients, which increased the risk of lingual perforation. Additionally, they emphasized that the radiolucent appearance on panoramic radiographs was not a reliable indicator for estimating the depth of the submandibular fossa. These findings support the importance of three-dimensional evaluation using pre-implant CBCT. Moreover, their reported mean submandibular fossa depth of 1.99±0.94 was similar to the mean SF_{depth} found in our study. Additionally, the prevalence of type I fossa in their study (55.2%) was quite similar to the prevalence of type I fossa in our study (52%).

Parnia *et al.* evaluated CT scans of 100 edentulous patients and reported that the depth of the submandibular fossa was greater than 2 mm in 80% of cases[3]. They reported that 20% of the cases had a submandibular fossa depth less than 2 mm (type I), 52% had a depth between 2 and 3 mm (type II), and 28% had a depth greater than 3 mm. The maximum recorded depth of submandibular fossa was 6.6 mm. They did not find significant correlation between the depth of the fossa and age or gender. In our study, the percentage of edentulous patients with submandibular fossa depth greater than 2 mm was 33.6%, which was considerably lower compared to the findings by Parnia *et al*. Additionally, the maximum measured depth of the submandibular fossa in our study was 4.61 mm. Furthermore, we observed a significant relationship between the depth of the submandibular fossa and age, as well as gender.

Souza *et al*. examined posterior mandible of 100 patients who were missing premolars and molars[11]. They measured the depth of the submandibular fossa and reported that 19% of their patients had an undercut in the submandibular fossa, which could pose a risk during implant placement. In their study, the minimum submandibular fossa depth was 0 mm, maximum depth was 5 mm, and the mean depth ranged from 1.70 to 1.99 mm. In our study, we found a similar mean submandibular fossa depth of 1.80 mm in edentulous patients, which aligns with their findings. However, contrary to our results, Souza *et al*. did not find a significant relationship between submandibular fossa depth and gender. In our study, we observed that the submandibular fossa was significantly deeper in both dentate and edentulous male patients.

Ramaswamy *et al*. examined the depth of the submandibular fossa on CBCT images of 100 partially and completely edentulous patients[12]. Similar to our study findings, they found no significant difference in submandibular fossa depths between the right and left sides of the mandibles in either male or female patients.

Rajput *et al*. investigated submandibular fossa in 140 edentulous patients using CBCT and observed that the submandibular fossa depth in male patients was significantly greater than that in female patients, which aligns with our findings[13]. Furthermore, they report the frequencies of type I, type II, and type III fossa as 23%, 62%, and 15%, respectively. In our study, the prevalence of type I fossa among edentulous patients was found to be 56.1%.

In a study conducted by Bayrak *et al*., the depth of the submandibular fossa was measured as 2.85±0.8 mm[14]. Their study included a large sample of patients (500 individuals) comprising both dentate and edentulous individuals. In contrast to our study, they did not find a significant association between age or gender and submandibular fossa depth. However, they did observe a statistically significant difference in submandibular fossa depths between the right and left sides. Additionally, they report a prevalence rate of 55.5% for type I fossa, which was quite similar to our findings.

Nilsun *et al*. examined the submandibular fossa in pre-implant CBCT images of 112 patients[1]. According to their study, the submandibular fossa was found to be significantly deeper in patients aged over 35 years compared to those under 35 years old. In our study, we observed a weak negative correlation between age and submandibular fossa depth when considering the entire study population. However, when we analyzed dentate and edentulous patients as separate groups, no correlation was found between submandibular fossa depth and age. Our findings suggest that the depth of submandibular fossa is influenced by dental condition of the mandible rather than patient age. Furthermore, in our study, the submandibular fossa depth was significantly higher in male patients compared to female patients.

Borahan *et al*. conducted a study on the morphology of the submandibular fossa in 300 patients using CBCT images taken prior to dental implantation[6]. Similar to our study, they did not observe a significant difference between the types of right and left hemi-mandibles. Although they did not directly compare the actual depths of submandibular fossa by gender, they concluded that type I fossa was more prevalent in women, while type III fossa was prevalent in men, which aligns with our findings. Furthermore, similar to our results, they found no significant association between age and fossa type.

Yıldız *et al*. examined the submandibular fossa in 78 dry human mandibles using CT scans[15]. In their study, 73 mandibles were completely edentulous. In contrast to our findings, they report a lower incidence of type I fossa, which was found in 28.5% of cases.

