Root Proximity Characteristics and Type of Alveolar Bone Loss: A Case-control Study

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Abstract

Objective: This study assessed root proximity (RP) in patients with and without periodontitis in terms of prevalence, distribution, location along the root, width and severity, and explored the role of RP characteristics in the type of alveolar bone loss (horizontal or angular). **Materials and methods:** Root proximity was studied in the interdental spaces of 250 patients with periodontitis and 80 patients without disease. Linear measurements were performed in digitized radiographs. Root proximity was classified by location along the root, width and severity. Bone defect type (horizontal or angular) at the RP site was recorded. **Results:** Root proximity prevalence did not differ between periodontitis and non-periodontitis groups. For both groups, most RPs were located at the middle root third. Root proximity width and severity in periodontitis sites were different between horizontal and angular bone loss sites. Root proximity width was greater in horizontal bone loss sites. In periodontitis, a unit (pixel) increase in the RP width decreased the probability to detect an angular bone defect by 20%, while a unit decrease in RP severity increased the possibility to detect angular bone loss by 71%. **Conclusion:** Root proximity prevalence was similar for both patients with and without periodontitis. The RP location along the root was not related to the existence of periodontitis. Root proximity width and severity differed between horizontal and angular bone loss sites. Root proximities had greater width in horizontal than angular bone loss sites.

Key words: Periodontal diseases, periodontal bone loss, dental digital radiography, root proximity, angular bone loss

Introduction

Root proximity is one of the key factors that the clinician should evaluate to determine the individual tooth prognosis before periodontal treatment. Trossello and Gianelly (1979) introduced the term "root proximity" (RP) for cases where the radiographic distance between the roots of adjacent teeth was ⩽ 1.0 mm. Artun *et al.* (1986) used a different cut-off point and suggested that RP should be diagnosed when the distance between the roots of adjacent teeth was < 0.8 mm, as assessed on periapical radiographs. For Kramer (1987) the cut-off point for RP was 1.0 mm, because 1.0 mm is the minimum to achieve adequate septal space between the roots. Today, RP is interpreted as an interradicular distance of < 0.8 mm (Vermylen *et al.*, 2005a; 2005b; Avila *et al.*, 2009). Heins and Wieder (1986) found in human periodontitis subjects that the minimal histologic interradicular distance at the closest RP site was between 4 mm and less than 0.1 mm. In sites with interradicular distance < 0.5 mm there was no cancellous bone and there was only lamina dura. In sites with interradicular distance < 0.3 mm there was no alveolar bone at all.

The importance of RP in the presence (Vermylen *et al.*, 2005a; 2005b) and progression (Kim *et al.*, 2008) of periodontitis and in the determination of tooth prognosis has been studied, though further research is requested. The absence of RP is compatible with favourable tooth prognosis (Avila *et al.*, 2009). Vermylen *et al.* (2005a) found that RP in untreated periodontitis patients had no influence on the distance from the cemento-enamel junction (CEJ) to the alveolar crest, since in untreated severe periodontitis patients this distance did not statistically significantly differ between sites presenting RP and sites not presenting RP. They demonstrated that RP is a symmetrical and localized but widespread

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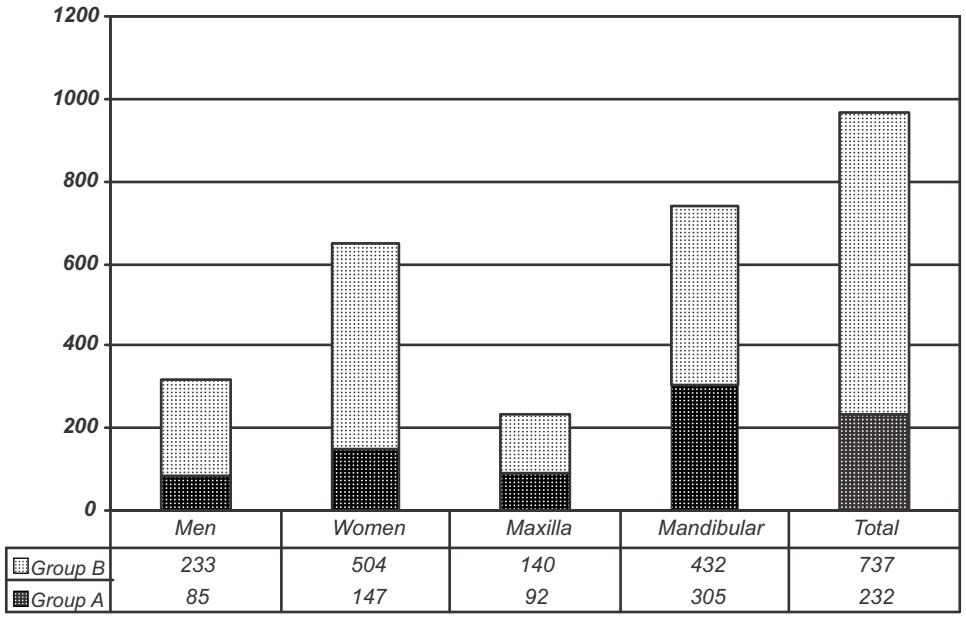

Figure 1. Number of interdental spaces with root proximity in the total patient population and in groups A and B by sex and jaw.

