

## Original Article

# Fenestration and dehiscence in the alveolar bone of anterior maxillary and mandibular teeth in cone-beam computed tomography of an Iranian population

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## ABSTRACT

**Background:** The presence of dentoalveolar lesions such as fenestration and dehiscence has great clinical importance. This study was designed to determine the incidence of bony fenestrations and dehiscences associated with the anterior teeth by using cone-beam computed tomography images. **Materials and Methods:** A total of 216 images (1189 teeth) were included in this cross-sectional study. The presence of fenestration and dehiscence at the buccal and lingual/palatal surfaces and also their relative levels on the roots of the teeth were determined. McNemar's, Chi-square, and Cochran's Q tests were used for data analysis. A value of  $P < 0.05$  was considered to be statistically significant.

**Results:** The incidence of fenestration and dehiscence was 17.6% and 3.9%, respectively with the maxillary fenestrations being more prevalent ( $P < 0.0001$ ). No significant differences were observed in the incidence of dehiscences between the jaws ( $P = 0.824$ ) and among the tooth types ( $P = 0.689$ ). The lesions were more frequent at the buccal surfaces (80%–92.5%). About 85.9% of the fenestrations occurred in the apical root thirds, whereas dehiscences had the highest prevalence in the cervical thirds. Fenestration and dehiscence incidences were significantly higher in females ( $P < 0.05$ ). There was no significant difference among the age groups regarding these lesions.

**Conclusion:** Fenestration and dehiscence were observed more on the buccal surfaces and also in the apical and cervical root thirds, respectively. Age had no significant influence on the occurrence of these lesions in contrast to the sex.

**Key Words:** Alveolar bone, cone-beam computed tomography, mandible, maxilla, periodontics

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## INTRODUCTION

The alveolar bone is part of the periodontal tissue, and its anatomy is different in different patients. It is affected by the location, angulation, and tilt of the teeth as well as by occlusal forces. The anatomy of the alveolar bone is of great clinical importance

because of the presence of dentoalveolar lesions such as fenestration and dehiscence. Fenestration is the condition, in which the bony coverage of the root surface is lost, and the root surface is only covered by

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the periosteum and gingiva. In such lesions, marginal bone is intact. When this bone defect spreads toward the marginal bone, it is called dehiscence.<sup>[1]</sup>

Fenestration and dehiscence bone defects are observed more in the facial than lingual root surfaces and also more in anterior than in posterior teeth.<sup>[1]</sup>

Curved and protruding root form, labial tooth protrusion, occlusal trauma, bruxism, and tooth movement along with the thin cortical bone plate are some of the predisposing factors for these bone defects.<sup>[2]</sup>

Therefore, dentists should have adequate knowledge of the anatomy of normal bone to achieve satisfactory results, to improve esthetic outcomes and to prevent complications of periodontal, endodontic, and orthodontic treatments. It is recommended that dentists determine the alveolar bone morphology through imaging before treatment.<sup>[3]</sup>

The diagnosis of fenestration and dehiscence is not easy clinically because although clinical findings derived from the gingival probing and conventional radiographic modalities can provide the guidelines for evaluating the alveolar bone defects, not fenestrations.<sup>[4]</sup>

Two-dimensional modalities include bitewing; periapical and panoramic radiographs are used to help in periodontal examinations. These modalities have limitations such as overlapping of anatomical structures, difficulty in standardization and determination of the dimension, and the presence of bone defects.<sup>[5,6]</sup>

Braun *et al.* showed that using cone-beam computed tomography (CBCT), the precise analysis of periodontal defects becomes possible due to the third dimension. Thus, bone defects could be detected significantly more accurate.<sup>[7]</sup>

CBCT is a novel method in dentistry with proven superiority in the maxillofacial area over computed tomography (CT) scan. CBCT exposes the patient to less radiation than does CT.<sup>[8]</sup> CBCT has suitable capability in assessing the alveolar bone because of its high resolution. In this technique, the evaluation of small defects of the alveolar bone and their locations is possible because of the lack of superimposition of adjacent structures.<sup>[8]</sup>

There are several studies<sup>[5,7,9-12]</sup> and reviews,<sup>[13-15]</sup> on different aspects of using CBCT in the analysis of

periodontal bone defects and soft-tissue structures. Mengel *et al.*<sup>[11]</sup> and Leung *et al.*<sup>[16]</sup> did *in vitro* studies on the accuracy and reliability of CBCT in the detection of periodontal bone defects.

