Original Article

Classification of Alveolar Bone Destruction Patterns on Maxillary Molars by Using Cone-beam Computed Tomography

G Ozcan, AE Sekerci

Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Erciyes University, 38039 Kayseri, Turkey

Abstract

Objective: The defective diagnosis of alveolar structures is one of most serious handicaps when assessing available periodontal treatment options for the prevention of tooth loss. The aim of this research was to classify alveolar bone defects in the maxillary molar region which is a challenging area for dental implant applications. To our knowledge, this is the first study of periodontal bone defect prevalence by using cone-beam computed tomography (CBCT). **Materials and Methods:** In this study, the remaining alveolar bone patterns of 669 maxillary molars of 243 patients with periodontal bone loss were investigated on four aspects and the furcation areas of teeth, and then they were classified into six main groups. Combined periodontal-endodontic lesions (CPELs) were also reported in another category. **Results:** Following exclusion of 39 (5.8%) teeth with CPEL, the most common group was horizontal bone defects (71.4%) and the least seen group was three-walled vertical bone defects (1.9%) in all alveolar bone sides of teeth. Osseous crater was found at the rate of 6.7% on interdental alveolar bone. Dehiscence and fenestration were detected at rates of 2.7% and 3.3%, respectively. In the assessment of furcation areas, there was no furcation involvement in 61.4% of all teeth and the rate of Grade-II involvements was 26.2%. **Conclusions:** The most appropriate treatment option may be decided through accurate imaging of periodontal defect morphology. CBCT can provide comprehensive information about the remaining alveolar bone structures. In this way, the need for dental implant can be prevented in many cases and be replaced with a more conservative approach on the maxillary molar region.

Keywords: *Classification, cone-beam computed tomography, maxillary molars, periodontal bone loss, prevalence*

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Introduction

Accurate evaluation of the remaining bone morphology is essential for the diagnosis, treatment planning, and prognosis of periodontal diseases.[1] Clinical probing and intraoral radiography are still the basic diagnostic tools in periodontology. On the other hand, studies have proved the limitations of both techniques in the determination of bone loss patterns.[2-4] The major limitation of these techniques is their deficiency in assuring available three-dimensional (3D) parameters to define the classification of alveolar bone destruction, especially the evaluation of complex defect structures such as combined intrabony defects, craters, and furcation involvement.[5] Cone-beam computed tomography (CBCT) provides high contrast 3D images of periodontal structures that help to determine a definite diagnosis and treatment options for successful periodontal therapy.

Periodontal disease begins with inflammation from the gingiva. If the problem is not treated, the inflammation spreads to the bone and leads to induce the destruction of the alveolar bone. Most studies

Address for correspondence: Dr. G Ozcan, Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Erciyes University, 38039 Kayseri, Turkey.
E-mail: gozcan89@gmail.com

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suggest a distance of 2 mm from the cementoenamel junction (CEJ) to the alveolar crest (AC) to reflect normal periodontium.[6-8] If this distance is more than 2 mm, it means the presence of periodontal bone loss. Periodontal bone loss classification is investigated in seven main groups: Horizontal and vertical (angular) defects, craters, furcation involvement, dehiscence, fenestration, and combined endodontic-periodontal lesions [Figure 1]. Vertical defects were classified by Goldman and Cohen on the basis of the number of osseous walls so that they may have one, two, or three walls [Figure 2a-c].[9] Sometimes, the number of walls in the apical portion of the defect is often greater than its occlusal portion, in which case the term "combined osseous defect" is used [Figure 2d1-d3]. Osseous crater is another type of bone loss in which concavities in the crest of the interdental bone are confined within the facial and lingual walls [Figure 2e].[10] When a bone loss of alveolar bone occurs on the facial or lingual surface of a tooth that may extend to the full length of the root, it is called "dehiscence" [Figure 2f]. When a "window" of bone loss occurs on the facial or lingual aspect of a tooth that is bordered by alveolar bone along its coronal aspect, it is called "fenestration" [Figure 2g].[11] In 1958, Irving Glickman graded furcation involvement into four classes by qualifying the range of the bone destruction in the furcation area [Figure 2h1-h3], by Glickman.[12] When an angular intrabony defect communicates with a periapical lesion in the pulpal origin, it results in a "combined periodontal-endodontic lesion (CPEL)"[Figure 2i1 and i2].[13]

The posterior maxilla has been associated with significantly higher implant failure rates compared to other sites of alveolar bone due to its having thin cortical bone and large marrow spaces.[14] In addition, clinical difficulties because arise procedures such as maxillary sinus elevation and bone augmentation are usually needed to increase the amount of vertical bone height in the posterior maxilla.[15] For these reasons, the preservation of a hazardous maxillary molar becomes a reasonable conservative treatment option, especially in periodontitis patients.[16]

Horizontal bone loss and bone craters generally cannot be treated with regeneration; thus, these lesions require flap surgery combined with osseous surgery.[17] For intrabony (vertical) defects, if the contour of the remaining bone and the number of osseous walls are suitable, there is a perfect opportunity for bone regenerating to practically the level of the AC.[18] Therefore, accurate diagnosis of alveolar defects by CBCT is critically important in terms of treatment options.

The purpose of this study was to evaluate the diagnostic value of CBCT in examining the 3D topography of alveolar bone defects to determine the regeneration and reconstruction potential when considering treatment options for the maxillary molar area which is a troublesome region for endosseous implants.