Table 1. Mean number of interdental spaces with root proximity (RP) per patient in the total patient population and in groups A and B by sex and jaw.

Parameters	Total (n = 330) mean ± SD	Group A (n = 80) mean ± SD	Group B (n = 250) mean ± SD	Student's *t*-test (*p*-value)
Total	2.94 ± 1.35	2.9 ± 1.35	2.95 ± 1.36	0.28 (0.78)
Sex				
Men	2.81 ± 1.42	2.74 ± 1.34	2.8 ± 1.45	0.33 (0.74)
Women	3.0 ± 1.32	3.0 ± 1.35	3.0 ± 01	0.0 (1.0)
Student's *t*-test	1.18	0.83	0.87	--
p-value	0.238	0.41	0.39	
Jaw				
Maxilla	1.20 ± 1.03	1.15 ± 1.01	1.22 ± 1.04	0.53 (0.60)
Mandible	1.73 ± 1.03	1.75 ± 1.11	1.73 ± 1.0	0.17 (0.87)
Student's *t*-test	6.61	3.58	5.56	--
p-value	< 0.0001	< 0.0005	< 0.0001	

phenomenon in periodontitis patients and to a lesser extent in control patients (Vermylen *et al.*, 2005b). Patients with bilateral RP had a 3.6 times higher chance to have periodontitis. They suggested that the existence of RP should be considered as a risk marker for periodontal disease (Vermylen *et al.*, 2005b). Kim *et al.* (2008) radiographically assessed the association between RP and the risk for alveolar bone loss in a closed-panel longitudinal cohort study and found that RP is a significant local risk factor for further bone loss in mandibular incisors.

Tal (1984) reported that the number of angular defects increased with increasing interproximal distance and demonstrated that an interdental space of 2.6 mm was "critical" for the healing of the surgically treated bone defects. The role of the characteristics of RP on the existence of angular or horizontal bone loss in the interproximal area has not been thoroughly addressed in the literature yet. Therefore, the aim of the present study was to assess RP in patients with and without periodontitis in terms of prevalence, distribution, location along the root, width and severity and to explore the possible role of the characteristics of RP in the type of the alveolar bone loss.

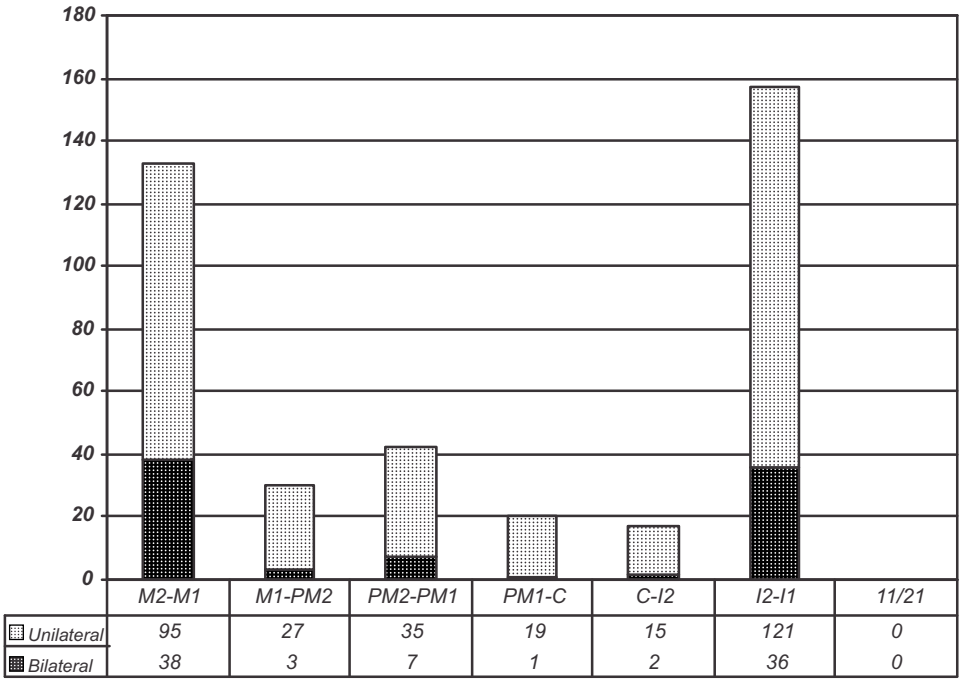

Figure 2. Number and distribution of unilateral and bilateral root proximities in the 397 maxillary interdental spaces. M2-M1, interdental space between second and first molar; M1-PM2, interdental space between first molar and second premolar; PM2-PM1, interdental space between second and first premolar; PM1-C, interdental space between first premolar and canine; C-I2, interdental space between canine and lateral incisor; I2-I1, interdental space between lateral and central incisor; 11/21, interdental space between central incisors.