İçöz *et al*. conducted a retrospective evaluation of CBCT images from 203 patients ranging in age from 18 to 77 years[16]. They report the mean depth of the submandibular fossa as 1.73±0.68 mm. They found that the mean fossa depth was greater in men (1.87±0.71 mm) compared to women (1.54±0.6 mm). Additionally, they report that there was no significant correlation between fossa depth and age. The most common type of fossa observed in their study was type I, which was consistent with the findings of our study.

Bone resorption rate is known to vary based on factors such as age, gender and race. In particular, women and elderly individuals experience a decrease in bioplastic activity over time, leading to replacement of normal bone with fatty bone[17]. Furthermore, facial morphology has a direct or indirect impact on the loss of the alveolar crest. Consequently, alveolar resorption can be more pronounced following tooth loss[17].

In a study involving individuals with metabolic disorders that can impact bone resorption, no difference was found in residual alveolar crest resorption between edentulous females and edentulous males[18]. However, multiple studies have reported that completely edentulous females tend to have less voluminous mandibular alveolar crests compared to males, largely due to osteoporosis[19]. This resorption of the alveolar crest can complicate implant surgery in severely atrophic mandibles compared to normal mandibles[20]. There is a risk of serious and potentially life-threatening vascular injuries if a lingual perforation occurs during implant placement[21].

Our study had several limitations. Firstly, since it was a retrospective study, we were unable to conduct clinical examination of the patients. Consequently, we could not determine the specific duration of tooth loss or the length of the edentulous period for each patient. As a result, we were unable to assess the potential relationship between the duration of edentulism and submandibular fossa depth.

In conclusion, we found that the mean SF_{depth} was 2.03±0.73 mm. Among dentate patients, the deepest point of the submandibular fossa was observed in the region of lower second molar. Additionally, the SF_{depth} was higher in dentate patients compared to edentulous patients, as well as in male patients compared to female patients. We observed that type I and type II fossa were more prevalent in women, while type III fossa was more prevalent in men. Furthermore, type I fossa was more common among edentulous patients, whereas type II and type III fossa were more common among dentate patients.

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Sažetak

PROCJENA SUBMANDIBULARNE JAMICE POMOĆU *CONE BEAM* KOMPJUTORIZIRANE TOMOGRAFIJE

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Cilj ovog istraživanja bio je procijeniti anatomiju submandibularne jamice pomoću *cone beam* kompjutorizirane tomografije (CBCT) i utvrditi njezin odnos sa zubnim statusom, dobi i spolom. U istraživanje je bilo uključeno 230 klijenata (srednja dob 43,24±17,70 godina; 96 muškog spola i 134 ženskog spola). Bio je 101 djelomice bezub klijent i 129 klijenata s očuvanim zubima. Snimke dobivene pomoću CBCT služile su za mjerenje dubine submandibularne jamice (SF_{depth}) i udaljenosti njezine najdublje točke do mentalnog foramena ($SF_{distance}$). Radiološke karakteristike submandibularne jamice uspoređene su s dobi, spolom i zubnim statusom. Analiza 460 polovina mandibula otkrila je 239 (52%) mandibula tipa I., 175 (38%) mandibula tipa II. i 46 (10%) mandibula tipa III. Kod klijenata s očuvanim zubima SF_{depth} je bila značajno veća (2,21±0,68 mm) u usporedbi s djelomice bezubim klijentima (1,80±0,73 mm, p<0,001). Srednja vrijednost SF_{depth} bila je značajno veća kod muških klijenata s očuvanim zubima i djelomice bezubih muških klijenata (2,42±0,73 mm odnosno 2,03±0,82 mm) nego kod istih skupina ženskih klijenata (2,07±0,61 mm odnosno 1,62±0,59 mm, p<0,001). Kod klijenata s očuvanim zubima je najdublja točka submandibularne jamice najčešće bila smještena na razini drugog molara (79,8%). Zaključeno je da je submandibularna jamica plića kod djelomice bezubih klijenata u usporedbi s klijentima s očuvanim zubima. Dubina submandibularne jamice veća je kod muških klijenata nego kod klijentica.

Ključne riječi: *Submandibularna jamica; Cone beam kompjutorizirana tomografija; Mandibula; Anatomija*