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Characteristics and Prevalence of Anterior Buccal Mandibular Depression Area in Cone Beam Computed Tomography Images

SUMMARY

Background/Aim: *The purpose of this study was to assess the anterior buccal mandibular depressions (ABMD) prevalence and clinical characteristics at cone beam computed tomography images (CBCT).* ***Material and Methods:*** *198 CBCT images with minimal depression between the mandibular molars were evaluated retrospectively. Presence and location of ABMD, its maximum depth, maximum width, cortical width, if any, alveolar crest width at maximum depth, the distance between maximum depth and alveolar crest apex and existing teeth in the relevant region were examined in cross-sectional views. Panoramic radiography of ABMD patients was evaluated for trabecular pattern and radiopacity to determine the area of interest. The possible lingual depression area on the maximum depth of ABMD slice was investigated and the same measurements for ABMD was performed. The presence of aperture / foramen in the ABMD area was also investigated.* ***Results:*** *The prevalence of ABMD was found as 43.43% where 82 cases were at bilateral side and 4 cases were only at left side. Lingual depression was observed in 20.7% right side and 30.2% left side of the ABMD cases. There was no statistically significant difference for maximum depth between different age groups. Most frequent location was observed in lateral and canine region (27.4%) followed by lateral-first premolar area (25.6%). Least frequent location was at canine-second premolar area (1.2%).* ***Conclusions:*** *ABMD is a lesser known area with a high prevalence observed on CBCT images. The detectability of the area on panoramic radiographs is limited. Clinicians should take into consideration ABMDs' characteristics to avoid confusion with periapical pathologies. Failure to detect these areas before implant surgeries may cause complications. For this reason, it is important to be examined in detail for ABMD before surgery.*

Key words: Cone-Beam Computed Tomography, Mandible, Panoramic Radiography

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Introduction

The anterior buccal mandibular depression (ABMD) which is a bony depression area located between the area of the mental protuberance and mental foramen, inferior to the mental fossa, extends horizontally beneath the apices of the teeth[1,2]. It is not a well-known anatomical landmark that rarely is mentioned in the textbooks and dental literature[2]. It is first mentioned by Humphrey in 1858, as "a small notch in the alveolar margin, which as a remnant of the former fissure may sometimes be seen as late as the second year"[3]. Hrdlicka examined the anthropoid and ape materials, claimed the depression area only was seen in human beings which he called the area as mental fossae, in spite of that the definition of the area in the paper was compatible with the ABMD. He also mentioned that the area may show racial differences for development and persistence[4]. DuBrul and Sicher defined the area as horizontal groove bilaterally to the mental region, said they cannot find any description in the literature[2].

At 1989, Arensburg *et al.* examined 970 dry mandibles of adult and children from different chronological periods, geographic regions and ethnic origin. They also examined 38 nonhuman primate mandibles and concluded the area as they named it as "ABMD" is limited to the mankind in agreeing with the Hrdlicka[2,3].

From birth to adolescence, ABMD by degrees disappears, while its incidence increases during aging and tooth loss. The reason for this change seems to be the constant remodeling of the mandible. During tooth eruption, remodeling of the alveolar bone causes a decrease in the prevalence of ABMD. It will reappear in older individuals, possibly following alveolar bone resorption associated with tooth loss[5].

Arensburg claimed that the etiology of the ABMD may be genetic and developmental due to the presence of ABMD in first steps of hominoids[3,4]. The etiology of the ABMD is not clear but Littner *et al.* suggest that there may be some association between the opposition and resorption of alveolar bone in the life cycle. Also, the mentalis and depressor muscles' activity suggested as an additional factor[5,6].

The study of Littner *et al*, the only study in which depression was examined histologically, showed that there was no pathological tissue, muscle addition or any tissue that could cause this depression in the area concerned. They reported the tissues in the ABMD region examined microscopically as adipose tissue, loose connective tissue, striated muscles, blood vessels and nerve fibers[5]. The studies were on cadavers or anthropological fossils and there is no study which uses cone beam computed tomography (CBCT) images of living subjects investigating the ABMD.