Materials and Methods

Images contained either conventionally or digitally should allow acquiring measurements that reproduce the actual status to determine whether there is remaining alveolar bone structure for periodontal treatment planning.[19] To properly and accurately depict periodontal bone status, proper techniques of exposure and development are required. Standardized, reproducible techniques are required to obtain reliable radiographs for pre- and post-treatment comparisons.[20] CBCT offers many advantages over conventional radiography, including the accurate 3D imaging of teeth and supporting structures. CBCT avoids the problems of geometric superimposition and unpredictable magnification and can provide valuable diagnostic information in periodontal evaluation.

The Ethics Committee of the University of Erciyes, Faculty of Dentistry, approved the study protocol. It was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Written informed consent was obtained from the patients.

The CBCT database was searched and patients whose CBCT images included the maxilla (NewTom 5G with a voxel size of 0.125 mm) were selected from the archive of the Department of Oral and Maxillofacial Radiology at the Faculty of Dentistry. The CBCT images had been taken because of the patients' previous dentomaxillofacial problems. Of 2219 patients, 502 patients who also underwent panoramic radiographs (Instrumentarium OP200D digital, 66–85 kVp, 10–16 mA, 14.1 s exposure time) were determined.

The exclusion criteria were edentulous posterior maxilla and any pathologic lesions on the posterior maxilla and presence of distance from the CEJ to the AC of <2 mm on the maxillary molars. In the examination of CBCT scans, endodontic treatments and metallic restorations with scatter effects and inadequate CBCT image quality in the related region (due to patient movement, operator errors, etc.,) were also excluded from the study. The final sample group included data from 669 teeth (347 right, 322 left) of 243 patients (126 men and 117 women).

For all CBCT images, limited fields of view of 8 cm × 8 cm, 8 cm × 16 cm, 12 cm × 8 cm, and 15 cm × 12 cm were selected and the data were reconstructed with slices at an interval of 0.25 mm.

The CBCT maxillary images were analyzed in the NNT viewer, which is a simple version of the NNT Software in a Dell Precision T5400 workstation (Dell, Round Rock, TX, USA), and a 32-inch Dell liquid crystal display screen with a resolution of 1.280 × 1.024 pixels in a darkroom. The contrast and brightness of the images were adjusted using the image processing tool in the software to ensure optimal visualization. Standard exposure and patient positioning protocols were used for all the patients.

On the CBCT images, the morphology of the AC was classified as a horizontal or vertical defect (one-walled, two-walled, three-walled, or combined osseous defect) on four surfaces (mesial, distal, buccal, and palatinal) of the maxillary molars. Otherwise, osseous crater defects were defined on the interdental area of teeth. Dehiscence and fenestration were identified on buccal and palatinal alveolar bone. Of these, furcation involvements (none, Grade I–II, or III) and CPEL were detected to place in another category.

Statistical analysis

Statistically significant differences were evaluated using the Chi-square test with SPSS 16.0 for Windows (SPSS, Chicago, IL, USA). The total number of defects, unilateral or bilateral occurrences, and the incidence and the correlations between the left and right side and between males and females with age in decades were analyzed. $P < 0.05$ was considered statistically significant. To check for the diagnostic reproducibility of the inter-reliability of the investigators, 10% of the CBCT images assigned by them were randomly examined each day for two consecutive weeks. Examination of results using the Wilcoxon matched pairs signed-rank test showed no statistically significant differences between two observers indicating diagnostic reproducibility.

Results

The study consisted of 117 (48.1%) females and 126 (51.8%) males. The mean age of the patients was 43.7 (standard deviation 9.9), with ages ranging from 20 to 75 years. Following the removal of 39 teeth with CPEL, to classify the presence of alveolar bone loss, a distance of 2 mm from the CEJ to the AC was used as the parameter of normality. Bone loss was found at 2520 sites in relation to 630 teeth. There were 1799 sites (71.38%) with horizontal bone loss and 512 sites (20.33%) with vertical bone loss. Among the vertical bone defect sites, 42 sites presented combined osseous defects with a rate of 6.86%. On buccal and palatinal alveolar bone, dehiscences and fenestrations were determined at 34 (2.69%) and 42 (3.33%) sites, respectively. Crater osseous defects were detected at 86 sites (6.74%) on the mesial and distal alveolar bone of teeth. Furthermore, 387 teeth (61.42%) showed no furcation involvement. Table 1 gives an overview of the frequency percentage of all kinds of defects and the grades of furcation involvements.

The results of the frequency percentage of bone loss patterns of maxillary molar teeth according to gender and also the value of gender comparisons are presented in Table 2. There were no significant differences between males and females for each tooth ($P > 0.05$). The frequency percentage of various periodontal defects according to decades for intervals is shown in Table 3. The prevalence of vertical defects increases with age that of osseous craters decreases with age.

The frequency distribution of various periodontal defects of the maxillary molar teeth and also the value of bilateral comparisons are summarized in Table 4. The value of the distal surface of the first molars was only just significantly different ($P = 0.03$). In addition, the prevalence of craters and combined defects was highest between the first and second molars. The three-walled vertical defect was commonly seen on the second molars. Table 5 shows the distribution of furcation involvements according to gender and decades for intervals. The results revealed that the furcation grades increased with age. The value of comparisons between males and females and total percentage for age decades are also presented in Table 5. The gender comparison in the first molars was significantly different ($P = 0.04$). The distribution of CPEL according to gender and decades for intervals and total percentage of CPEL for each tooth and gender are shown in Table 6. The highest rate of CPEL was observed at #16 (10.7%).