Several studies have determined the frequency of bony defects such as fenestration and dehiscence in the alveolar processes on dry human skulls through autopsy in several countries.<sup>[17,18]</sup> In addition, the major studies on human populations have compared the frequency of these lesions on different classes of facial skeletal deformities.<sup>[19,20]</sup>

To the best of our knowledge, no epidemiological survey has been conducted on an Iranian population on alveolar bone defect. These epidemiological studies help to plan proper treatment strategies, particularly in orthodontic treatment. These findings could be helpful how to be applied orthodontic force on the teeth having this kind of alveolar bone defects.

With the possibility of using the CBCT imaging archive and considering the current lack of sufficient information about this population, this study was designed to assess the incidence of fenestration and dehiscence and the locations of these lesions on the root surfaces of maxillary and mandibular anterior teeth by CBCT images.

## MATERIALS AND METHODS

In this cross-sectional study, all CBCT images of patients who had been referred to a Private Maxillofacial Radiology Center and School of Dentistry in Rasht during 2016 were reviewed. This study was confirmed by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1396.48). After evaluating all available CBCT images, those of CBCT images of the patients with normal dentoalveolar structures of anterior maxillary and mandibular teeth are included in this study.

However, generalized bone loss secondary to periodontal disease or a systemic condition, positive history of trauma, orthodontic treatment, and the presence of apical lesion as well as root canal therapy on anterior maxillary or mandibular teeth were considered as exclusion criteria. Poor quality CBCT images were also excluded from this study.

CBCT images were obtained with a Vatech CBCT device (Gyeonggi-do, Korea) (voxel size: 0.2 mm, FOV: 8 cm × 8 cm for maxilla or mandible mode and 12 cm × 9 cm for maxilla and mandible mode) from

the faculty of dentistry in Rasht, Iran, and with a New Tom VG (Verona, Italy) (voxel size: 0.2–0.24 mm, FOV: 10 cm × 10 cm for standard zoom mode and 22.5 cm × 22.5 cm for full zoom mode) from a private maxillofacial radiology clinic.

After the reconstruction of volumetric data, cross-sectional images with 1-mm thickness and distance in buccolingual or buccopalatal dimensions were provided. Two maxillofacial radiologists independently evaluated cross-sectional and axial images for the presence or absence of fenestration and dehiscence. Figures 1 and 2 illustrate fenestration and dehiscence in cross-sectional views of anterior maxillary teeth. In addition, the locations and extension of the bony lesions were designated according to the cervical, middle, and apical third of buccal or lingual (palatal) surfaces.

Fenestration was considered as a local bone defect or as bone exposure of overlying alveolar bone on the root surface with the intact marginal bone. When the bone defect spread to the marginal bone, this was considered to be dehiscence. In equivocal cases, the reported results were based on the consensus agreement between the two observers. Two observers were maxillofacial radiologists having more than 10 years of experience on CBCT images. After 2 weeks, the observers reviewed the 20 images again to determine intraobserver reliability.

### Statistical analysis

After data collection, the data were entered into SPSS, 22 (IBM Corporation, Armonk, NY, USA). The frequencies of fenestration and dehiscence were determined by a 95% confidence interval.

To compare the frequency of dehiscence and fenestration based on the involved jaw, the tooth type, and the location of the lesions along root surfaces, McNemar’s test was used. The Chi-square test and Cochran’s Q tests were used to compare the frequency of these lesions in the gender and age groups. A value of  $P < 0.05$  was considered to be statistically significant.

