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Fenestration and Dehiscence Types in Turkish Subpopulation Skulls

Türk Alt Popülasyonuna Ait Kuru Kafalardaki Fenestrasyon ve Dehisens Tipleri

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ABSTRACT

Objective: The objective of the study is to evaluate the fenestration and dehiscence types in Turkish human skulls according to 2 classifications.

Methods: For the study, 297 skulls with 1808 teeth were analyzed from a collection of anatomy laboratories of 2 universities. Yang's and Pan's classifications were used to determine fenestration and dehiscence types. Chi-square and Fisher's exact tests were used for statistical analysis.

Results: There was no statistical difference in the presence of fenestration and dehiscence between the maxilla and mandible ($P > .05$). Type IV was most common fenestration in the maxilla ($P = .029$). Types III and IV were the most common types in the mandible ($P < .05$). CI DI and CI DII were the most common dehiscence in the maxilla and mandible, respectively ($P < .05$). The maxillary first premolar showed the highest prevalence of fenestration ($P < .001$). The mesial root of the maxillary first molar showed the highest prevalence of dehiscence ($P < .05$).

Conclusion: The prevalence of fenestration and dehiscence was 8.70% and 10.06%, respectively, in Turkish human skulls. Fenestration in maxilla were mostly located in middle and apical of the root (type IV), the ones in mandible were in the coronal third of the root (type III). The most affected tooth was the maxillary first premolar for fenestration and the maxillary first molar for dehiscence. Most dehiscences in the maxilla were located in the coronal (CI DI), and they were located in both the coronal and middle thirds (CI DII) in the mandible.

Keywords: Alveolar bone, dehiscence, dry skull, endodontics, fenestration, mucogingival surgery

ÖZ

Amaç: Çalışmanın amacı Türk insan kuru kafataslarındaki dehisens ve fenestrasyon tiplerini iki sınıflamaya göre değerlendirmektir.

Yöntemler: Çalışma için iki üniversitenin anatomi laboratuvarlarının koleksiyonundan 1808 dişe sahip 297 kafatası analiz edildi. Fenestrasyon ve açılma tiplerinin belirlenmesinde Yang ve Pan'ın sınıflandırmaları kullanıldı. İstatistiksel analizde ki-kare ve Fisher exact testleri kullanıldı.

Bulgular: Maksilla ve mandibula arasında fenestrasyon ve dehisens varlığı açısından istatistiksel fark bulunamadı ($P>.05$). Maksillada en sık görülen fenestrasyon Tip IV idi ($P=.029$). Alt çenede en sık görülen tip III ve IV tipi idi ($P<.05$). CI DI ve CI DII sırasıyla maksilla ve mandibulada en sık görülen dehisens tipleriydi ($P<.05$). Üst birinci küçük azı dişi en yüksek fenestrasyon prevalansını gösterdi ($P<.001$). En yüksek dehisens prevalansı ise maksiller birinci moların mezial kökünde görüldü ($P<.05$).

Sonuç: Türk insan kafataslarında fenestrasyon ve dehisens prevalansı sırasıyla %8.70 ve %10.06 idi. Maksilladaki fenestrasyonların çoğu kökün hem orta hem de apikal üçlüsünde konumlanan tip IV sınıfına aitti. Mandibuladaki fenestrasyonlar ise koronal üçlüde (tip III) yerleşmişti. En çok etkilenen diş grupları; fenestrasyon için üst birinci premolar, ve dehisens için üst birinci molardı. Maksilladaki dehisensin çoğu koronal bölgede (CI DI) konumlanırken, mandibuladakileri çoğu ise hem koronal hem de orta üçlüyü içeren CI DII sınıfına aitti.

Anahtar Kelimeler: Alveolar kemik, dehisens, kuru kafatası, endodonti, fenestrasyon, mukogingival cerrahi