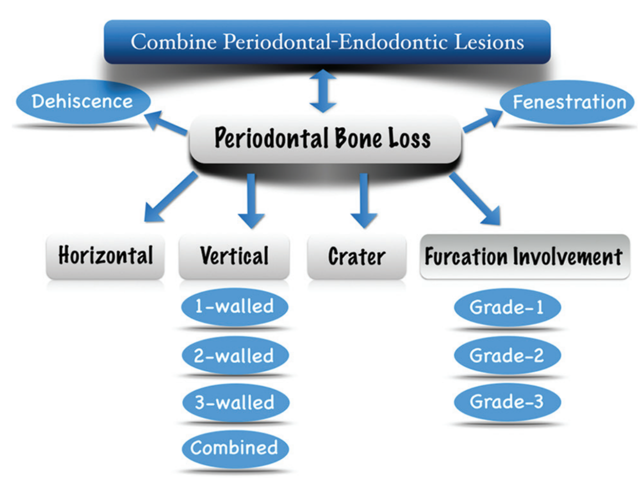

Figure 1: The classification of alveolar bone loss

Table 1: The frequency percentage of various periodontal defects and furcation involvements of maxillary molar teeth

	16 (*n*=108)	17 (*n*=142)	18 (*n*=74)	26 (*n*=109)	27 (*n*=133)	28 (*n*=64)	Total (*n*=630)
None	1.38	0.88	0.33	0.22	0.18	0.78	0.63
Horizontal	69	70	78.7	70.6	72.7	68.3	71.38
Vertical-1	7.9	10	9.1	7.5	9.2	9.7	8.92
Vertical-2	3.5	2.6	2	2	3.3	1.5	2.65
Vertical-3	1.1	2.6	2	0.6	3	1.1	1.9
Combined	5.3	7	4.7	8.2	7.9	7	6.86
Crater	7.4	10.2	4.7	7.8	5.3	1.6	6.74
Dehiscence	4.6	2.1	1.3	6	0.8	0.8	2.69
Fenestration	8.8	1	0	7.3	1.5	0	3.33
Furcation-0	51.9	55.6	86.5	53.2	57.9	82.8	61.42
Furcation-1	6.5	11.3	4.1	4.6	11.3	3.1	7.61
Furcation-2	33.3	29.6	9.5	33.9	25.6	14.1	26.2
Furcation-3	8.3	3.5	0	8.3	5.3	0	4.76

Table 2: The frequency percentage of various periodontal defects of maxillary molar teeth according to gender and also value of gender comparisons

	16		17		18		26		27		28	
	Male (*n*=52)	Female (*n*=56)	Male (*n*=73)	Female (*n*=69)	Male (*n*=36)	Female (*n*=38)	Male (*n*=60)	Female (*n*=49)	Male (*n*=66)	Female (*n*=67)	Male (*n*=38)	Female (*n*=26)
Mesial												
None	0	7.1	1.4	0	0	0	0	0	0	0	0	0
Horizontal	63.5	71.4	46.6	40.6	33.3	42.1	27	73.5	47	29.1	36.8	52
Vertical-1	15.4	7.1	11	18.8	33.3	31.6	7.1	10.2	22.7	7.7	36.8	28
Vertical-2	5.8	5.4	2.7	5.8	2.8	2.6	2.4	2	6.1	1.7	2.6	0
Vertical-3	1.9	1.8	5.5	1.4	0	2.6	0.8	2	4.5	0.9	2.6	0
Combined	9.6	5.4	19.2	15.9	16.7	15.8	7.1	10.2	10.6	12.8	15.8	20
Crater	3.8	1.8	13.7	17.4	13.9	5.3	3.2	2	9.1	5.1	5.3	0
P	0.35		0.46		0.73		0.53		0.28		0.55	
Distal												
None	0	1.8	1.4	1.4	0	0	0	0	0	0	2.6	0
Horizontal	32.7	48.2	50.7	58	84.2	84.2	53.3	20.5	51.5	67.2	89.5	80.8
Vertical-1	25	14.3	24.7	26.1	2.6	2.6	18.3	6.8	18.2	16.4	0	11.5
Vertical-2	5.8	5.4	5.5	1.4	5.3	5.3	3.3	0.9	9.1	4.5	0	3.8
Vertical-3	3.8	1.8	2.7	1.4	2.6	2.6	0	0	4.5	1.5	0	0
Combined	17.3	8.9	8.2	8.7	5.3	5.3	15	8.5	13.6	10.4	7.9	3.8
Crater	15.4	19.6	6.8	2.9	0	0	10	5.1	3	0	0	0
P	0.39		0.75		0.74		0.92		0.32		0.13	
Buccal												
None	0	0	0	0	0	2.6	0	0	0	0	0	0
Horizontal	75	71.4	91.8	52.1	97.2	89.5	80	73.5	92.4	89.6	89.5	84.6
Vertical-1	1.9	0	0	0	0	0	0	0	0.8	0	0	0
Vertical-2	1.9	1.8	1.4	0	0	0	0	2	0	1.5	0.8	3.8
Vertical-3	0	0	1.4	2.6	0	5.3	0	0	0.8	3	0.8	3.8
Combined	0	1.8	1.4	0.9	0	0	1.7	0	0.8	1.5	0.8	7.7
Dehiscence	5.8	7.1	4.1	1.7	2.8	2.6	6.7	10.2	0.8	1.5	0.8	0
Fenestration	15.4	17.9	0	1.7	0	0	11.7	14.3	0.8	3	0	0
P	0.81		0.49		0.39		0.6		0.85		0.78	
Palatinal												
None	1.9	0	1.6	0	0	0	1.7	0	1.5	0	2.6	0
Horizontal	96.2	92.9	54	91.3	97.2	97.2	91.7	87.8	89.4	94	97.4	96.2
Vertical-1	0	0	0	0	0	2.8	0	0	1.5	0	0	3.8
Vertical-2	1.9	0	0.8	2.9	0	0	1.7	0	1.5	1.5	0	0

Contd...

