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Original Article

The evaluation of visibility of mandibular anatomic landmarks using panoramic radiography

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Abstract

Aim: The mandibular canal, mandibular foramen, mental foramen, and incisive canal are important anatomical structures for dental surgery. The aim of this study was to evaluate the visibility of these important landmarks in different age groups and to compare the visibility in the dentulous group with the edentulous group on panoramic radiographs.

Methodology: Panoramic radiographs of 500 patients (237 males and 263 females; mean age:39.2) were evaluated for this study; the visibility of their anatomical landmarks was analyzed, and scores were noted.The data obtained were analyzed using the SPSS 21 package program.The value of $p<0.05$ was considered statistically significant.

Results: The mandibular canal, mandibular foramen, mental foramen, and incisive canal were visible in 89.8%, 88%, 80.6%, and 12.8%of all radiographs, respectively.Twenty-three(4.6%) patients had total tooth loss.The visibility of the anatomical landmarks were most clearly observed in groups below 25 years old.

Conclusions: Panoramic radiographs provide useful information on the visibility of anatomical landmarks. However, using 3D imaging methods before surgical procedures will provide more accurate results.

Keywords: Panoramic radiography, mandible, anatomical landmark

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Introduction

The radiologically diagnosis of a pathology requires a certain knowledge of anatomic landmarks. This diagnosis cannot be made without knowing the variations of anatomical structures (1).

Knowledge of the morphological and anatomical variations related to anatomic landmarks of the mandible is necessary in implant surgery, especially for the inferior alveolar nerve bundlebecause it exists in various locations and has many alterations.Individual, gender, race, age,radiological technique, and the amount of edentulous alveolar ridge resorption significantly affect these variations (2).

There are some difficulties during mandible surgical procedures, such as implant surgery in the interforaminal region and the symphysis; careless injury to the inferior alveolarnerve and mental nervecauses paresthesia in the lip and chin (3). The inferior alveolar nerve leaves the mandibular corpus at the mental foramen and generally forms an anterior

loop after traversing a short behind pathway before returning into the mandible (4). Currently, several surgeons work on the anterior region of the mandible (intermental area) involving implant placement, orthognathic surgery, and screw fixation. The intermental area is presumed to be safe for surgical operations, and theoccurrence of a mandibular incisive canal is a problem in this region. The inferior alveolar nerve may extend beyond the mental foramen as an intraosseous anterior loop. The mandibular canal includes the inferior alveolar nerve and blood vessels. It is divided into mental and incisive branches. In some cases, the radiologically visibility ofthe incisive branches may be seen (5).

Radiography is a non-invasive method for diagnosis and treatment planning before surgical operationsin the mandible. The panoramic radiography technique is a curved plane tomographic radiographic modality, in which the mandibular canal seems to be a radiolucent line limited by two outer radiopaque lines. The mandibular canal starts at the mandibular foramen and reaches the mental foramen. Panoramic radiographsare usually magnified and have anatomical structure superimposition. However, panoramic radiography has some advantages, such as being cost effective andeasily accessible and requiringa minimum amount of time to obtain a radiograph. Therefore, panoramic radiography is widely used for diagnosing, imaging, and deciding the best surgical treatment options (6).

In light of this information, the aim of this study was to evaluate the visibility of mandibular anatomic landmarks on panoramic radiographs.

Materials and Methods

After obtaining ethical approval, 500 digital panoramic radiographs of patients who were referred to the Department of Dentomaxillofacial Radiology in the Faculty of Dentistry, Hatay Mustafa Kemal University, were retrospectively evaluated. These radiographs were obtained using the Vatech panoramic imaging device (Vatech Global, Korea). All images were evaluated by two dentomaxillofacial radiologists (GS and CAB) with the same Planmeca Romexis software program. The patients' gender and age were recorded. Patientswere divided into six age groups: 14-24, 25-34, 35-44, 45-54, 55-64, and 65+ years.