CBCT is an accurate, cost-effective, and relatively low-radiation three-dimensional (3D) imaging technique. In addition, it is a safe method that is frequently used in dentistry and allows three-dimensional examination[7].

Implant planning with conventional two-dimensional images such as periapical and panoramic radiographs has limitations such as distortion, magnifications, and superposition, which lead to inaccurate information[8–12]. The American Academy of Oral and Maxillofacial Radiology recommends the use of CBCT for preoperative implant evaluation and treatment planning This recommendation becomes even more important in the presence of limited bone amount, as seen in clinical evaluation[10,13,14]

ABMD is clinically noticeable only during radiological examinations. Since the beam passes through less bone than the bone surrounding the depression site, its appearance appears to be a radiolucent area. Care should be taken when examining the radiograph, as lingual mandibular salivary gland depression, another radiolucent area in the mandible, may present a similar image on intraoral radiographs[2]. Besides, the ABMD which may seem as radiolucency in the periapical and panoramic radiographs can mistakenly was diagnosed as pathology. Since ABMD has a similar appearance to the lingual anterior mandibular bone depression (LA), which gives the mandible another radiolucent image, care should be taken in its diagnosis[15]. Also, the area may cause surgery complications due to concavity and thinning of the mandible bucco-lingually like perforations of the buccal cortical plate in implant dentistry or etc. The anatomy of the lower region of the anterior mandible makes it vulnerable to perforation, especially when atrophy, depression, or increased length of dental implants[16].

The aim of this study is to assess the clinical detectability and anatomical features of this lesser known area using CBCT, which may influence the diagnostic or surgery processes.

Material and Methods

Patient Selection and Study Design

This study was approved by Faculty of Medicine Ethics Committee with the number 2018/224. 198 patients' CBCT images who applied to the Faculty of Dentistry, Dentomaxillofacial Radiology Department for various reasons retrospectively investigated in this study. The CBCT device from which the images was obtained was Planmeca ProMax 3D Classic (Planmeca ProMax 3D; Planmeca Oy; Helsinki, Finland) with following parameters; 90 kVp, 4-10 mA, 200 µm voxel size. The measurements were performed using Planmeca Romexis 4.6.2.R software (PLANMECA Romexis, Helsinki, Finland). Randomized selected of the 20 patients' CBCT images were re-evaluated after 2 weeks for intra-observer reliability.

Diagnostically acceptable CBCT images with the appropriate FOV area between first molars were included in this study. Exclusion criteria were CBCT scans showing any pathology or congenital/developmental anomaly involving the area. Also any history of surgical procedure except tooth extraction, the presence of impacted tooth/teeth, delayed tooth eruption, extensive mandibular crest resorption cases were excluded from the study. Extensive mandibular resorption cases were excluded due to Arensburg *et al.* claim of the complete alveolar resorption prevents the formation of ABMD[3].

Assessment of the Radiographic Data

A cross-sectional line was drawn in accordance with the mandible shape, the cross sectional images was created with 1 mm section thickness and 1 mm interslice distance. Measurements were performed in cross-sectional images based on Bayrak *et al.* method[17].

In the sagittal section, a reference line was drawn from the most prominent point of the buccal side of the mandible to the lower edge of the mandible. If concavity occurred between this line and the buccal side of the mandible, it was accepted as ABMD. A second line was drawn from the deepest point of the depression area. Reference line was perpendicularly measured. At the cross-sectional image which showed the deepest point of the depression area, a vertical measurement was done from the adjacent tooth apex of the crest to the deepest point of ABMD. Mandibular bucco-lingual dimension was measured horizontal to the ground plane. At the deepest point of ABMD, cortical thickness of mandible was measured horizontally (Figure 1).