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INTRODUCTION

"Gomphosis," a unique type of fibrous joint, exists between the teeth and the alveolar bone that supports the root in the presence of masticatory forces.[1] The interaction between the physiology of teeth and alveolar bone is bidirectional, with advanced bone loss causing tooth mobility and missing; similarly, the nonexistence of the tooth also leads to the resorption of the alveolar bone.[2] The deficiencies in the alveolar bone and the structure of the "gomphosis" joint, which is termed fenestration or dehiscence, concern all disciplines of dentistry.[3] These defects have importance in the prognosis of periodontal surgery, implant placement, orthodontic treatment planning, the spread of an endodontic infection, or the processes of endodontic treatment, including the extrusion of irrigation solution or medicaments. Fenestration and dehiscence are the bone defects that characterize the absence of alveolar bone and the exposed root surface, and since they are generally asymptomatic and detected by periodontists during mucogingival surgery, clinical detection requires the utmost attention.[4] American Association of Endodontists described fenestration as a window-shaped defect with an intact bridge-like bone on the coronal part of the root, while dehiscence has no bridge-like bone with a total interruption of bone and a denuded root surface.[5] Etiological factors of these bone defects are various, including topography or dimensions of the root and its location on alveolar bone, periodontal or endodontic infection, trauma, high frenum attachment, abnormal occlusal forces in strength or direction, improper orthodontic forces, and in addition to these, an insufficient alveolar bone thickness that leads to malnourishment predisposes to fenestration and dehiscence.[4-6]

In different populations, many studies investigated fenestration and dehiscence using dry skulls[3,6-14] or cone-beam computed tomography (CBCT). [4,15-17] These studies reported the distribution or prevalence according to the tooth groups or different skeletal patterns. However, the detection of the presence is not sufficient from the clinical perspective. The width or height of the denuded root surface, the located root third, the involvement of apical foramen, and the coexistence of dehiscence and fenestration should be determined to estimate the prognosis or to decide the treatment. To determine the different properties of bone defects, 2 types of classifications of Yang et al[15] and Pan et al[4] were described in the literature. Yang et al[15] defined the dehiscence type as follows: CI DI, which is on the coronal third; CI DII, which is on the coronal and middle thirds; CI DIII, which is on the whole root; CII DI, which is located on the total root surface with the involvement of apical foramen; CII DII, which includes a periapical lesion; CII DIII, which is the coexistence of dehiscence and fenestration; and CIII, which is located on buccal and lingual aspects. Pan et al[4] classified the fenestration types as follows: type I, II, and III which are positioned on the apical, middle, and coronal thirds, respectively, and type IV which is placed on the apical and middle together, type V, on the middle and coronal together, and type IV, which is extended to whole root surface excluded of bone margin. There are limited data about the analysis of different patterns of fenestration and dehiscence; the literature was generally focused on the presence of defects.

Lately, according to these classifications, bone defects were investigated using CBCT.[4,15,17] Unfortunately, it is noted that CBCT has a major limitation in that it cannot detect the presence of bone and assumes a defect area in the case of bone thickness below the voxel size of the device.[18] There is no study in the literature that investigates the types of fenestration and dehiscence using a dry skull or mandible directly. Therefore, we aimed to analyze the distribution of fenestration and dehiscence types with direct observation using a dry skull maxilla and mandible. The null hypothesis of our study was that no difference would be detected between types of fenestration or dehiscence.

MATERIAL AND METHODS

Three hundred fifty-eight (358) dry adult human skulls of Turkish origin were selected from the anatomy department laboratory of Süleyman Demirel University, Faculty of Medicine, and Akdeniz University, Faculty of Medicine, with the obtained allowance. The age and gender of the skulls were unknown. Inclusion criteria were the preserved skulls, the presence of at least 1 tooth, intact alveolar bone, and no signs of dental infection as a visible bone defect in the periodontal area, alveolar bone, or the apical region of the tooth. In addition to these, teeth with completed eruption and without advanced occlusal wear or excessive caries and dry maxilla or mandible without certain postmortem damage such as cracks or fractures were included. Exclusion criteria were deformed, fragmented, or ragged alveolar bone, postmortem damage, edentate jaws, misaligned teeth, and teeth without structural integrity. Two observers of this study (D.Y., a 6-year experienced endodontist, and A.M.N., a 10-year experienced periodontist) performed the selection of skulls according to the inclusion or exclusion criteria. To exclude periodontal loss, the interproximal bone loss of each specimen was analyzed. The teeth were evaluated individually in terms of interproximal bone height rather than the general status of the teeth in the skull. The teeth with interproximal bone loss >2 mm were not included. After the inclusion and exclusion criterion, 297 skulls (133 mandibles and 164 maxillae) were selected. The samples selected were those that both observers agreed to include according to the inclusion criteria. For the study, 1808 teeth in the 297 skulls were examined.