Radiographs with inadequate quality, with artifacts to prevent the appearance of the mandible, and with fractures or pathologies in the mandible were excluded from the study. Anatomical structures in the mandible (mandibular canal, mandibular foramen, mental foramen, and incisive canal) were classified according to a visibility scale reported by Singh et al. (7) and Nagaraj et al. (8), which consists of four components: good visibility (above average), moderate visibility (average), poor visibility (below average), and invisibility. Data were recorded and analyzed statistically, and the interobserver agreement was calculated using the intraclass correlation coefficient (ICC).

Statistical Analysis

The data obtained in this study were analyzed using the SPSS 21 package program. Dependence between variables was analyzed by Chi-Square analysis. The significance level used was 0.05; there was a significant difference/dependency in the case of $p < 0.05$ and no significant difference/dependence in the case of $p > 0.05$.

Results

The interobserver agreement was very high and meaningful (ICC at 0.7 and above indicates a good agreement) (Table 1). The subjects included 237 males (47.4%) and 263 females (52.6%). Twenty-three subjects were completely edentulous and 477 were dentate, with the age range of14 to 81 years and the mean age of 39.2 years (Table 2). The mandibular canal, mandibular foramen, mental foramen and incisive canal were visible in 89.8%, 88%, 80.6%, and 12.8% of the cases, respectively (Graph. 1-3, Fig. 1, and Table 3). Anatomic landmarks were frequently visiblein the 14-24 age group and were the least visible in patients over 65 years old.

Table 1. Interobserver agreement

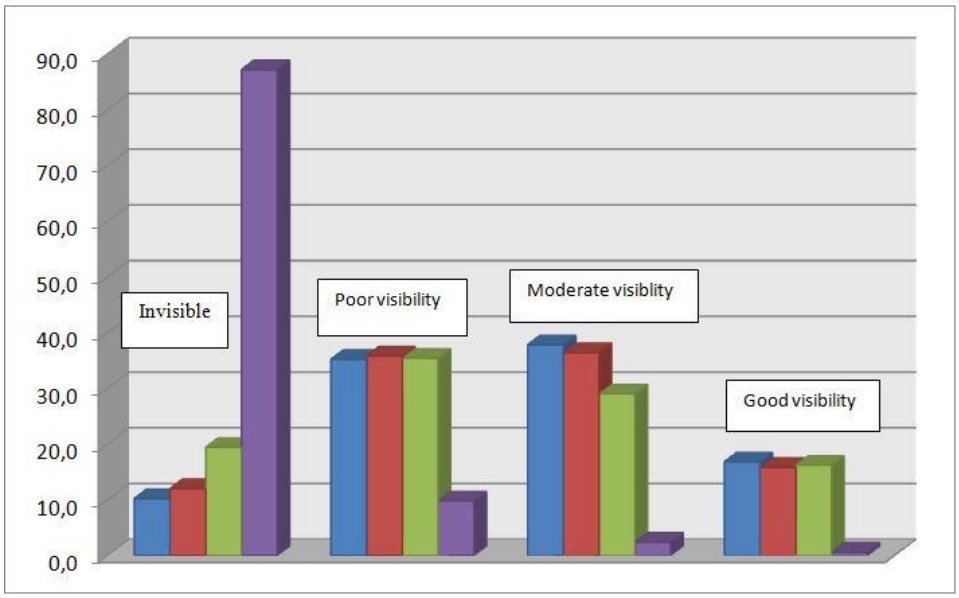
	ICC	p
Mandibular canal	0,927	0,0001
Mandibular foramen	0,951	0,0001
Mental foramen	0,983	0,0001
Incisive canal	0,922	0,0001