## RESULTS

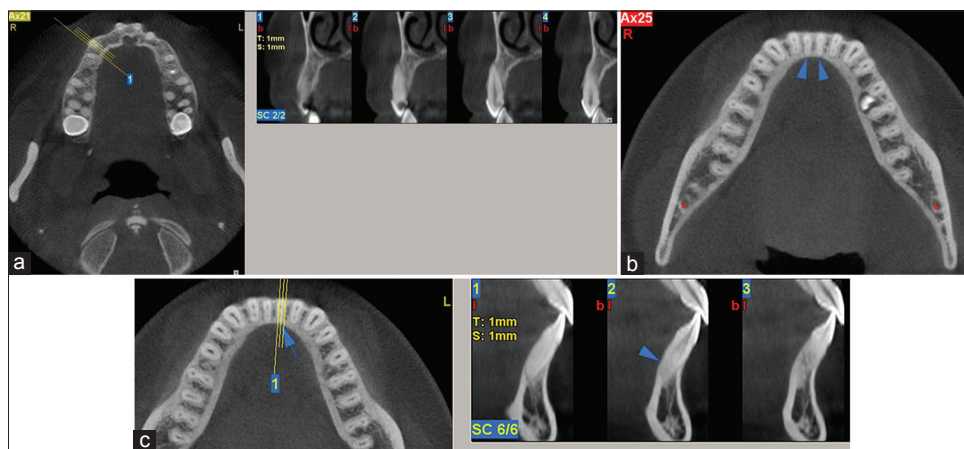
In this cross-sectional study, 216 image samples were reviewed to determine the presence of fenestration and dehiscence. A total of 67.6% of the images (146 cases) were from females and 32.4% (70 cases) from males. Most of the samples (72.2%) were from individuals between the ages of 30 and 60 years.

The frequency of fenestration in 216 CBCT images was 17.6% (13%–23.1%, with 95% confidence interval). Dehiscence was observed in 9.3% (5.9%–13.7%, 95% confidence interval) of cases. Table 1 illustrates that there was a statistically significant difference between the maxilla and mandible ( $P = 0.0001$ ) in the frequency of fenestration, but there was no statistically significant difference ( $P = 0.82$ ) in the frequency of dehiscence between the jaws.

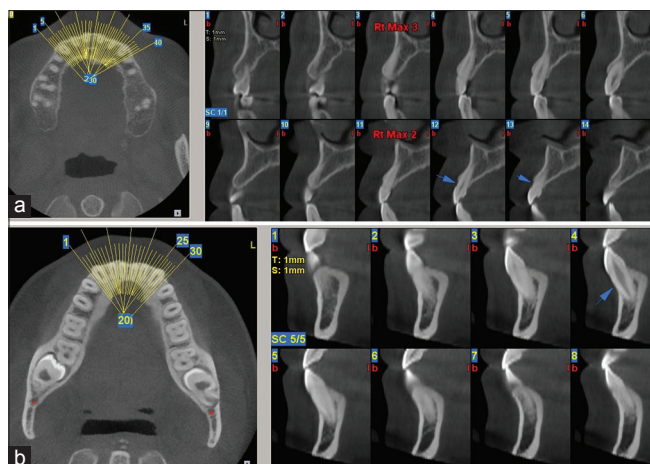
**Table 1: Comparison of frequency of fenestration and dehiscence in the maxilla and mandible**

Bone defects	Jaw	Absence, n (%)	Presence, n (%)	$P^*$
Fenestration	Maxilla	181 (83.8)	35 (16.2)	0.0001
	Mandible	213 (98.6)	3 (1.4)	
Dehiscence	Maxilla	205 (94.9)	11 (5.1)	0.824
	Mandible	207 (95.8)	9 (4.2)	

\*McNemar’s test,  $P \leq 0.05$



**Figure 1:** Fenestration bone defect at the apical third of the right maxillary canine in cross-sectional view (a) and lingual aspect of mandibular central incisors in axial view (b) and in cross-sectional view of left mandibular central incisor (c).



**Figure 2:** Dehiscence bone defect at the cervical third of the right maxillary tooth in cross-sectional view (a) and at the level of middle third toward cervical portion of right mandibular central incisor (b).