The presence of fenestration and dehiscence according to the classifications was recorded with a direct visual examination. To define the fenestration, the presence of a bridge-like bone structure was confirmed, and the types were recorded according to Pan et al.[4] The absence of bone at least 4 mm apical to the interproximal bone[8] was defined as dehiscence and classified according to Yang et al[15] in terms of its position at the root (Figure 1). For each individual specimen that contains dehiscence, the depth of bone defect was measured with a periodontal probe (PCP UNC 15, Hu-Friedy, Frankfurt, Germany) to confirm 4 mm of bone loss.

The data analysis was performed by 2 observers (a 10-year experienced periodontist and a 5-year experienced endodontist), independently, in accordance with the classifications. Before saving the data, the observers were calibrated with the evaluation of 10% of the teeth (180 teeth); subsequently, kappa scores were stated (ranging from 0.93 to 0.94). After the calibration, the bone defect type in each individual tooth was recorded on a study chart. All specimens were examined by 2 observers independently.

Statistical analysis was performed using Statistical Package for the Social Sciences Statistics version 22.0 software for Windows (IBM Corp., Armonk, NY, USA). To compare the types of fenestration and dehiscence in the maxilla and mandible, the chi-square

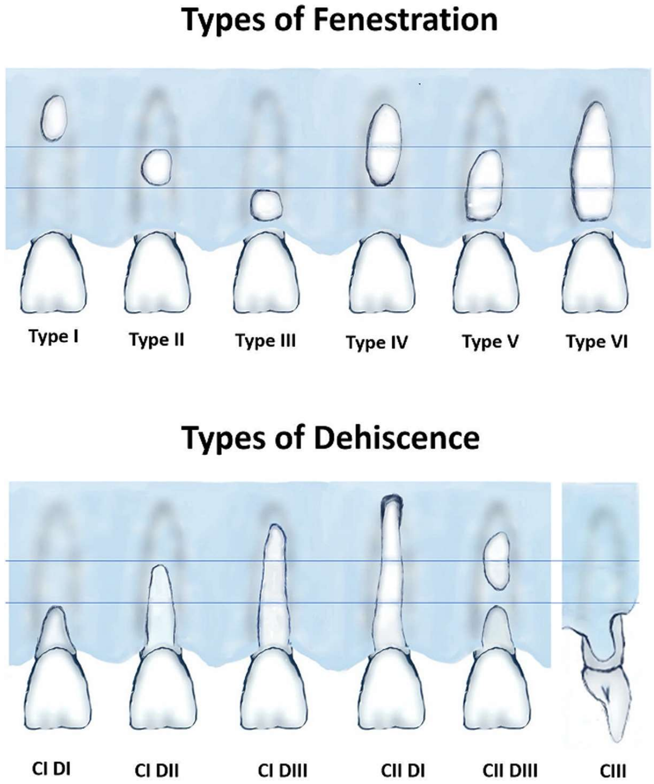

Figure 1. Types of fenestration and dehiscence.

test and, if necessary Fischer exact test, was performed. To evaluate the interobserver reliability, the Cohen's kappa test was used. The level of statistical significance was set at $P < .05$ with a 95 % CI.

RESULTS

A total of 1808 teeth were examined in 297 skulls. There was no significant difference between the maxilla and mandible in the presence of fenestration ($P = .64$) and dehiscence ($P = .12$). All fenestrations were located in the buccal aspect; there was no fenestration in the lingual aspect of the root, while 0.27% of dehiscence was located on both sides.

In terms of the distribution of the fenestration, in the maxilla, the highest rate (28.23%) was in the first premolar ($P < .001$). The lowest rate (4.65%) was in the distal root of the second molar. In the mandible, the highest (16.66%) rate was in the canine ($P = .042$). The lowest (5.58%) rates were in the distal roots of the first and second molars equally (Table 1).

Table 2 shows the distribution of the fenestration types according to the classification of Pan et al.[4] In the maxilla, the most common type of fenestration was type IV (27.05%) ($P = .029$). The rarest type was type VI (8.13%). In the maxilla, there was no statistical difference between type I (24.41%) and type II (24.41%) ($P > .05$). However, type I (24.41%), type II (24.41%), and type IV (27.05%) were statistically higher compared to type III (9.30%), type V (5.81%), and type VI (8.13%) ($P < .001$).

In the mandible, the most observed types of fenestration were type III (38.88%) and type IV (31.94%). Type VI of fenestration was not detected (Figure 2). There was no statistical difference between type III (38.88%) and type IV (31.94%) ($P > .05$). Type III (38.88%) and type IV (31.94%) were statistically higher than type I (5.55%), type II (11.11%), and type V (12.50%) ($P < .05$).