Table 2. The patient number according to the age groups

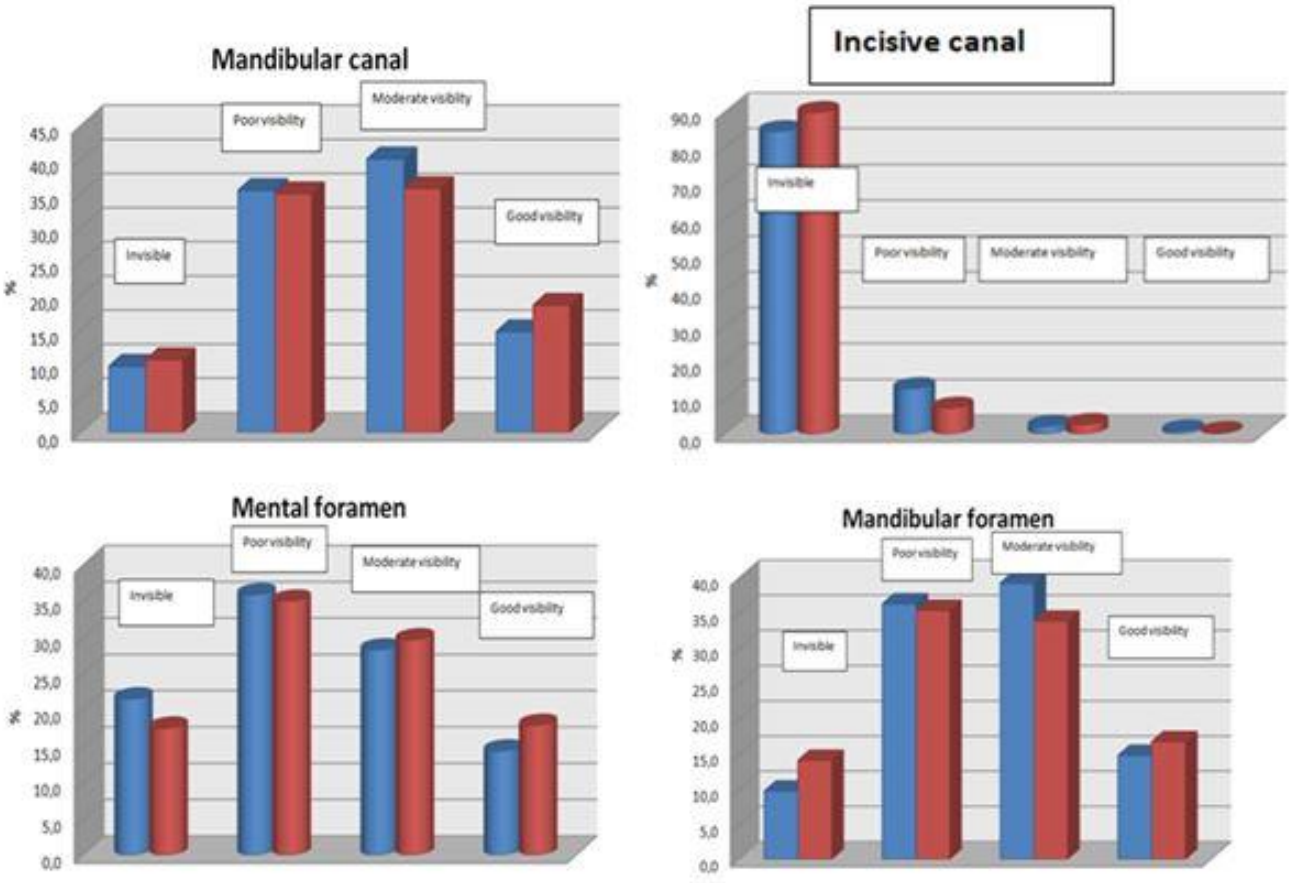
		n	%
Age groups	14-24	133	26,6
	25-34	90	18,0
	35-44	82	16,4
	45-54	90	18,0
	55-64	54	10,8
	65+	51	10,2
	Total	500	100,0