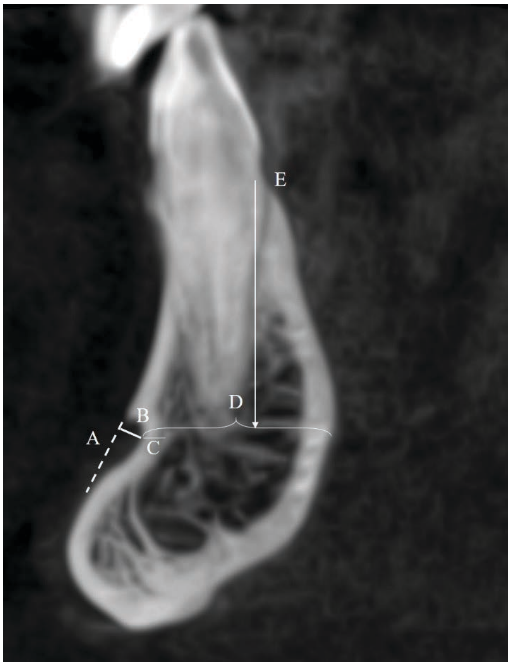

Figure 1. A) Reference line, B) Maximum depth of the ABMD, C) Cortical thickness at deepest point of ABMD, D) Alveolar crest width at deepest point of ABMD, E) Distance from apex of the mandibular crest to the deepest point of ABMD

If there was a lingual concavity at the slice of the deepest point of ABMD, the same measurements was applied for this region like ABMD. The cortical thickness, maximum depth, vertical distance from alveolar crest apex to the deepest point level was measured (Figure 2).

The presence of aperture/foramen at the ABMD area was investigated on cross-sectional images, the interslice distance and slice thickness adjust as the 0.2 mm for the raising the detectability of the possible foramen/aperture. Panoramic radiographs were evaluated in ABMD positive cases and detectability, radioopacity and trabecular pattern investigated via Kaffe *et al.* method[2].

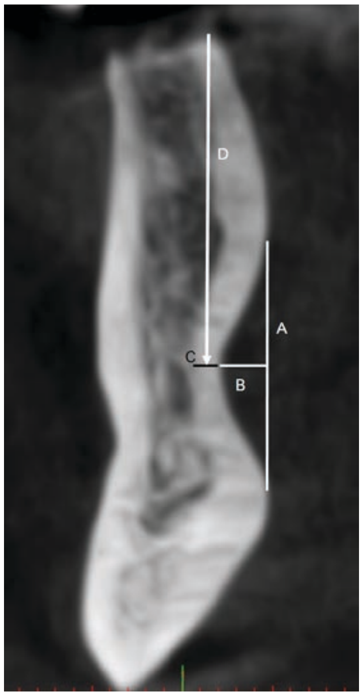

Figure 2. A) Reference line, B) Maximum depth of the lingual depression, C) (Black line) Cortical thickness at deepest point of ABMD, D) Distance from apex of the mandibular crest to the deepest point point of ABMD

The following criteria were used for evaluation of the ABMD images: The borders of the ABMD were graded as: 1= not detected, 2= poorly defined, and 3= well defined. The radiopacity of the depression was graded as: 1= identical to the surrounding bone, 2= slight decrease in radiopacity compared to the surrounding bone, and 3= markedly radiolucent.

Trabecular pattern was categorized as: 1= similar number and shape of bony trabeculae as in the adjacent bone, 2= some changes in trabecular shape and reduction in number of trabeculae, and 3= total absence of trabecular pattern and no trabecular seen in the area[2].

In this study frequencies, percentages and descriptive statistics (mean, standard deviation etc.) were used to report demographic information and variables related to ABMD. One-Way ANOVA test with Bonferroni Post Hoc test or t-test is was performed to test the differences between continuous and grouped variables such as panoramic characteristics, maximum depth, cortical and alveolar crest width. Pearson correlation test was used to detect the relations between two continuous variables such as maximum depth and age. Chi-square test was preferred to determine the relations between two discrete variables such as lingual depression and panoramic characteristics or presence of ABMD and gender. All the statistical analysis was performed with the IBM SPSS Statistics version 24.