In terms of dehiscence, in the maxilla, dehiscence was most detected in the mesial root of the first molar, with a rate of 19.58% ($P = .028$). The lowest rate (4.10%) was in the mesial root of the second molar. In the mandible, the highest (18.82%) rate was in the mesial root of the first molar ($P = .032$). The lowest (5.10%) rate was in the distal root of the second molar (Table 3).

Table 3 shows the distribution of the dehiscence types according to the classification of Yang et al.[15] In the maxilla, CI DI (29.80%) was the highest type, while the rarest type was CIII (5.10%) (Table 3). CI DI was statistically higher than CI DII, CII DI, CII DIII, and CIII ($P < .001$) in the maxilla.

In the mandible, types of CII DI, CII DIII, and CIII were not detected. CI DII was the highest type with a rate of 49.41%. The rates of CI DI and CI DIII were 24.70% equally. CI DII was statistically higher compared to other types ($P = .0013$).

For the interobserver reliability, there was no statistical difference between groups according to Cohen's kappa test ($P > .05$), and the kappa score was 0.92.

DISCUSSION

Fenestration was most commonly located in the maxillary first premolar, while dehiscence was most common in the mesial root of the maxillary first molar. According to our results, type III fenestration (involving the coronal third) and CI DII dehiscence (involving coronal and middle thirds) were the most common in Turkish human skulls. The null hypothesis that no difference would be detected between types of fenestration or dehiscence was rejected. This first study to analyze the presence of fenestration and dehiscence using the human skull with direct visual examination reported the defect prevalence as 18.80% in the Turkish subpopulation.

Meticulous knowledge must be obtained before periodontal surgery. If the presence of fenestration or dehiscence is detected during the mucogingival surgery, it disperses the prognosis of the treatment and moreover, causes changes in treatment planning.[8,14] In our study, fenestration and dehiscence existed equally in the maxilla and mandible, contrary to others that report a

Table 1. The Distribution of Fenestration and Dehiscence According to the Jaw and Teeth

		Total	Central	Lateral	Canine	First Premolar	Second Premolar	First Molar		Second Molar	
								Mesial	Distal	Mesial	Distal
Defect Type	Jaw	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Fenestration	**Maxilla**	**100 (n=86)**	-	6.97 (n=6)	17.64 (n=15)	28.23 (n=24)	6.97 (n=6)	11.62 (n=10)	9.30 (n=8)	15.11 (n=13)	4.65 (n=4)
	Mandible	**100 (n=72)**	12.50 (n=9)	12.50 (n=9)	16.66 (n=12)	12.50 (n=9)	12.50 (n=9)	11.11 (n=8)	5.58 (n=4)	11.11 (n=8)	5.58 (n=4)
	P	**.64**	**-**	**.062**	**.35**	**<.001***	**.56**	**.089**	**.012***	**.058**	**.76**
Dehiscence	**Maxilla**	**100 (n=97)**	12.37 (n=12)	12.37 (n=12)	16.49 (n=16)	12.37 (n=12)	7.21 (n=7)	19.58 (n=19)	10.30 (n=10)	4.10 (n=4)	6.18 (n=6)
	Mandible	**100 (n=85)**	8.23 (n=7)	10.58 (n=9)	14.11 (n=12)	16.47 (n=14)	9.41 (n=8)	18.82 (n=16)	11.76 (n=10)	7.05 (n=6)	5.88 (n=3)
	P	**.12**	**.043***	**.29**	**.85**	**.16**	**.098**	**.70**	**.82**	**.62**	**.036***

*Statistical difference according to chi-square and Fisher's exact test ($P < .05$).