Table 3. The visibility rates

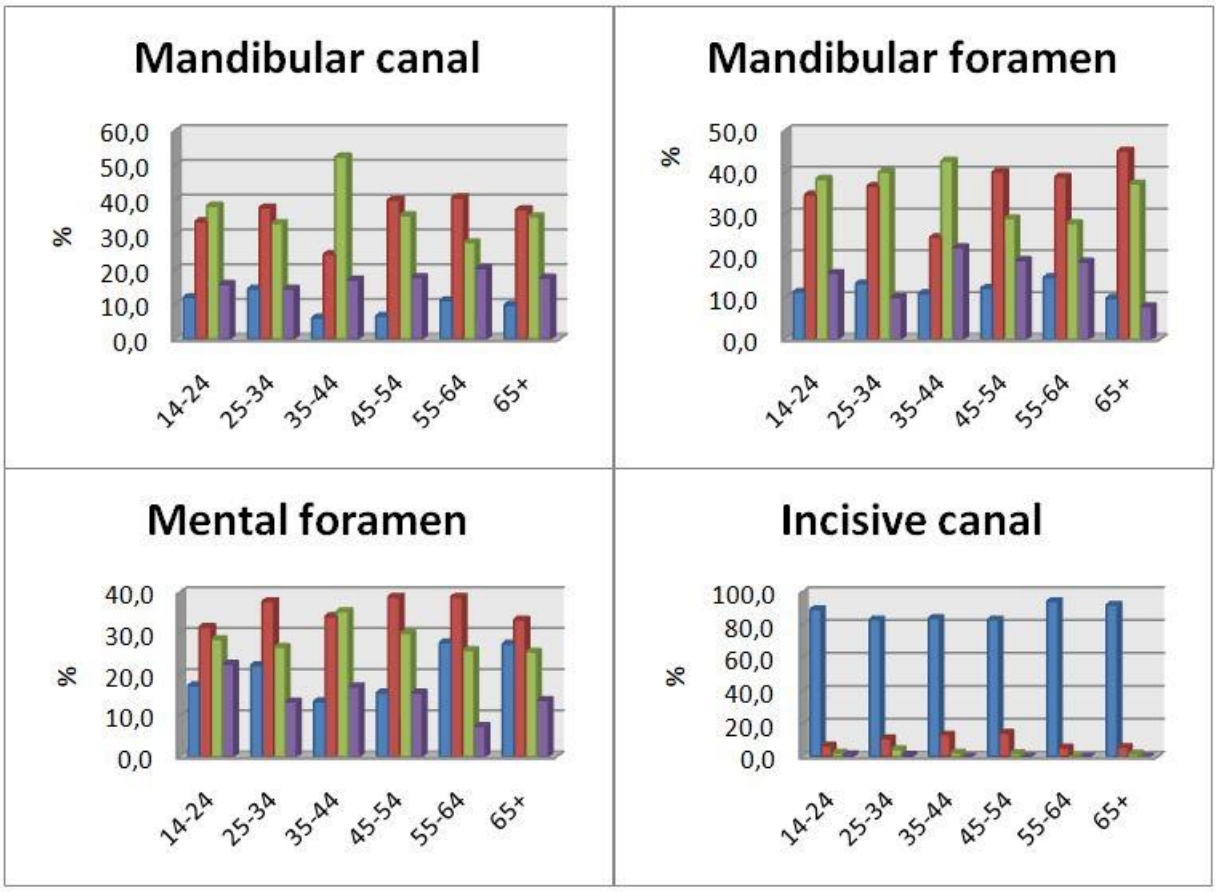
		n	%
Gender	Male	237	47,4
	Female	263	52,6
	Total	500	100,0
Mandibular canal	Invisible	51	10,2
	Poor visibility	176	35,2
	Moderate visibility	189	37,8
	Good visibility	84	16,8
	Total	500	100,0
Mandibular foramen	Invisible	60	12,0
	Poor visibility	179	35,8
	Moderate visibility	182	36,4
	Good visibility	79	15,8
	Total	500	100,0
Mental foramen	Invisible	97	19,4
	Poor visibility	177	35,4
	Moderate visibility	145	29,0
	Good visibility	81	16,2
	Total	500	100,0
Incisive canal	Invisible	436	87,2
	Poor visibility	49	9,8
	Moderate visibility	12	2,4
	Good visibility	3	,6
	Total	500	100,0
Dental status	Edentulous	23	4,6
	Dentulous	477	95,4
	Total	500	100,0