Table 2: Contd...

	16		17		18		26		27		28	
	Male (*n*=52)	Female (*n*=56)	Male (*n*=73)	Female (*n*=69)	Male (*n*=36)	Female (*n*=38)	Male (*n*=60)	Female (*n*=49)	Male (*n*=66)	Female (*n*=67)	Male (*n*=38)	Female (*n*=26)
Vertical-3	0	0	0	4.3	2.8	0	1.7	0	3	3	0	0
Combined	0	0	0.8	0	0	0	1.7	2	1.5	1.5	0	0
Dehiscence	0	5.4	0	1.4	0	0	1.7	6.1	0	0	0	0
Fenestration	0	1.8	0.8	0	0	0	0	4.1	1.5	0	0	0
P	0.2		0.2		0.71		0.37		0.79		0.34	

Table 3: The frequency percentage of various periodontal defects of maxillary molar teeth according to decades for intervals

	None	Horizontal	Vertical-1	Vertical-2	Vertical-3	Total vertical	Combined	Crater	Dehiscence	Fenestration
20-30 (*n*=53)										
16	3.1	75	6.2	0	6.2	4.7	0	6.2	6.2	6.2
17	6.25	75	10.4	2	2		4.1	0	0	0
18	0	62.5	16.7	0	0		0	0	0	0
26	2.3	63.6	4.5	2.3	0		13.6	13.6	4.5	9
27	1.8	66.1	7.1	1.8	5.3		10.7	14.3	0	0
28	0	87.5	0	0	0		0	25	0	0
Total	2.4	69.3	8	1.4	2.8		6.6	8.5	1.9	2.8
30-40 (*n*=162)										
16	5.4	69.5	5.4	1	1	4.4	4.3	13	6.5	6.5
17	0.7	70	7.8	2.9	3.6		5.7	1.6	1.4	1.4
18	0	80.6	8.3	0	2.8		4.2	8.3	0	0
26	0	75.8	5.6	0.8	0.8		8	4.8	6.5	6.5
27	0	74.3	9.6	3	1.5		8.8	4.4	0	1.5
28	0	85	12.5	1.25	1.25		3.75	0	0	0
Total	0.9	74.5	8	1.7	1.9		6.2	8	2.5	2.8
40-50 (*n*=261)										
16	0	57	7.9	3	0.8	5.2	4.3	7	5.2	9.6
17	0.4	69.2	12.5	2.5	2.1		3.3	8.3	3.3	1.6
18	0.8	78.1	10.2	2.3	0		5.5	4.7	1.6	0
26	0	67	8.5	3	0.6		6.1	11	3.6	8.5
27	0	75	8.5	2.6	1.8		8.5	5.4	0.9	0.9
28	2.1	78.1	9.4	1	1		5.2	2.1	0	0
Total	0.4	71.7	9.9	2.8	1.5		6.7	7.1	2.9	4.2
50-60 (*n*=122)										
16	0	69.3	6.8	3.4	0	5	8	15.9	0	9
17	0	76	11	3	0		14	3.5	0.5	0
18	0	84	5.4	3.6	0		5.4	0	3.6	0
26	0	72.7	10.2	1.1	1.1		5.7	2.3	11.3	4.5
27	0	76.25	12.5	3.75	2.5		3.75	2.5	0	0
28	0	75	9	1.8	1.8		9	0	3.6	0
Total	0	71.9	9	2.7	0.8		7.6	6.6	3.2	2.4
>60 (*n*=34)										
16	0	67.8	10.7	14.2	0	7.3	7.1	0	0	0
17	0	78.5	0	3.6	3.6		10.7	3.6	0	0
18	0	50	6.25	6.25	25		6.25	6.25	0	0
26	0	75	6.25	6.25	0		0	12.5	0	12.5
27	0	55.5	8.3	11.1	11.1		5.5	0	5.5	11.1
28	0	66.6	8.3	0	0		25	0	0	0
Total	0	65.4	6.6	8.1	6.6		8.1	4.4	1.5	4.4

Table 4: The frequency percentage of various periodontal defects of maxillary molar teeth and also value of bilateral comparisons