Table 2. Fenestration Types According to Pan et al[4] Classification Among Teeth and Jaws

Jaw	Type	Total	Central	Lateral	Canine	First Premolar	Second Premolar	First Molar		Second Molar		P
								Mesial	Distal	Mesial	Distal	
		% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	
Maxilla	Type I	24.41 (n=21)	-	3.48 (n=3)	3.48 (n=3)	10.46 (n=9)*	4.65 (n=4)	-	-	2.32 (n=2)	-	<.001
	Type II	24.41 (n=21)	-	3.48 (n=3)	3.48 (n=3)	6.97 (n=6)*	-	3.48 (n=3)	2.32 (n=2)	5.81 (n=5)	-	<.001
	Type III	9.30 (n=8)	-	-	-	-	-	3.48 (n=3)*	2.32 (n=2)	2.32 (n=2)	1.16 (n=1)	.001
	Type IV	27.05 (n=23)	-	-	6.97 (n=6)	10.46 (n=9)*	-	1.16 (n=1)	1.16 (n=1)	4.65 (n=4)	2.32 (n=2)	<.001
	Type V	5.81 (n=5)	-	-	-	-	2.32 (n=2)*	1.16 (n=1)	1.16 (n=1)	-	1.16 (n=1)	<.001
	Type VI	8.13 (n=7)	-	-	3.48 (n=3)	-	-	2.32 (n=2)	2.32 (n=2)	-	-	.26
	Total	**100 (n=86)**	-	**6.97 (n=6)**	**17.64 (n=15)**	**28.23 (n=24)***	**6.97 (n=6)**	**11.62 (n=10)**	**9.30 (n=8)**	**15.11 (n=13)**	**4.65 (n=4)**	**<.001**
Mandible	Type I	5.55 (n=4)	-	-	-	-	-	-	5.55 (n=4)	-	-	
	Type II	11.11 (n=8)	-	-	-	5.58 (n=4)	-	-	-	-	5.58 (n=4)	.49
	Type III	38.88 (n=28)	4.16 (n=3)	12.50 (n=9)*	4.16 (n=3)	6.94 (n=5)	-	5.58 (n=4)	-	5.58 (n=4)	-	.008
	Type IV	31.94 (n=23)	8.33 (n=6)	-	12.50 (9)*	-	-	5.58 (n=4)	5.58 (n=4)	-	-	.033
	Type V	12.50 (n=9)	-	-	-	-	12.50 (n=9)	-	-	-	-	-
	Type VI	-	-	-	-	-	-	-	-	-	-	-
	Total	**100 (n=72)**	**12.50 (n=9)**	**12.50 (n=9)**	**16.66 (n=12)***	**12.50 (n=9)**	**12.50 (n=9)**	**11.11 (n=8)**	**5.58 (n=4)**	**11.11 (n=8)**	**5.58 (n=4)**	**.042**

*statistical difference according to chi-square and Fisher's exact test ($P < .05$).

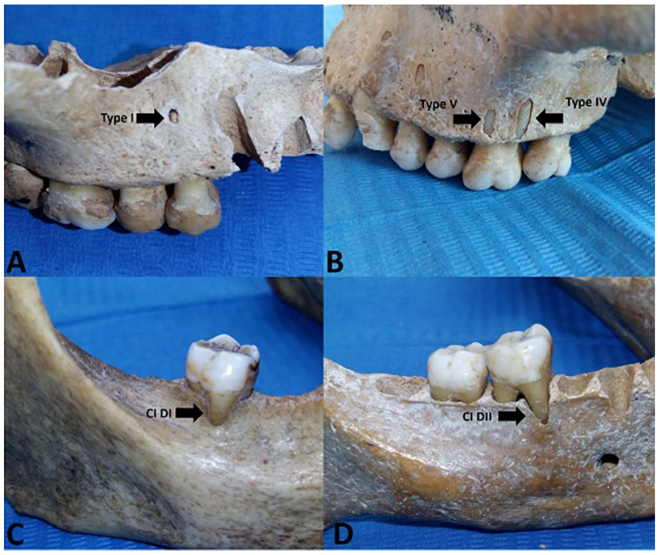

Figure 2. Types of fenestration and dehiscence. (A) Maxilla with type I fenestration. (B) Maxilla with type V and VI fenestration. (C) Mandible with CI DI dehiscence. (D) Mandible with CI DII dehiscence.

higher fenestration prevalence in the maxilla and a higher dehiscence prevalence in the mandible.[7,12,13] This difference can be attributed to racial factors or different methodologies. Another reason for various results may be related to the definition of defect. For instance, the definitions of dehiscence were different in various studies. While several studies defined it as the apically located bone crest of at least 4 mm,[8,13,14] others did not state any value in millimeters.[15,3,7,9]

Previous studies that used skulls reported a prevalence between 2.8% and 11.55% for fenestration and between 1.7% and 34.15% for dehiscence. Our study reporting 8.70% fenestration and 10.06% dehiscence rates are compatible with the literature. This study is the first report to analyze the fenestration and dehiscence with a direct visual examination using a skull in the Turkish subpopulation.