**Table 2: Comparison of the frequency of fenestration and dehiscence based on tooth number in the maxilla and mandible**

Lesion	Jaw	Tooth	n (%) total=1189	P*
Fenestration	Mandible	Canine	1 (0.08)	0.0001
		Lateral	4 (0.336)	
		Central	2 (0.168)	
	Maxilla	Canine	27 (2.27)	
		Lateral	15 (1.26)	
		Central	17 (1.42)	
Dehiscence	Mandible	Canine	8 (0.673)	0.689
		Lateral	4 (0.336)	
		Central	2 (0.168)	
	Maxilla	Canine	6 (0.504)	
		Lateral	6 (0.504)	
		Central	4 (0.336)	

\*Cochran's Q test,  $P \leq 0.05$

The frequency of fenestration and dehiscence in the 1189 teeth was 5.55% and 2.52%, respectively. Table 2 details the frequencies of these bone defects based on tooth number (type).

The frequency of fenestration and dehiscence in this study was much higher in females than in males, and these differences were statistically significant ( $P = 0.016$  for fenestration and  $P = 0.032$  for dehiscence). Meanwhile, the frequency of fenestration and dehiscence did not show any significant difference between age groups [Table 3].

In this study, 85.9% of fenestration lesions were detected in apical thirds, 12.6% in middle thirds, and 1.4% in cervical thirds. It should be noted that the number of cases of fenestration increased from

66 to 71 because the lesions can spread out to more than one level. Because dehiscence spreads from the alveolar bone crest, 100% of the lesions were found in the cervical third, 30% of cases spread up to the middle third, and only 6.6% of cases spread up to the apical third level [Table 4].

A total of 92.5% of fenestration and 80% of dehiscence lesions were observed on the buccal aspect of root surfaces [Table 5].

## DISCUSSION

To evaluate the frequency of fenestration and dehiscence lesions, different methods are used, such as imaging and anthropology. In several studies, human dried skulls were used to evaluate fenestration and dehiscence lesions,<sup>[3,17,18,21,22]</sup> whereas other studies<sup>[19,20,23-25]</sup> used CBCT images for this evaluation.

Assessing fenestration and dehiscence lesions using human dried skulls not only reduces the risk of non-recognition of these lesions but also eliminates the ability to observe the presence of these lesions clinically. Therefore, the use of CBCT images could be helpful in making appropriate treatment plans because of their ability to detect periodontal lesions and alveolar bone defects.<sup>[24]</sup>

In Mengel *et al.*'s study, CBCT, in comparison with the histologic specimens, revealed a mean deviation of  $0.19 \pm 0.11$  mm in the measurement of the alveolar bone defect.<sup>[11]</sup> In Leung *et al.* study, alveolar bone height can be measured to an accuracy of about 0.6 mm using a voxel size of 0.38 mm in CBCT. They presented that root fenestrations can be defined with greater accuracy than dehiscences.<sup>[16]</sup>

In the present study, the frequencies of fenestration and dehiscence in the studied sample were 17.6% and 9.3%, respectively, which is very low compared to the Nimigean *et al.*'s study, which found 89.58% for both lesions.<sup>[3]</sup> This difference can be explained by the Pan *et al.* theory.<sup>[24]</sup> In dry skulls, the structures of the tooth and alveolar bone are different; therefore, when they are exposed to the air and the soil (especially at labial levels), the alveolar bone is destroyed faster than the teeth, thus causing bone lesions.<sup>[24]</sup> In Nimigean *et al.*'s<sup>[3]</sup> study, they studied on dry skulls.