	16 (*n*=108)	26 (*n*=109)	17 (*n*=142)	27 (*n*=133)	18 (*n*=74)	28 (*n*=64)	Total	Total vertical
Mesial								
None	3.7	0	0.7	0	0	0	0.8	39.4
Horizontal	67.6	64.2	43.7	48.9	37.8	42.9	51.6	
Vertical-1	11.1	12.8	14.8	18	32.4	33.3	18.4	
Vertical-2	5.6	3.7	4.2	4.5	2.7	1.6	4	
Vertical-3	1.9	1.8	3.5	3	1.4	1.6	2.4	
Combined	7.4	12.8	17.6	16.5	16.2	17.5	14.6	
Crater	2.8	4.6	15.5	9	9.5	3.2	7.1	
P	0.61		0.64		0.77			
Distal								
None	0.9	0	1.4	0	0	1.6	0.6	33.4
Horizontal	40.7	51.4	54.2	59.4	86.5	85.9	59.5	
Vertical-1	19.4	17.4	25.4	17.3	2.7	4.7	16.5	
Vertical-2	5.6	2.8	3.5	6.8	5.4	1.6	4.4	
Vertical-3	2.8	0	2.1	3	2.7	0	1.9	
Combined	13	17.4	8.5	12	2.7	6.3	10.6	
Crater	17.6	11	4.9	1.5	0	0	6.4	
P	0.03*		0.16		0.34			
Buccal								
None	0	0	0	0	1.4	0	0.2	4.6
Horizontal	73.1	77.1	90.1	91	93.2	87.5	85.2	
Vertical-1	0.9	0	0	0.8	0	0	0.3	
Vertical-2	1.9	0.9	0.7	0.8	0	3.1	1.1	
Vertical-3	0	0	2.8	2.3	2.7	3.1	1.8	
Combined	0.9	0.9	1.4	1.5	0	4.7	1.4	
Dehiscence	6.5	8.3	3.5	1.5	2.7	1.6	4.1	
Fenestration	16.7	12.8	1.4	2.3	0	0	5.9	
P	0.81		0.86		0.22			
Palatinal								
None	0.9	0.9	1.4	0.8	0	1.6	1	3.9
Horizontal	94.4	89.9	92.3	91.7	97.3	96.9	93.1	
Vertical-1	0	0	0	0.8	1.4	1.6	0.5	
Vertical-2	0.9	0.9	2.1	1.5	0	0	1.1	
Vertical-3	0	0.9	2.1	3	1.4	0	1.5	
Combined	0	1.8	0.7	1.5	0	0	0.8	
Dehiscence	2.8	3.7	0.7	0	0	0	1.2	
Fenestration	0.9	1.8	0.7	0.8	0	0	0.8	
P	0.73		0.88		0.56			

*: Significancly different

Table 5: The frequency distribution of furcation involvement of maxillary molar teeth according to gender and decades for interval and also value of gender comparisons

	20-30 (*n*=53)				30-40 (*n*=162)				40-50 (*n*=261)				50-60 (*n*=122)				>60 (*n*=34)				*P*	Total			
	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III		None	Grade-I	Grade-II	Grade-III
16																									
Male (*n*=52)	2	0	1	0	2	0	5	0	12	2	8	3	5	0	6	4	1	0	1	0	0.04*	51.9	6.5	33.3	8.3
Female (*n*=56)	3	0	2	0	11	0	4	1	14	4	4	1	4	0	3	0	2	1	2	0					
17																									
Male (*n*=73)	5	0	2	0	5	4	6	1	18	2	7	1	6	1	8	2	2	0	3	0	0.17	55.6	11.3	29.6	3.5

Contd...

Table 5: Contd...

	20-30 (*n*=53)				30-40 (*n*=162)				40-50 (*n*=261)				50-60 (*n*=122)				>60 (*n*=34)				*P*	Total			
	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III		None	Grade-I	Grade-II	Grade-III
Female (*n*=69)	4	1	0	0	11	4	4	0	22	4	5	1	5	0	6	0	1	0	1	0					
18																									
Male (*n*=36)	4	0	1	0	6	2	0	0	15	0	0	0	4	0	3	0	1	0	0	0	0.71	86.5	4.1	9.5	0
Female (*n*=38)	1	0	0	0	10	0	0	0	15	1	1	0	7	0	0	0	1	0	2	0					
26																									
Male (*n*=60)	4	1	3	0	6	1	4	1	12	1	7	2	4	1	6	3	2	0	0	2	0.37	53.2	4.6	33.9	8.3
Female (*n*=49)	2	0	1	0	15	0	3	1	9	1	7	2	4	0	4	0	0	0	0	0					
27																									
Male (*n*=66)	4	0	0	0	13	4	4	1	23	3	5	0	4	1	1	0	1	0	2	1	0.09	57.9	11.3	25.6	5.3
Female (*n*=67)	4	2	2	2	4	2	5	1	12	3	8	2	10	0	4	0	2	0	3	0					
28																									
Male (*n*=38)	2	0	0	0	8	0	3	0	13	1	0	0	7	0	3	0	1	0	0	0	0.86	82.8	3.1	14.1	0
Female (*n*=26)	0	0	0	0	10	0	0	0	9	0	1	0	3	1	0	0	0	0	2	0					
Total (%)																									
Male + female (*n*=630)	66	7.5	22.6	3.8	62.3	10.5	23.5	3.7	66.6	8.4	20.3	4.6	51.6	3.3	36	7.4	41.2	3	47	8.8					

	None	Grade-I	Grade-II	Grade-III	None	Grade-I	Grade-II	Grade-III	*P*		
									16-26	17-27	18-28
Male (*n*=325)	58.9	7.4	27.3	6.4					0.9	0.8	0.7
					61.4	7.6	25.9	5.1			
Female (*n*=305)	64.1	7.9	24.3	3.6							

*: Significanly different

Table 6: The frequency distrubution and percentage of combined periodontal-endodontic lesions of maxillary molar teeth according to gender and decades for intervals