In our study, fenestration was most commonly observed in the maxillary first molar among all teeth. This result is compatible with a previous study performed in the Turkish subpopulation, which reported the highest fenestration prevalence in the first maxillary premolar compared to other teeth.[16] In addition to this study, in a previous report by the authors using CBCT in the Turkish subpopulation, they observed fenestration in 1 of the 2 maxillary first premolars.[19] In studies performed in the Turkish population, when considered in terms of racial factors, maxillary first premolar similarly showed a high fenestration rate. Besides, Pan et al[4] reported the most common fenestration in the maxillary first premolar in the Chinese population. Other studies performed in British,[8] American,[12] Egyptian,[3] North African,[13] or Mexican,[7] and South-East European[6] populations reported the most common fenestration was in the maxillary first molars.

Most studies reported that dehiscence was most common in the first molar and canines, respectively.[11-14] In our study, in the maxilla and mandible, dehiscence was most commonly located in the first molar, and mostly the mesial root was affected. Considering the first molars are the mastication center, the first located permanent teeth in the mouth, and are exposed to the centric and eccentric forces at most during mastication over time and

Table 3. Dehiscence Types According to Yang et al[4] Classification Among Teeth and Jaws

Jaw	Type	Total	Central	Lateral	Canine	First Premolar	Second Premolar	First Molar Mesial	First Molar Distal	Second Molar Mesial	Second Molar Distal	*P*
		% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	
Maxilla	CI DI	**29.89 (n=29)**	5.15 (n=5)	2.06 (n=2)	6.18 (n=6)	-	-	5.15 (n=5)	6.18 (n=6)	3.09 (n=3)	2.06 (n=2)	.85
	CI DII	**15.46 (n=15)**	-	1.03 (n=1)	1.03 (n=1)	4.12 (n=4)	7.21 (n=7)*	-	1.03 (n=1)	-	1.03 (n=1)	**.018**
	CI DIII	**22.67 (n=22)**	5.15 (n=5)	2.06 (n=2)	3.09 (n=3)	-	-	9.27 (n=9)*	2.06 (n=2)	1.03 (n=1)	-	**.016**
	CII DI	**10.30 (n=10)**	1.03 (n=1)	2.06 (n=2)	3.09 (n=3)	4.12 (n=4)	-	-	-	-	-	.273
	CII DIII	**17.52 (n=17)**	1.03 (n=1)	4.12 (n=4)	3.09 (n=3)	-	-	5.15 (n=5)	1.03 (n=1)	-	3.09 (n=3)	.76
	CIII	**5.15 (n=5)**	-	1.03 (n=1)	-	4.12 (n=4)*	-	-	-	-	-	**.019**
	Total	**100 (n=97)**	**12.37 (n=12)**	**12.37 (n=12)**	**16.49 (n=16)**	**12.37 (n=12)**	**7.21 (n=7)**	**19.58 (n=19)***	**10.30 (n=10)**	**4.10 (n=4)**	**6.18 (n=6)**	**.028**
Mandible	CI DI	**24.67 (n=22)**	2.35 (n=2)	2.35 (n=2)	1.17 (n=1)	1.17 (n=1)	3.52 (n=3)	5.88 (n=5)	5.88 (n=5)	3.52 (n=3)	-	.23
	CI DII	**49.40 (n=42)**	5.88 (n=5)	4.70 (n=4)	2.35 (n=2)	12.94 (n=11)	5.88 (n=5)	7.05 (n=6)	3.53 (n=3)	3.53 (n=3)	3.53 (n=3)	.45
	CI DIII	**24.65 (n=21)**	-	3.48 (n=3)	10.58 (n=9)*	2.35 (n=2)	-	5.88 (n=5)	2.35 (n=2)	-	-	.027
	CII DI	-	-	-	-	-	-	-	-	-	-	-
	CII DIII	-	-	-	-	-	-	-	-	-	-	-
	CIII	-	-	-	-	-	-	-	-	-	-	-
	Total	**100 (n=85)**	**8.23 (n=7)**	**9.41 (n=9)**	**14.11 (n=12)**	**16.47 (n=14)**	**9.41 (n=8)**	**18.82 (n=16)***	**11.76 (n=10)**	**7.05 (n=6)**	**3.53 (n=3)**	**.032**

*statistical difference according to chi-square and Fisher's exact test ($P < .05$).

the mastication center, a higher prevalence of dehiscence is expected compared to other teeth.