In our study, the prevalence of root fenestration based on the available anterior surface of the teeth was

**Table 3: Comparison of the frequency of fenestration and dehiscence based on the variables of sex and age groups**

Independent variables	Presence of fenestration, n (%)	P*	Presence of dehiscence, n (%)	P*
Sex				
Male	6 (15.8)	0.016	11 (55)	0.023
Female	32 (84.2)		9 (45)	
Age groups (years)				
≤20	1 (2.6)	0.365	1 (5)	0.714
20-30	3 (7.9)		4 (20)	
30-40	12 (31.6)		5 (25)	
40-50	13 (34.2)		2 (10)	
50-60	6 (15.8)		6 (30)	
60 ≥	3 (7.9)		2 (10)	

\*Chi-square test, P≤0.05

**Table 4: Distribution of fenestration and dehiscence on different levels of root surface**

Levels	Location of fenestration, n (%)	Extension of dehiscence, n (%)
Apical 3 <sup>rd</sup>	61 (81.5)	2 (6.6)
Middle 3 <sup>rd</sup>	9 (12.7)	9 (30)
Cervical 3 <sup>rd</sup>	1 (1.4)	30 (100)

**Table 5: Distribution of fenestration and dehiscence on involved root surfaces**

Root surface	Fenestration, n (%)	Dehiscence, n (%)
Buccal	61 (92.5)	24 (80)
Lingual	4 (6)	4 (13.3)
Palatal	1 (1.5)	2 (6.7)
Total	66 (100)	30 (100)

5.5%, which is consistent with the results obtained from other studies.<sup>[3,17,18,21,22,24]</sup>

The prevalence of dehiscence in the current study is 9.3% (2.52% of total teeth), which is much lower than what was reported by Yang *et al.*<sup>[25]</sup> (75% of participants, 8.8% of total teeth), Nimigean *et al.*<sup>[3]</sup> (53.6% of participants, 4.25% of total teeth), and Rupprecht *et al.*<sup>[21]</sup> (40.4% of participants, 4.1% of total teeth). The significant difference in the prevalence of dehiscence in the present study is likely because we only evaluated the anterior teeth, whereas other studies evaluated all teeth.<sup>[3,17,18,21,22,25]</sup>

On the other hand, differences in the prevalence of fenestration and dehiscence in various studies may be due to different measurement methods, racial variety, and how to interpret lesions in dried skulls or CBCT images.<sup>[24]</sup> Rupprecht *et al.*<sup>[21]</sup> also noted that different diagnostic criteria in different studies can influence the outcomes, and hence that the definition of

dehiscence varies from an alveolar bone defect in the absence of a cortical bone plate to an exposed root surface. The degree of dehiscence bone defect varies from 1 mm to 4 mm from the alveolar bone crest; this can, therefore, affect the results.<sup>[24]</sup>

In the current study, a higher incidence of fenestration was observed in the maxilla than in the mandible (16.2% vs. 1.4%), followed by canine, lateral, and central teeth. Most previous studies<sup>[17,19-22,24]</sup> reported similar results with a higher frequency of fenestration bone lesions in the maxilla than in the mandible.

Rupprecht *et al.*<sup>[21]</sup> and Nimigean *et al.*<sup>[3]</sup> reported the prevalence of fenestration based on the tooth number in the first molar, maxillary molar, mandibular molar, maxillary canines, mandibular canine, and lateral mandibular incisor. In Tal *et al.*'s study,<sup>[18]</sup> as in our study, the highest frequency of fenestration was observed in canine teeth. Pan *et al.*<sup>[24]</sup> reported that the prevalence of fenestration was higher in the maxillary first premolars, lateral incisors and canines, and mandibular molars. They believed that this difference in the prevalence of fenestration in teeth remains unknown in different populations.

While in the present study, the frequency of dehiscence in the maxilla and mandible was not significantly different, nearly all previous studies<sup>[18-22]</sup> reported a higher prevalence of dehiscence in the mandible, followed by the mandibular premolar and canine teeth.