Graphic 1. Visibility rates of mandibular canal (blue), mandibular foramen (red), mental foramen (green) and incisive canal (purple)



Graphic 2. Visibility rates for males (blue) and females (red)



Graphic 3. Visibility rates according to the age groups (blue: invisible, red: poor visibility, green: moderate visibility, purple: good visibility)

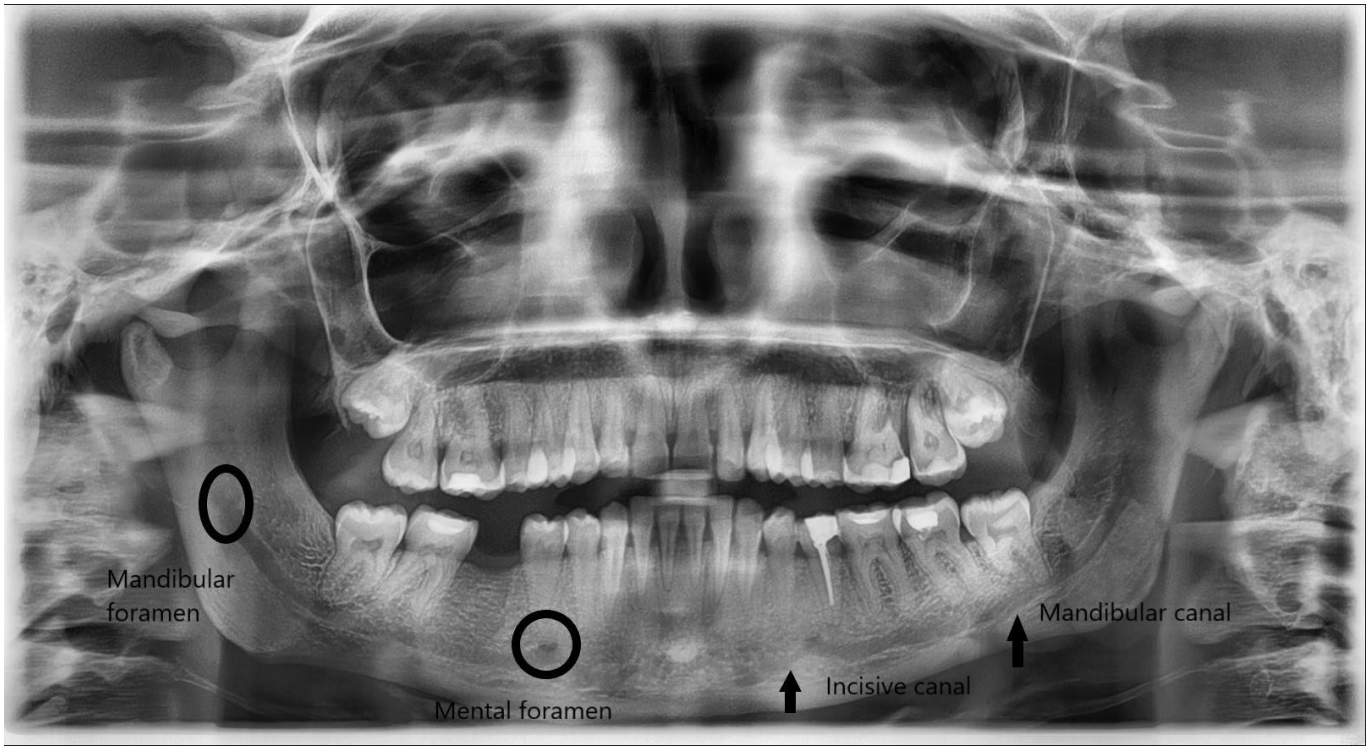


Figure 1. Assessed anatomical landmarks on panoramic radiograph

The following statistical results were observed (Tables 4-6):