Following the first molar, in our study, the first premolar (16.47%) and canine (14.11%) showed a high prevalence of dehiscence in the mandible, respectively. Previous reports found higher dehiscence in the mandibular canine.[6-8,12,13,20] The canine guides the mastication and occlusion and is located at the corner of the dental arc, consequently subject to prominent occlusal forces. Particularly in abnormal situations such as bruxism, these teeth may be more prone to loss of the surrounding alveolar bone.

Majority of the studies reported only the existence of fenestration and dehiscence. However, detecting the types of bone defects is substantial for understanding the severity of the defect and leads the treatment planning. Our study is the first to analyze bone defect types with the aid of systematic classification by direct visual examination of the skull. A few studies scrutinized the types of fenestration and dehiscence.[4,15,17] Without a detailed classification, previous studies reported defects with the involvement of the root third[6,14] or half[13] superficially. Edel divided the root into 2 and reported that 89.5% of fenestration was located in the apical half of the root. In our study, according to the classification of Pan et al,[4] types I, IV, and VI occupy the apical half of the root; consequently, 48.54% of fenestrations are located in the apical half. Analogically to our study, previous studies that divided the root into 3 reported the most common location as the apical third (ranging from 46% to 48.5%).[6,14] In Nimigean et al.'s study, the fenestration extended apical to the middle, analogical to type IV of our study, was 4.3%, considerably lower than our study, in which the most observed fenestration was type IV (29.50%). Race is one of the most important parameters for the difference in prevalence. Besides, meteorological differences affect the results; for instance, a previous study performed in skulls did not exclude the misalignment or malposition, which is closely correlated with the presence of the bone defect.[20]

We reported the most common type of fenestration in the maxilla which was type IV, located in the apical and middle thirds, while in the mandible, it was type III, which was located in the coronal third. Pan[4] reported that the most common one was type I and contrary to our study did not detect type III.

Since types IV, V, and VI, which involve 2/3 of the root, extend wider location compared to the other types, these types require more attention in mucogingival surgery for esthetic results. On the other hand, types I, IV, and V, which involve the apex of the root, are more related to the spread of an endodontic infection or extrusion of irrigation solution or other endodontic materials rather than esthetic concerns. Fenestrations located in the apical third, and involving the apical foramen have a unique clinical significance. When the apical foramen is involved, it could cause pain that might be misdiagnosed as pulpitis or periapical pathology.[21] A previous study that used CBCT reported that type I (involving the apical third) and type IV (involving the apical and middle third) were most commonly located in the maxilla in the Greek population.[17] We found that type I predominantly existed in the maxilla; however, type IV existed equally in the maxilla and in the mandible. In our study, type VI (involving the entire root) was 8% of all types in the maxilla and not shown in the mandible. According to the previous reports, the distribution of type VI was between 0% and 6%, similar to but a little lower than our result.[4,17]

Table 4. Previous studies that reported the prevalence of fenestration and dehiscence

Study	Race	Specimens	Total Prevalence	Fenestration	Dehiscence
Abdelmalek	Egyptian	154 skull	23.84%	9%	14.84%
Larato	Mexican-Indian	108 skull	7.5%	4.3%	3.2%
Elliott	American	52 skull	20.0%	10.93%	9.19%
Edel	North African	87 skull	15.35%	11.55%	3.8%
Davies	British	389 skull	13.6%	8.3%	5.3%
Rupprecht	American	146 skull	13.0%	9.0%	4.1%
Ezawa	Japanese	96 skull	13.1%	8.0%	5.1%
Grimound	French	81 skull	26.42%	11.22%	15.20%
Volchansky	South African	100 skull	8.3%	6.6%	1.7%
Volchansky	South African (Bantu)	43 skull	12.7%	6.2%	6.5%
Jordic-Srdjak	Croatican	163 skull	43.47%	9.32%	34.15%
Nimigean	South-East European	138 skull	12.80%	8.55%	4.25%
Tal	South African	100 skull	8.4%	2.8%	5.6%
Kalaitzoglou	Greek	432 CBCT	-	3.35%	-
Yağcı	Turkish	41 CBCT	26.51%	10.28%	16.23%
Pan	Chinese	306 CBCT	-	3.37%	-
Yang	Chinese	364 CBCT	-	-	8.5%
Our study	Turkish	297 skull	18.80%	8.70%	10.06%