Table 2. Comparison of the distribution of root proximities by group, sex and jaw

Parameters	1-RP	2-RP	3-RP	4-RP	5-RP	6-RP	Total RP	*p*-value
Total - Group A	13	19	25	13	6	4	232 (23.94%)	0.69[a]
Total - Group B	35	73	61	42	29	10	737 (76.06%)	
Men - Total	21	33	26	20	5	8	318 (32.82%)	0.032[a]
Women - Total	27	59	60	35	30	6	651 (67.18%)	
Men - Group A	8	4	10	7	1	1	85 (36.63%)	0.009[b]
Women - Group A	5	15	15	6	5	3	147 (63.37%)	
Men - Group B	13	29	16	13	4	7	233 (31.61%)	0.02[b]
Women -Group B	22	44	45	29	25	3	504 (68.39%)	
Maxillary - Total	102	93	27	7	0	0	397 (40.97%)	0.001[b]
Mandibular -Total	106	117	58	12	2	0	572 (59.03%)	
Maxillary-Group A	25	26	1	3	0	0	92 (39.65%)	0.15[b]
Mandibular-Group A	22	29	12	6	0	0	140 (60.35%)	
Maxillary-Group B	77	67	26	4	0	0	305 (41.38%)	0.001[b]
Mandibular - Group B	84	88	46	6	2	0	432 (58.62%)	
Maxillary - Group A	25	26	1	3	0	0	92 (23.17%)	0.02[b]
Maxillary - Group B	77	67	26	4	0	0	305 (76.83%)	
Mandibular - Group A	22	29	12	6	0	0	140 (24.47%)	0.24[b]
Mandibular - Group B	84	88	46	6	2	0	432 (75.53%)	
Bilateral - Group A	43	6	1	0	0	0	58 (23.48%)	0.44
Bilateral - Group B	136	25	1	0	0	0	189 (76.52%)	

[a]χ^2 test; [b]Fisher's exact test; 1-RP to 6-RP, one to six interdental spaces with root proximity per patient

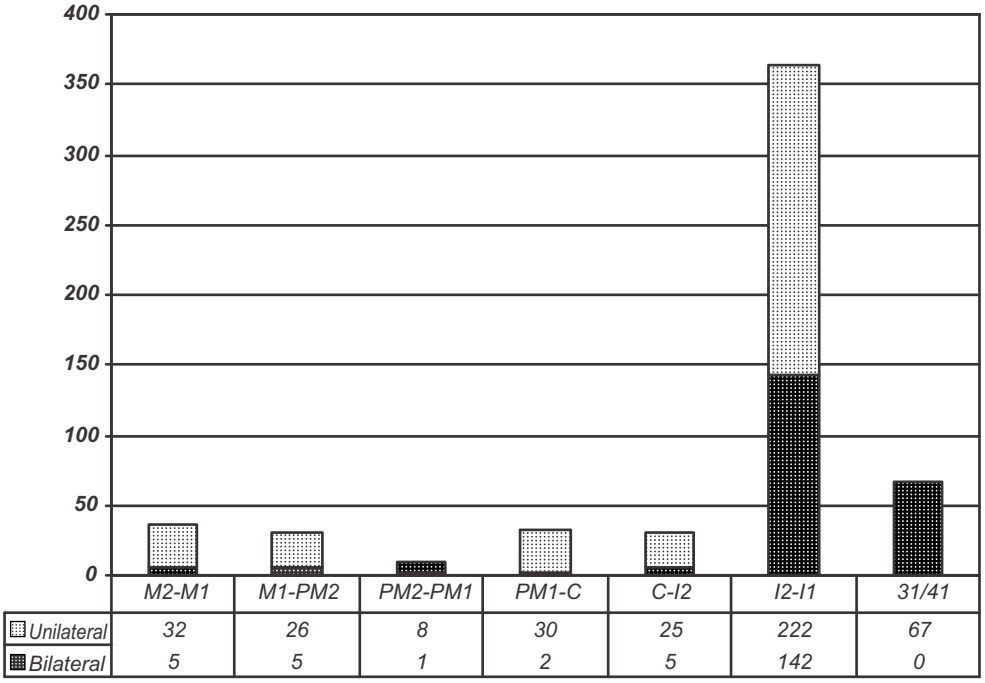

Figure 3. Number and distribution of unilateral and bilateral root proximities in the 572 mandibular interdental spaces. M2-M1, interdental space between second and first molar; M1-PM2, interdental space between first molar and second premolar; PM2-PM1, interdental space between second and first premolar; PM1-C, interdental space between first premolar and canine; C-I2, interdental space between canine and lateral incisor; I2-I1, interdental space between lateral and central incisor; 31/41, interdental space between central incisors.