- There were no significant differences between gender and the visibility of the mandibular canal (p>0.05); however, the good visibility rate was highest in females(18.6%).
- There were no significant differences between gender and the visibility of the mandibular foramen (p>0.05); however, the invisibilityrate was highest in females (14.1%). The rate of moderate visibility in males was 39.2%.
- There were no significant differences between gender and the visibility of the mental foramen (p>0.05); however, the good visibility ratewas highest in females (17.9%).
- There were no significant differences between gender and the visibility of incisive canal (p>0.05); however, the invisibility rate was highest in females (89.7%).
- There were no significant differences between the age groups and the visibility of the mandibular canal (p>0.05); however, the visibility rates were highest in the 35 and over age groups.
- There were no significant differences between the age groups and the visibility of the mandibular foramen cases (p>0.05); however, the good visibility rate was highest in the 35-65 age group.
- There were no significant differences between the age groups and the visibility of the mental foramen (p>0.05); however, the good visibility rate was highest in the 14-24age group.
- There were no significant differences between the age groups and the visibility of the incisive canal (p>0.05); however, good visibility rates were highest in the 55+ age groups.
- There were no significant differences between the edentulous group and the visibility of the mandibular canal (p>0.05). Although not statistically significant, the good visibility rate in the edentulous group was higher than dentulous group.
- There were significant differences between the edentulous group and the visibility of the mandibular foramen (p <0.05). The good visibility rate in the dentulous group was significantly higher than edentulous group (p <0.05).
- There were no significant differences between the edentulous group and the visibility of the mental foramen (p>0.05). Although not statistically significant, the invisibility rate in the edentulous group was higher than dentulous group.
- There were no significant differences between the edentulous group and the visibility of the incisive canal (p>0.05). Although not statistically significant, the invisibility rate was higher in the edentulous group.

Table 4. The visibility of anatomical landmarks according to gender

		Gender						Chi-square analysis	
		Male		Female		Total			
		n	%	n	%	n	%	Chi-square	p
Mandibular canal	**Invisible**	**23**	**9,7**	**28**	**10,6**	**51**	**10,2**		
	Poor visibility	84	35,4	92	35,0	176	35,2		
	Moderate visibility	95	40,1	94	35,7	189	37,8	**1,8**	**0,604**
	Good visibility	35	14,8	49	18,6	84	16,8		
	Total	237	100,0	263	100,0	500	100,0		
Mandibular foramen	Invisible	23	9,7	37	14,1	60	12,0		
	Poor visibility	86	36,3	93	35,4	179	35,8		
	Moderate visibility	93	39,2	89	33,8	182	36,4	3,3	0,346
	Good visibility	35	14,8	44	16,7	79	15,8		
	Total	237	100,0	263	100,0	500	100,0		
Mental foramen	Invisible	51	21,5	46	17,5	97	19,4		
	Poor visibility	85	35,9	92	35,0	177	35,4		
	Moderate visibility	67	28,3	78	29,7	145	29,0	2,1	0,551
	Good visibility	34	14,3	47	17,9	81	16,2		
	Total	237	100,0	263	100,0	500	100,0		
Incisive canal	Invisible	200	84,4	236	89,7	436	87,2		
	Poor visibility	30	12,7	19	7,2	49	9,8		
	Moderate visibility	5	2,1	7	2,7	12	2,4	-	0,182
	Good visibility	2	,8	1	,4	3	,6		
	Total	237	100,0	263	100,0	500	100,0		