Results

Total of 198 patients were included in this study: 114 female (57.6%), 84 male (42.4%). Minimum, maximum and mean age of the study group are; 8, 89 and 46.23 respectively. In 86 patients (43.43% of the total cases) ABMD was observed where 82 of the cases are bilateral (95.35% of the ABMD cases) and 4 cases (4.65 % of the ABMD cases) were observed at only left side. ABMD was present in 54 (64.3%) of 84 male cases and 32 (28.1%) of 114 female. Lingual depression areas were observed in 17 cases at the right side (20.7% of the total right sided ABMD), and 26 cases at the left side (30.2% of the total left sided ABMD).

Locations of the ABMD areas were listed at Table 1. At the right side, the most frequent location for ABMD was at lateral incisor-canine area whereas at the left side the most frequent location was lateral incisor-first premolar area. The minimum, maximum depth of ABMD, cortical, alveolar crest width, maximum depth to alveolar crest apex distance, maximum depth of lingual depression areas and cortical width of lingual depression areas values shown at Table 2.

Table 1. Total numbers and percentages of ABMDs' locations

	Right Side		Left Side		Total	
Location	n	%	n	%	n	%
1-3	-	-	6	7	6	3.6
1-4	4	4.9	2	2.3	6	3.6
2	2	2.4	3	3.5	5	3
2-3	25	30.5	21	24.4	46	27.4
2-4	19	23.2	24	27.9	43	25.6
2-5	2	2.4	3	3.5	5	3
3	13	15.9	18	20.9	31	18.5
3-4	16	19.5	8	9.3	24	14.3
3-5	1	1.2	1	1.2	2	1.2

Table 2. Maximum depth, maximum width, cortical and alveolar crest width at deepest point of ABMD, distance from deepest point of ABMD to alveolar crest values. Maximum depth, cortical width and from deepest point of lingual depression to alveolar crest values if lingual depression found at the ABMD area

	Right Side			Left Side			Total		
	Mean (±std deviation)	Minimum	Maximum	Mean (±std deviation)	Minimum	Maximum	Mean (±std deviation)	Minimum	Maximum
Maximum Depth (mm)	1.30 (±0.58)	0.40	3.06	1.31 (±0.59)	0.40	3.31	1.31 (±0.58)	0.40	3.31
Maximum Width (mm)	8.38 (±2.11)	4.82	14.87	8.22 (±2.06)	4.60	13.39	8.30 (±2.08)	4.60	14.87
Cortical Width (mm)	1.51 (±0.43)	0.80	2.41	1.48 (±0.45)	0.57	3	1.49 (±0.44)	0.57	3
Alveolar Crest Width(mm)	8.51 (±1.91)	2	13	8.51 (±1.94)	3.40	12.61	8.51 (±1.92)	2	13
Max. Depth-Alveolar Crest Apex Distance (mm)	18.06 (±4.13)	3.81	25.84	18.08 (±4.06)	7.60	28.20	18.07 (±4.08)	3.81	28.20
Maximum Depth (Lingual Depression)	1.61 (±0.88)	0.40	3.03	1.61 (±0.89)	0.80	4.02	1.61 (±0.87)	0.40	4.02
Cortical Width (Lingual Depression)	1.42 (±0.40)	0.89	2	1.56 (±0.49)	0.45	2.40	1.50 (±0.46)	0.45	2.40
Max. Depth-Alveolar Crest Apex Distance (Lingual Depression)(mm)	17.10 (±3.87)	9.80	26.23	17.58 (±3.41)	10.80	25.20	17.39 (±3.56)	9.80	26.23