	20-30 (*n*=55)	30-40 (*n*=175)	40-50 (*n*=275)	50-60 (*n*=129)	>60 (*n*=37)	Total (*n*=669) (%)
16						
Male (*n*=63)	0	3	4	3	1	13 (10.7)
Female (*n*=58)	0	2	0	0	0	
17						
Male (*n*=78)	0	2	2	0	1	8 (5.3)
Female (*n*=72)	1	0	2	0	0	
18						
Male (*n*=38)	0	1	0	1	0	2 (2.6)
Female (*n*=38)	0	0	0	0	0	
26						
Male (*n*=64)	0	1	2	1	0	6 (5.2)
Female (*n*=51)	0	1	0	0	1	
27						
Male (*n*=73)	1	2	3	1	0	7 (5)
Female (*n*=67)	0	0	0	0	0	
28						
Male (*n*=41)	0	1	1	1	0	3 (4.5)
Female (*n*=26)	0	0	0	0	0	
Total						
Male (*n*=357)	1	10	12	7	2	32 (9)
Female (*n*=312)	0	3	2	0	1	7 (2.2)
Male + female (*n*=669) (%)	2 (3.6)	13 (7.4)	14 (5.1)	7 (5.4)	3 (8.1)	39 (5.8)

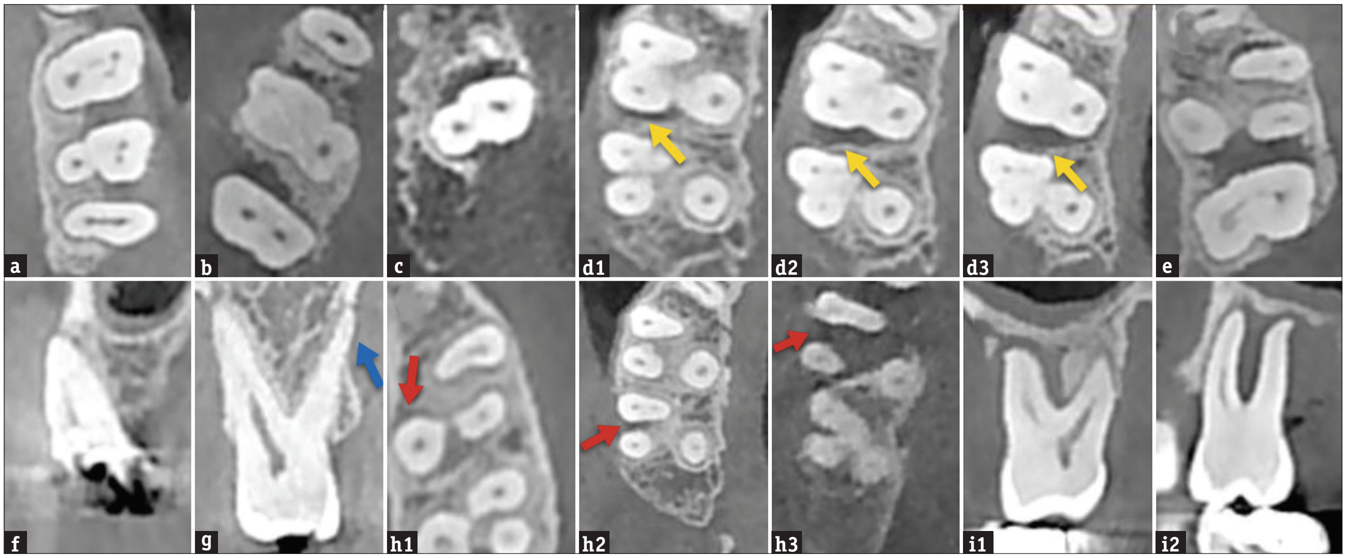

Figure 2: The cone-beam computed tomography images of various alveolar bone defects, furcation involvements and combined periodontal-endodontic lesion. One-walled vertical defects in interdental area of left maxillary molars (a). Two-walled vertical defect at mesial surface of second maxillary molar (b). Three-walled vertical defect on mesial surface of second maxillary molar (c). The number of walls in combined osseous defect on the distal surface of the first maxillary molar from apical to coronal sections (yellow arrows) (d1-d3). The crater at the interdental area of the maxillary molars (e). Dehiscence on the buccal surface of the maxillary molar (f). Fenestration on the palatinal surface of the maxillary molar (blue arrow) (g). Furcation involvements from Grade I–III (red allows) (h1-h3). Combine periodontal-endodontic lesion in coronal (i1) and sagittal (i2) sections

Discussion

Successful periodontal therapy depends on many factors. One of the most significant factors is the identification of the pattern of periodontal bone destruction so as to plan the treatment procedures.[21] Assessment of intrabony defects, maxillary trifurcations, buccal and lingual bone loss, and interdental craters is challenging to observe on 2D radiographs. Due to the limitations of clinical examination and periapical radiographs to detect 3D defect architecture, accurate imaging of the morphology of the remaining bone is the most deterministic factor when deciding on periodontal treatment options. Several studies have compared CBCT and 2D radiographs with regard to the advantages of periodontal diagnosis, and all of them reported that CBCT provided valuable outcomes relatively.[5,10] In spite of these comparative studies, our retrospective study is the first to be conducted on periodontal bone loss classification by CBCT.