In our study, the prevalence of bone defects was reported more on the buccal surface (92.5% of fenestration bone defect and 80% of dehiscence bone defect) than on the lingual or palatal

surfaces. This finding is similar to the report of Rupprecht *et al.* (94.5%).<sup>[21]</sup> Nimigean *et al.*<sup>[3]</sup> and Tal<sup>[18]</sup> did not report any lesions at the lingual or palatal surfaces. Most previous studies reported the same results regarding the location of bone lesions on the buccal, palatal, and lingual surfaces.<sup>[19,21,22,24,25]</sup>

In this study, the highest frequency of fenestration was observed in the apical third (85.9%). In other studies,<sup>[3,21,22,24]</sup> the frequency of fenestration was reported to range from 54.73%–92.57%. However, due to the nature of dehiscence lesions, 100% of the lesions were observed in the cervical area, while in 30% of cases, they extended up to the middle third and only in 6.6% of cases did they spread to the apical portion. The results of the present study were consistent with the Yang *et al.* study.<sup>[25]</sup>

In the present study, the prevalence of fenestration and dehiscence lesions was significantly higher in females than in males. There were no significant differences in the prevalence of bone defects between female and male groups in some studies,<sup>[18,24]</sup> while a much higher incidence of these lesions was reported in females than in males in other studies.<sup>[21,25]</sup> The reason for this difference is believed to be the thinness of the alveolar bone in females.

There was no significant difference among the age groups in terms of the frequency of fenestration and dehiscence. This result is consistent with Yang *et al.*'s study.<sup>[25]</sup> However, some researchers<sup>[3,21,24]</sup> reported that the prevalence of fenestration and dehiscence decreases with age. The logical reasoning for this concept is that aging increases the chance of periodontal disease, and hence, the deterioration of these bony defects is intensified, and the teeth are lost. Therefore, the prevalence of the bone defects of dehiscence and fenestration are lower in the remaining available teeth.<sup>[24]</sup>

In general, the position of teeth in the dental arch seems to be one of the most important determinants of alveolar bone thickness and contour.<sup>[3]</sup> After mucogingival flap surgery, the marginal bone naturally remodels to repair. If the alveolar bone is thin, sufficient bone healing does not occur after the surgery, and the risk of bone loss increases. Such conditions convert existing fenestration lesions to dehiscence and small dehiscence lesions to a widespread problem.<sup>[21,25]</sup>

Kim and Kratchman noted that marginal bone defects have a significant effect on the prognosis of endodontic surgeries. If the thickness of the buccal bone is >3 mm, then desirable results will be obtained.<sup>[26]</sup> Spray *et al.* concluded that if the thickness of the alveolar bone is >2 mm, the long-term results of implant placement would be satisfactory.<sup>[27]</sup> Merheb *et al.* also reported that dehiscence affects implant stability. It is recommended that bone augmentation before implant surgery be performed in patients with thin alveolar bones.<sup>[28]</sup>

Furthermore, the alveolar bone must be examined before orthodontic treatment to detect the presence of fenestration and dehiscence in the bone. These bony defects are present on the alveolar bone coverage of the prominent and buccally-protruded roots. These teeth are more likely to exhibit fenestration and dehiscence. Thus, rapid orthodontic movements can aggravate alveolar bone lesions and spread bone loss. In such situations, gingival augmentation is recommended before beginning orthodontic treatment.<sup>[21]</sup>

One clinically important factor is that fenestration and dehiscence are not detectable by conventional radiographs. These lesions are usually detected by exposure of the alveolar bone during periodontal surgeries. The presence of fenestration and dehiscence lesions can interact with the process of wound healing.<sup>[3]</sup>

Further studies of the effects of fenestration and dehiscence on the extent and pattern of alveolar bone loss as well as on repair following surgical treatments are needed. It is also important to conduct more studies to determine the frequency of fenestration and dehiscence lesions on all tooth numbers in the Iranian population, and hence that high-risk areas will become more apparent during the planning for periodontal surgeries and orthodontic treatments.

## CONCLUSION

The prevalence of fenestration in this study was consistent with the results of previous studies. The prevalence of dehiscence in this study was lower than the results of previous studies. The frequency of fenestration was higher in the maxilla, especially on labial surfaces. The maxillary canines were the most common sites of fenestration. Fenestration was

detected most often in the apical third. Dehiscence extension was observed more in the cervical 3<sup>rd</sup>, followed by the middle thirds. The prevalence of alveolar bone defects was higher in females than in males.

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### Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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