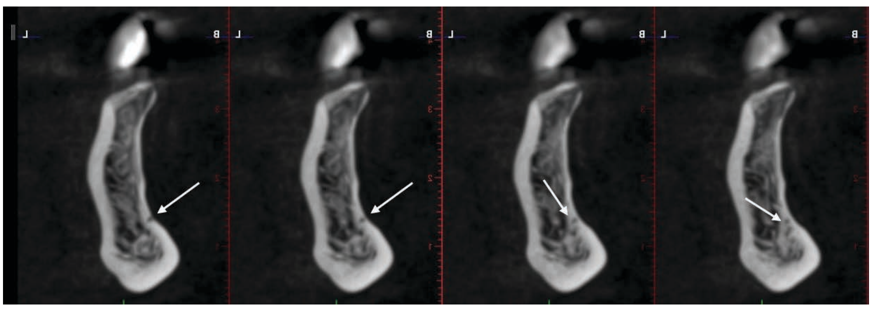

Figure 3. A foramen/aperture and bony canal were observed at ABMD area

Aperture/foramen (Figure 3) was observed at 26 (31.7%) of 82 cases of ABMD at the right side and 32 (37.2%) of the 86 cases located on the left side. In total 58 (34.5%) of the 168 ABMD areas were showed apertures/foramina. Table 3 shows the frequencies and percentages of ABMD cases in different age groups.

Table 4. shows the statistical analysis of ABMD depth at different age groups. There was no statistical difference of the depth at different age groups. There was no statistical significant difference was seen at presence percentage of tooth at relevant area with maximum depth. The percentage of tooth was calculated as for example, if ABMD area located between 2-4 area and only canine tooth is present, the percentage of present tooth is 33.3 %.

Table 3. The frequencies and percentages of ABMD at different age groups

Age Group	ABMD present	Total Case	Prevalence
≤20	4	13	%30.76
21-30	10	25	%40.00
31-40	11	27	%40.74
41-50	24	51	%47.05
51-60	18	44	%40.90
61-70	13	28	%46.42
≥70	6	10	%60.00

Table 4. Maximum depth of the ABMD areas in different age groups

Age Groups	MAXIMUM DEPTH											
	SIDE											
	RIGHT				LEFT				TOTAL			
	n	Mean (±std deviation) (mm)	Minimum Depth (mm)	Maximum Depth (mm)	N	Mean(±std deviation) (mm)	Minimum Depth (mm)	Maximum Depth (mm)	n	Mean(±std deviation) (mm)	Minimum Depth (mm)	Maximum Depth (mm)
≤20	4	1.22 (±0.53)	0.6	1.81	4	1.17 (±0,53)	0.63	1.71	8	1.19 (±0.49)	0.60	1.81
21-30	10	1.48 (±0.68)	0.63	2.68	10	1.57 (±0.66)	1.02	3.31	20	1.53 (±0.65)	0.63	3.31
31-40	11	1.16 (±0.56)	0.60	2.28	11	0.99 (±0.39)	0.60	1.81	22	1.07 (±0.47)	0.60	2.28
41-50	22	1.17 (±0.54)	0.45	2.41	24	1.25 (±0.62)	0.45	3.03	46	1.21 (±0.58)	0.45	3.03
51-60	18	1.41 (±0.54)	0.40	2.24	18	1.49 (±0.67)	0.40	2.86	36	1.45 (±0.61)	0.40	2.86
61-70	11	1.20 (±0.55)	0.72	2.47	13	1.22 (±0.51)	0.57	2.61	24	1.21 (±0.52)	0.57	2.61
≥71	6	1.23 (0.52)	0.82	2.15	6	1.26 (±0.28)	1.02	1.72	12	1.24 (±0.40)	0.82	2.15

Table 5. The mean values and total numbers of maximum depth, cortical width, alveolar crest width for different panoramic radiographic characteristics of ABMD