Studies that analyzed that the clinical results depend on the dimension and morphology of the defect[22] and the number of walls in the defect.[23] While determining the treatment plan, visualization of the defect morphology by 3D techniques is very effective to estimate the prognosis. The morphology of the osseous defect substantially indicates the treatment technique to be used. One-wall vertical defects usually require to be recontoured surgically. Three-wall defects, especially if they are narrow and deep, may be successfully treated with techniques that attempt new attachment and bone reconstruction. According to their depth, width, and general configuration, two-wall vertical defects can be treated with either of these two methods.[9]

Vertical defects detected radiographically have been reported to occur frequently on the distal[24] and mesial surfaces[25] and they increase with age.[24-26] However, Larato reported that three-wall defects are more commonly found on the mesial surfaces of the upper and lower molars.[27] In the present study, an interesting observation is that the frequency of vertical defects (one-walled, two-walled, three-walled, and combined defect) on mesial and distal surfaces was almost 8 times higher than that on buccal and palatinal surfaces. Further, on mesial surfaces, three-wall defects were found to be more common than on other surfaces, and the rate of vertical defects in those over 40 years of age was relatively high, as in previous studies, correlatively. Because of the regeneration potential in vertical defects, the interdental areas and second molars, which have the highest rate of three-walled defects, should be assessed more carefully.

Manson reported that craters were found to make up about one-third (35.2%) of all defects.[28,29] Our results were lower than this (6.7%). The frequency of craters was a little higher on mesial surfaces than on distal surfaces and their rate decreased with age. The rate of healthy bone was more frequent on palatinal surfaces and it also decreased with age although horizontal bone loss had the highest rate on the palatinal surfaces of wisdom teeth.

On buccal and palatinal alveolar bone, dehiscence and fenestration generally occur due to the morphology and position of the root. Rupprecht *et al*. reported that the prevalence of dehiscence and fenestration in dry human skulls was 4.1% and 9%, respectively.[30] In the current study, the frequency of dehiscence and fenestration was lower. The difference may be due to the fact that the present research is an *in vivo* study. When comparing gender, the frequency of dehiscence and fenestration was a little higher in females, but there was no significant difference between decades for interval. In the determination of treatment plan, the presence of dehiscence and fenestration is an important factor that should not be overlooked.

Combined lesions occur when pulpal necrosis and periapical lesion occur on a tooth that is also periodontally involved. In all cases of CPEL, the endodontic infection should be controlled before deciding the treatment options of the periodontal lesion, especially when regenerative or bone-grafting techniques are planned.[9] In this study, the prevalence of CEPL in males was 4 times higher than in females. However, we did not attain any outcome about this frequency for the comparison.

The prevalence of furcation-involved molars is not clear[25,31] although Wouters *et al*. found a higher prevalence in the upper molars.[26] Studies indicate that the prevalence and severity of furcation involvement increase with age.[32,33] In the present study, the frequency of Grade-II and Grade-III involvement was highest in those over 60 years of age and the prevalence of Grade-III involvement in males was almost twice as high as that in females. Furcation bone loss is more difficult to treat than interdental bone loss, and in advanced lesions of Grade-III furcation involvement, the prognosis may be so hazardous that extraction and tooth replacement with dental implants should be done as soon as possible to maintain as much bone to support the implants.

Less bone density and lower bone-to-implant contact assure less support and resistance to occlusal loading. The bone appositional index for implants in the posterior maxilla characteristically ranges from 30% to 60% whereas for the anterior mandible, it typically ranges from 65% to 90%. Clinical studies have shown that areas of the jaw indicating thin cortical bone shell and large cancellous spaces, such as the posterior maxilla, have significantly lower success rates than areas of denser alveolar bone.[34-37] For all of these reasons, the edentulous posterior maxilla is challenging because of alveolar resorption, omnipresent poor bone quality, and the fact that procedures such as maxillary sinus elevation and bone augmentation are needed to increase the amount of vertical bone height.

Conclusions

Because of the high failure rate of endosseous implants in the posterior maxilla, the periodontal approaches are becoming more remarkable for maxillary molars. One of the most deterministic factors to evaluate treatment procedures is the making of a definite diagnosis of the defect morphology and classification. Currently, thanks to the lower radiation dose used in CBCT, imaging with 3D techniques is becoming more widely available for routine periodontal treatment planning in hazardous teeth with complex bone loss structures. Their results of this study may shed light on the prevalence of various periodontal defects and improve the alternative point of view for their treatments.

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Conflicts of interest

There are no conflicts of interest.

References

1. Langen HJ, Fuhrmann R, Diedrich P, Gunther RW. Diagnosis of infra-alveolar bony lesions in the dentate alveolar process with high-resolution computed tomography: Experimental results. Invest Radiol 1995;30:421-6.
2. Brägger U. Radiographic parameters: Biological significance and clinical use. Periodontol 2000 2005;39:73-90.
3. Eickholz P, Hausmann E. Accuracy of radiographic assessment of interproximal bone loss in intrabony defects using linear measurements. Eur J Oral Sci 2000;108:70-3.
4. Tugnait A, Clerehugh V, Hirschmann PN. The usefulness of radiographs in diagnosis and management of periodontal diseases: A review. J Dent 2000;28:219-26.
5. Vandenberghe B, Jacobs R, Yang J. Topographic assessment of periodontal craters and furcation involvements by using 2D digital images versus 3D cone beam CT: An *in-vitro* Study. Chin J Dent Res 2007;10:21.
6. Hausmann E, Allen K, Clerehugh V. What alveolar crest level on a bite-wing radiograph represents bone loss? J Periodontol 1991;62:570-2.
7. Källestål C, Matsson L. Criteria for assessment of interproximal bone loss on bite-wing radiographs in adolescents. J Clin Periodontol 1989;16:300-4.
8. Regan JE, Mitchell DF. Roentgenographic and dissection measurements of alveolar crest height. J Am Dent Assoc 1963;66:356-9.
9. Goldman HM, Cohen DW. The intrabony pocket: Classification and treatment. J Periodontol 1958;29:272.
10. Vandenberghe B, Jacobs R, Yang J. Diagnostic validity (or acuity) of 2D CCD versus 3D CBCT-images for assessing periodontal breakdown. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104:395-401.
11. Braun X, Ritter L, Jervøe-Storm PM, Frentzen M. Diagnostic accuracy of CBCT for periodontal lesions. Clin Oral Investig 2014;18:1229-36.
12. Glickman I. Clinical Periodohtalogy, 2nd ed. Phiiodeiphia. Sounders, 1958. p. 694-6.
13. Singh P. Endo-perio dilemma: A brief review. Dent Res