Table 5. The visibility of anatomical landmarks according to the age groups

		Age groups														Chi-square analysis	
		14-24		25-34		35-44		45-54		55-64		65+		Total			
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	Chi-square	p
Mandibular canal	Invisible	16	12,0	13	14,4	5	6,1	6	6,7	6	11,1	5	9,8	51	10,2		
	Poor visibility	45	33,8	34	37,8	20	24,4	36	40,0	22	40,7	19	37,3	176	35,2		
	Moderate visibility	51	38,3	30	33,3	43	52,4	32	35,6	15	27,8	18	35,3	189	37,8	16,2	0,365
	Good visibility	21	15,8	13	14,4	14	17,1	16	17,8	11	20,4	9	17,6	84	16,8		
	Total	133	100,0	90	100,0	82	100,0	90	100,0	54	100,0	51	100,0	500	100,0		
Mandibular foramen	Invisible	15	11,3	12	13,3	9	11,0	11	12,2	8	14,8	5	9,8	60	12,0		
	Poor visibility	46	34,6	33	36,7	20	24,4	36	40,0	21	38,9	23	45,1	179	35,8		
	Moderate visibility	51	38,3	36	40,0	35	42,7	26	28,9	15	27,8	19	37,3	182	36,4	16,267	0,364
	Good visibility	21	15,8	9	10,0	18	22,0	17	18,9	10	18,5	4	7,8	79	15,8		
	Total	133	100,0	90	100,0	82	100,0	90	100,0	54	100,0	51	100,0	500	100,0		
Mental foramen	Invisible	23	17,3	20	22,2	11	13,4	14	15,6	15	27,8	14	27,5	97	19,4		
	Poor visibility	42	31,6	34	37,8	28	34,1	35	38,9	21	38,9	17	33,3	177	35,4		
	Moderate visibility	38	28,6	24	26,7	29	35,4	27	30,0	14	25,9	13	25,5	145	29,0	16,1	0,371
	Good visibility	30	22,6	12	13,3	14	17,1	14	15,6	4	7,4	7	13,7	81	16,2		
	Total	133	100,0	90	100,0	82	100,0	90	100,0	54	100,0	51	100,0	500	100,0		
Incisive canal	Invisible	119	89,5	75	83,3	69	84,1	75	83,3	51	94,4	47	92,2	436	87,2		
	Poor visibility	9	6,8	10	11,1	11	13,4	13	14,4	3	5,6	3	5,9	49	9,8		
	Moderate visibility	3	2,3	4	4,4	2	2,4	2	2,2	0	0,0	1	2,0	12	2,4	-	0,528
	Good visibility	2	1,5	1	1,1	0	0,0	0	0,0	0	0,0	0	0,0	3	,6		
	Total	133	100,0	90	100,0	82	100,0	90	100,0	54	100,0	51	100,0	500	100,0		

Table 6. The visibility of anatomical landmarks according to the dental status

		Dental status						Chi-square analysis	
		Edentulous		Dentulous		Total			
		n	%	n	%	n	%	Chi-square	p
Mandibular canal	Invisible	5	21,7	46	9,6	51	10,2		
	Poor visibility	8	34,8	168	35,2	176	35,2		
	Moderate visibility	5	21,7	184	38,6	189	37,8	-	0,155
	Good visibility	5	21,7	79	16,6	84	16,8		
	Total	23	100,0	477	100,0	500	100,0		
Mandibular foramen	Invisible	3	13,0	57	11,9	60	12,0		
	Poor visibility	14	60,9	165	34,6	179	35,8		
	Moderate visibility	5	21,7	177	37,1	182	36,4	-	0,049
	Good visibility	1	4,3	78	16,4	79	15,8		
	Total	23	100,0	477	100,0	500	100,0		
Mental foramen	Invisible	6	26,1	91	19,1	97	19,4		
	Poor visibility	8	34,8	169	35,4	177	35,4	-	0,549
	Moderate visibility	4	17,4	141	29,6	145	29,0		