		Right Side				Left Side				Total			
			Maximum Depth	Cortical Width	Alveolar Crest Width		Maximum Depth	Cortical Width	Alveolar Crest Width		Maximum Depth	Cortical Width	Alveolar Crest Width
	Grades	n	Mean	Mean	Mean	n	Mean	Mean	Mean	n	Mean	Mean	Mean
Borders of the area	1	72	1.25	1.52	8.73	74	1.25	1,46	8,6	146	1,25	1,49	8,66
	2	9	1.59	1.44	7.44	10	1.67	1,6	7,42	19	1,63	1,52	7,43
	3	1	2.21	0.89	2	2	1.83	1,6	10,9	3	1,95	1,36	7,93
Radiodensity of the area	1	72	1.25	1.52	8.73	73	1.26	1,47	8,67	145	1,26	1,5	8,7
	2	9	1.59	1.44	7.44	12	1.57	1,55	7,51	21	1,58	1,5	7,48
	3	1	2.21	0.89	2	1	2.24	1,4	9,2	2	2,23	1,15	5,6
Trabecular pattern	1	75	1.25	1.51	8.74	80	1.25	1,45	8,51	155	1,25	1,48	8,62
	2	6	1.75	1.49	6.63	4	2.35	2,15	7,5	10	1,99	1,75	6,98
	3	1	2.21	0.89	2	2	1.83	1,6	10,9	3	1,95	1,36	7,93

Table 5 shows the relation between panoramic image characteristics of ABMD with maximum depth, cortical width, alveolar crest width for both sides separately and for total of the group. There is a statistically significant difference between borders of the area with maximum depth of ABMD and alveolar crest width ($p<0.05$).

Discussion

According to the literature, anterior mandible has been relatively recognized to be safe for implant placement without serious complications and implants are placed in the space between the mental foramens in this area[18]. However, serious complications may develop even with implant placement in the interforaminal area because of variations of anterior mandible. Numerous studies have reported on life-threatening complications caused by implants[18,19].

In our study, we evaluated the characteristics of ABMD in CBCT images of living subjects, which make this study of its first in the literature, ABMD which reported with high prevalence is an overlooked area depended on the difficulty to detect on clinical radiographs[1,2].

The prevalence of ABMD was reported between 13.8 % to 37; also in Littner *et al.*; 1995, 41% (with 7 fetuses included)[1,3,5,6]. The difference of the prevalence in studies may be the difference of the study groups that varieties in age, ethnicity and historical ages of the samples[5]. Also, the genetic variations between various human groups may be reason for the wide range of prevalence. The prevalence of the ABMD may differ at different ethnic groups. The study of Arensburg *et al.* observed the lowest prevalence in the samples of modern Australians. The highest prevalence was seen in Bedouin children samples as 77.2% followed by 39.3% of samples from England (middle ages)[3]. Some of the studies showed ABMD prevalence may change with the age. The Littner *et al.* reported prevalence of ABMD in adults (mean age of the study group was 80.5%) is 31.8% [5]. Arensburg *et al*. reported that in their study that all of the mandibles of 0 to 6 months babies show ABMD. They reported prevalences for 7 months to 6 years old, 7-year-old to 12 years old are 74.2% and 43.5% respectively. They reported the prevalence for adults (12 years and older) as 32.1% [3]. Kaffe *et al.* reported the prevalence as 68% in children and 32% in adults[2]. In our study, the total prevalence was 43.43% which seem a little higher than the previous reports. The reason for this may be the difference of the study group and also the study design. As ABMD reported various prevalence values in different ethnic groups, the Turkish ethnic group may have a higher prevalence of ABMD. Also in our study design, we used CBCT images, but other studies used cadavers or anthropological fossils/human remains at their studies via naked eye assessment. As we assess the mandible at cross-sectionally at CBCT images, we think that the detection possibility of vestigial ABMD's may increase.

There is no gender prediction seen in Littner *et al's* study[1,5]. No data present for the gender prediction at Arensburg *et al's*, Littner's, Kaffe's studies[2,3,6]. In our study, the prevalence of ABMD was 64.3% in males 28.1% in females.

Arensburg *et al*. reported the depth of ABMD is between 1.5-4 mm and 10-15 mm long. Also, they reported the width is between 3-6 mm[3]. Kaffe *et al*. did not report the mean depth of the area, they classified the areas' depth as less than 3 mm and 3 mm or more. They reported 82% of the ABMD was shallower than 3 mm and 18% has a depth of 3 mm or more. They found that the ABMD was deeper in children and with age becoming shallower and almost disappears with age increases.