J (Isfahan) 2011;8:39-47.
14. Bühler H. Survival rates of hemisected teeth: An attempt to compare them with survival rates of alloplastic implants. Int J Periodontics Restorative Dent 1994;14:536-43.
15. Walter C, Weiger R, Dietrich T, Nicola LN, Zitzmann NU. Does three-dimensional imaging offer a financial benefit for treating maxillary molars with furcation involvement? – A pilot clinical case series. Clin Oral Implants Res 2012;23:351-8.
16. Walter C, Weiger R, Zitzmann NU. Periodontal surgery in furcation-involved maxillary molars revisited – An introduction of guidelines for comprehensive treatment. Clin Oral Investig 2011;15:9-20.
17. Anitua E, Alkhraisat MH, Miguel-Sánchez A, Orive G. Surgical correction of horizontal bone defect using the lateral maxillary wall: Outcomes of a retrospective study. J Oral Maxillofac Surg 2014;72:683-93.
18. Rosling B, Nyman S, Lindhe J. The effect of systematic plaque control on bone regeneration in infrabony pockets. J Clin Periodontol 1976;3:38-53.
19. Langlois Cde O, Sampaio MC, Silva AE, Costa NP, Rockenbach MI. Accuracy of linear measurements before and after digitizing periapical and panoramic radiography images. Braz Dent J 2011;22:404-9.
20. Nicopoulou-Karayianni K, Mombelli A, Lang NP. Diagnostic problems of periodontitis-like lesions caused by eosinophilic granuloma. J Clin Periodontol 1989;16:505-9.
21. Misch KA, Yi ES, Sarment DP. Accuracy of cone beam computed tomography for periodontal defect measurements. J Periodontol 2006;77:1261-6.
22. de Faria Vasconcelos K, Evangelista KM, Rodrigues CD, Estrela C, de Sousa TO, Silva MA. Detection of periodontal bone loss using cone beam CT and intraoral radiography. Dentomaxillofac Radiol 2012;41:64-9.
23. Froum SJ, Weinberg MA, Rosenberg E, Tarnow D. A comparative study utilizing open flap debridement with and without enamel matrix derivative in the treatment of periodontal intrabony defects: A 12-month re-entry study. J Periodontol 2001;72:25-34.
24. Nielsen IM, Glavind L, Karring T. Interproximal periodontal intrabony defects. Prevalence, localization and etiological factors. J Clin Periodontol 1980;7:187-98.
25. Papapanou PN, Tonetti MS. Diagnosis and epidemiology of periodontal osseous lesions. Periodontol 2000 2000;22:8-21.
26. Wouters FR, Salonen LE, Helldén LB, Frithiof L. Prevalence of interproximal periodontal intrabony defects in an adult population in Sweden. A radiographic study. J Clin Periodontol 1989;16:144-9.
27. Larato DC. Intrabony defects in the dry human skull. J Periodontol 1970;41:496-8.
28. Manson JD. Bone morphology and bone loss in periodontal disease. J Clin Periodontol 1976;3:14-22.
29. Manson JD, Nicholson K. The distribution of bone defects in chronic periodontitis. J Periodontol 1974;45:88-92.
30. Rupprecht RD, Horning GM, Nicoll BK, Cohen ME. Prevalence of dehiscences and fenestrations in modern American skulls. J Periodontol 2001;72:722-9.
31. Easley JR, Drennan GA. Morphological classification of the furca. J Can Dent Assoc (Tor) 1969;35:104-7.
32. Hou GL, Tsai CC. Relationship between periodontal furcation involvement and molar cervical enamel projections. J Periodontol 1987;58:715-21.
33. Tal H, Lemmer J. Furcal defects in dry mandibles. Part II: Severity of furcal defects. J Periodontol 1982;53:364-7.
34. Jaffin RA, Berman CL. The excessive loss of Branemark fixtures in type IV bone: A 5-year analysis. J Periodontol 1991;62:2-4.
35. Balshi TJ, Wolfinger GJ. Management of the posterior maxilla in the compromised patient: Historical, current, and future perspectives. Periodontol 2000 2003;33:67-81.
36. Jemt T. Failures and complications in 391 consecutively inserted fixed prostheses supported by Brånemark implants in edentulous jaws: A study of treatment from the time of prosthesis placement to the first annual checkup. Int J Oral Maxillofac Implants 1991;6:270-6.
37. Grant BT, Pancko FX, Kraut RA. Outcomes of placing short dental implants in the posterior mandible: A retrospective study of 124 cases. J Oral Maxillofac Surg 2009;67:713-7.