According to the classification of Yang et al,[15] in our study, the most common dehiscence in the maxilla was CI DI, which is located in the coronal third, and in the mandible, it was CI DII, which is located in the coronal and middle thirds. This was congruent with Yang et al.[15]

In our study, the coexistence of fenestration and dehiscence, CII DIII, was observed at a rate of 0.9%, and all were in the maxilla. Yang et al[15] classified the coexistence of defects as dehiscence and reported that the prevalence of CII DIII was 0.47% in the Chinese population. Without using this classification, a previous study reported that the prevalence of coexistence was 0.3% in the Japanese population.[22] In our study, the types of fenestration and dehiscence were analyzed using dry mandibles and maxillae. According to dehiscence classification,[15] CII DII means dehiscence with the accompanied periapical lesion. It cannot be detected with direct measurement using a skull if the lesion did not reach the outline of the bone. Thus, we excluded this type of dehiscence from the study.

In our study, all fenestrations were in the buccal aspect of the root. For dehiscence, the prevalence of CIII, which means located on both sides, was 0.27% and mostly observed in the maxillary first premolar. However, it was not detected in the mandible. Previously, lingual defects were reported between 0.023% and 3.9%,[4,6,12,14] while others reported no lingual defects.[10,7,3,20,23]

In our study, type 5 and type 6 fenestrations and CII DI, CII DIII dehiscences, which are a larger root involvement, had a lower prevalence similar to previous reports.[4,15,17] This relatively lower prevalence can be explained by the fact that the wider involvement of the defect and insufficient bone support make the tooth more prone to loss, particularly in cases such as aggressive periodontitis, and true prevalence cannot be detected.

In the literature, the prevalence of fenestration and dehiscence was investigated using CBCT or skull. Investigation using CBCT is valuable for clinical judgment, but on the other hand, it is risky compared to the direct measurement, and when used as a method in prevalence studies, it will lead to skeptical results due to the presence of alveolar bone with dimensions below the voxel size cannot be detected and is considered as a bone defect.

The prevalence or distribution in many populations and every teeth group was analyzed using dry skulls with direct observation or CBCT. Besides, the classification of dehiscence and fenestration has been defined by studies using CBCT.[4,15] However, there is a major limitation of CBCT that disturbs the results. The presence of bone cannot be viewed under a thickness less than the voxel size of CBCT, meaning that the thin bone may be regarded as a defect area. Previous studies that used CBCT demonstrated that the fenestration and dehiscence rates were 2.5 times higher with a 0.25 mm voxel size[24] and 3 times higher with a 0.36 mm voxel size than exist.[25] It is obligatory to note that, even with a high resolution, that is, the 0.125 mm voxel size, bone <1mm cannot be detected and is assumed a defect area.[26] This result renders all of the examinations that use CBCT skeptical. Thus, the types of bone defects must be directly observed to rule out radiographic obstruction. Direct visual examination is highly accurate and reliable; however, it cannot be used in the clinic. Moreover, skulls must have been well prevented to hamper the formation of post-mortem defects.

The limitations of our study are the use of the skull in the examination of bone defects and the possibility that some defects have occurred post-mortem. Besides, the age and gender of the specimens were unknown; thus, the relationship was not detected. Moreover, the type of CII DII was excluded from the analysis. To complete the analysis of classification, further studies in different populations that analyze the defect types with a direct observation using a skull or cadaver and, in addition to direct observation, using a radiographic method to confirm a possible periapical lesion of the specimens are needed. The strength of our study is that it is the first study to examine the prevalence of fenestration and dehiscence in the Turkish subpopulation with high precision using the human skull with a direct visual examination. Besides, it is also the first study in the literature to examine bone defects within the scope of systematic classification using the skull.

Considering the limitations of the study, we concluded several results; fenestration and dehiscence were similar in the maxilla and mandible. The prevalence of fenestration and dehiscence was detected at 8.70% and 10.06%, respectively, as the first report in the Turkish subpopulation using a skull. Fenestration and dehiscence were most commonly detected in the maxillary first premolar and maxillary first molar, respectively. For fenestration, type IV (involving apical and middle thirds) was most common in the maxilla, while type III (involving the coronal third) and type IV were most common in the mandible. For dehiscence, CI DI (involving the coronal third) was most common in the maxilla, while Cl DII (involving the coronal and middle thirds) was most common in the mandible.

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