Littner reported the depth of ABMD from 0.5 mm to 3 mm (with the mean of 1.81 ± 0.81) in fetuses and 0.5 mm to 3.8 mm (with the mean of 2.36 ± 0.88) in adults. The width of the area was reported in the same paper from 3 mm to 5.1 mm in fetuses (with the mean of 3.85 ± 0.89 mm) and 3.4 to 7 mm (with the mean of 5.44 ± 1.22 mm) in adults. The paper did not mention the location related with the tooth but they measured the length as from 5.9 to 8.8 mm (with the mean of 7.3 ±1.08 mm) in fetuses and from 8.8 to 18.9 mm in adults[17]. We reported the minimum value of 0.40 and the maximum value of 3.31 for ABMD depth. The values were in accordance with the previously reported ones. In our study, there was no statistically significant difference between different age groups and the depth of the ABMD. The most of the ABMD lesions were seen at 2-3 (27.4 % of the ABMD, 11.61 % of total assessed hemimandible) and 2-4 (25.6% of the ABMD cases, 10.85% of the total assessed hemimandibles) areas.

Littner *et al*., discovered for the first time 12 of 14 cadavers which showed ABMD there were small apertures containing nerves and blood vessels[5]. In our study, 58 (34.5 %) of a total of 168 ABMD cases had small apertures located at ABMD region. The reason of the low frequency may be the different assessment of presence. In CBCT the detection possibility of apertures is limited with various factors like image quality, voxel size, the thickness of the section and interstice distance. Also, we believe that as ABMD prevalence showed different values at different ethnic groups, the presence of aperture may be also influenced by genetic/racial/ethnic differences like in accessory mental foramen[20]. As we did not see the connection between mandibular canal/anterior mandibular canal with the aperture's canal so we did not classify the apertures as accessory mental foramina.

Radiographically the detectability of the ABMD is not always possible. Littner *et al.* reported at dry mandibles 14% of the ABMD cases showed defined borders, poorly defined borders at 35%, a slight reduction in radiodensity in 57% and change in trabecular pattern in 21% at periapical radiographs where Kaffe *et al.* reported 20% of the cases showed defined borders and 49% showed poorly defined borders[2,6]. The borders of the ABMD cannot detected at 31% in Kaffe's study and

51% of the cases in Littner's study respectively[2,6]. Littner *et al*. performed also panoramic and CT on the materials and propose the CT for preferred modality for detection[6]. Kaffe *et al.* reported a slight decrease in radiodensity in 62% of the cases where 10% showed a significant decrease in periapical radiographs of the ABMD cases in dry mandibles. They reported only 2 of 82 cases showed a reduction in trabeculation. They reported none for loss of trabecular pattern[2]. They also mentioned that no correlation was seen between the depth of ABMD and the appearance of its borders[2]. Littner *et al*. showed that the presence of soft tissue may interfere with the detection of the ABMD. They noted that not only the detection of the boundaries, but also the radiopacity of the area affected by the presence of soft tissue may decrease. They observed a decrease in radiopacity in 2 of 14 ABMD cases with the presence of soft tissue, and in 9 without soft tissue[1]. In our study, the decreased radiodensity was seen at 13.09% of the cases (22 of 168) on panoramic radiographs. Trabecular pattern change was seen at 7.73%. The low percentages in our study may derivered from the different radiological method used. As previous studies used periapical radiographs mostly, the detection possibility is much more for density change in this method.

The limitations of this study were a small study group, an absence of data from younger than 8 years old and the study group consisted from a local area. More studies from different cities/regions needed to decide the exact prevalence of ABMD in Turkish people. The method for assessment of detectability and properties of ABMD at panoramic radiographs was mostly observer dependent/subjective.

Conclusions

ABMD is a lesser known area with a high prevalence observed on CBCT images. The detectability of the area on panoramic radiographs is limited. Clinicians should take into consideration ABMDs' characteristics to avoid confusion with periapical pathologies. Failure to detect these areas before implant surgeries may cause complications. For this reason, it is important to be examined in detail for ABMD before surgery.

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