	Good visibility	5	21,7	76	15,9	81	16,2		
	Total	23	100,0	477	100,0	500	100,0		
Incisive canal	Invisible	22	95,7	414	86,8	436	87,2	-	0,537
	Poor visibility	1	4,3	48	10,1	49	9,8		
	Moderate visibility	0	0,0	12	2,5	12	2,4		
	Good visibility	0	0,0	3	,6	3	,6		
	Total	23	100,0	477	100,0	500	100,0		

Discussion

In this study, the visibility of important anatomical landmarks in the mandible (mandibular canal, mandibular foramen, mental foramen, and incisive canal) was evaluated on panoramic radiographs. Knowing the localizations of these important structures and obtaining sufficient visibility are important for the surgical approach so that unwanted complications and legal processes may be prevented.

Panoramic radiography is a modality used for obtaining a single tomographic image of the maxillary and mandibular arches and their supporting structures (9); it is one of the most important parts of routine dental examinations. The ease of obtaining the panoramic radiographs, the presence in almost every patient's archive, and the observability of the anatomical structures of the lower jaw were one someof the reasons that we preferred for this study.

In Nagaraj et al.'s study (8), the visibility of the mandibular canal, mental foramen, and incisive canal was present in 98%, 99%, and 23%, respectively. These results were higher than our results; the reason for this may be that our sample size was higher. Basappa et al. (10) reported that the mental foramen showed good visibility in 77%, and the mandibular canal was visible in 74%. The present study found higher results, likely because Basappa et al. had a smaller sample size than we did.

Jacobs et al. (11) reported the visibility of the mandibular canal as 99%, with good visibility in 49% of the cases. The mental foramen could be observed in 94% of the cases, while good visibility was achieved in only 49% of the cases. The incisive canal was identified in 15% of the images, with good visibility in only 1.3%; these results were lower in the present study. Jacobs et al. (11) also reported that the subjects'dental status had no effect on the visibility of anatomical structures in the interforaminal region. Similarly, in our study, there were no significant relationships between dental status and the visibility of mandibular landmarks except for the visibility of the mandibular foramen. Jalili et al. (12) reported that the mental foramen and incisive canal wereseen in 84.2% and 51.7% of the cases, respectively. The visibility of these structures was not affected by gender, but a relationship between the mandibular foramen and mandibular canal with age was found. Abesi et al. (13) and Shahidi et al. (14) reported that incisive canals were visible in 32.1% and 38% of their cases, respectively. Sakhdari et al. (15) and Jacobs et al.'s studies (16) noted higher incisive canalvisibility results (87.5% and 93%, respectively) than our study did.We believe that this was because they used computed tomography and cone beam computed tomographyas their imaging method. However, Mardinger et al. (17) and Mwaiva et al. (18) reported an incisive canal in 80% and 96% of mandibles, respectively, which is also higher than our results. This may be a result of human cadavers being used in these studies. We think that direct observation on the cadaver can give clearer results compared to the radiographs.

In this study, anatomic landmarks were frequently visible in the 14–24 age group andthe least visible in patients over 65 years old. This may be due tobone density changes: the cortical bone becomes thicker and sclerotic with age, but the bone's collagen will decrease (19–21). Therefore, radiation absorption and transmission varies with age, causing differences in the appearance of anatomical structures (12).

Conclusions

The visibility of the mandibular canal, mandibular foramen, and mental foramen can be observed using panoramic radiography. However, it is recommended that the 3D imaging method be used as cone beam computed tomography for incisive canal imaging. The sufficient imaging of anatomical landmarks should be considered before surgical procedures in the maxillofacial region. Clinicians should carefully evaluate panoramic radiographs so that complications can be avoided and patient health and satisfaction can be guaranteed.

Ethical Approval: Ethics committee approval was received for this study from Hatay Mustafa Kemal University.

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