Materials and methods

Study sample

Conventional periapical radiographs from 330 patients were studied. The patients originated from the pool of patients of the Department of Periodontology, Dental School, University of Athens, and from private practices. Group A included data from 80 control subjects (31 men and 49 women, mean age 27.5 ± 0.6 years). Group B included data from 250 subjects (82 men, 168 women; mean age 44 ± 0.5 years) presenting with moderate to advanced periodontitis. Clinical attachment level measurements were used for the diagnosis of periodontitis (Armitage, 1999). The patient inclusion criteria were: presence of all teeth (third molars were excluded) and presence of full-mouth periapical radiographs. The patient exclusion criteria were: orthodontic treatment, phase I periodontal treatment for the last six months, periodontal surgery, medical condition or medication affecting the periodontium, and presence of supernumerary or impacted teeth. Each subject signed an informed consent form prior to enrollment in the study. The study protocol was conducted in accordance with the Helsinki Declaration of 1975 as revised in 2008 and was approved by the Ethics and Research Committee of the Dental School, University of Athens, Greece.

All radiographs were taken with the long-cone paralleling technique with the central beam directed to

Table 3. Comparison of the distribution of the root proximities in response to location and severity between the maxilla and the mandible in the total patient population and in groups A and B.

Parameters	Location of RP			Severity of RP			
	Coronal	Middle	Apical	S-1	S-2	S-3	Total
Total							
Maxillary	61	307	31	206	163	30	399
	6.29%	31.69%	3.20%	21.26%	16.83%	3.09%	41.18%
Mandibular	52	475	43	229	288	53	570
	5.36%	49.02%	4.44%	23.63%	29.72%	5.47%	58.82%
Z/*p*-value	1.20	8.50	1.97	1.56	8.32	3.57	7.77
	0.23	< 0.001	0.05	0.12	< 0.001	0.004	< 0.001
χ^2/*p*-value		8.84 (< 0.01)			12.44 (< 0.001)		
Group A							
Maxillary	22	64	6	55	25	12	92
	9.48%	27.59%	2.58%	23.71%	10.77%	5.17%	39.65%
Mandibular	19	99	22	72	57	11	140
	8.19%	42.68%	9.48%	31.03%	24.58%	4.74%	60.35%
Z/*p*-value	0.66	3.88	4.28	2.13	4.99	0.29	4.46
	0.51	0.0001	< 0.0001	0.03	< 0.0001	0.77	< 0.0001
χ^2/*p*-value		7.24 (< 0.01)			2.84 (> 0.05)		
Group B							
Maxillary	39	243	25	151	138	18	307
	5.29%	32.97%	3.39%	20.48%	18.72%	2.45%	41.65%
Mandibular	33	376	21	157	231	42	430
	4.47%	51.04%	2.84%	21.31%	31.35%	5.69%	58.35%
Z/*p*-value	1.00	7.56	0.83	0.48	6.85	4.38	6.41
	0.32	< 0.001	0.83	0.63	< 0.0001	< 0.001	< 0.0001
χ^2/*p*-value		9.05 (< 0.01)			13.01 (< 0.001)		

Severity category S-1, > 0.5 and ⩽ 0.8 mm; S-2, > 0.3 and ⩽ 0.5 mm; S-3, ⩽ 0.3 mm; RP, root proximity

Student's *t*-test was used for comparison of the above measurements between groups A and B, men and women, maxilla and mandible. Root proximity frequency per patient, interdental space, severity and location were also calculated. The χ^2 test or Fisher's exact test for small numbers was performed for comparisons between the above categorical variables, while the Z-test was used for comparison of two percentages. Logistic regression models were fit to evaluate the association between width, location, position and severity of RP (as independent variables) and bone defects, on a site-specific basis. Results were considered significant at 5% significance level (p = 0.05). Statistical analysis was conducted using the STATA 9.0 software package.

Results

Analysis per patient

Table 1 presents the number of interdental spaces with RP per patient in the total patient population and in groups A and B by sex and jaw. The mean number of interdental spaces with RP per patient (prevalence of RP) did not differ between groups A and B. RP prevalence was higher for the mandible than the maxilla in the total patient population (*t*-test = 6.61, p < 0.0001), in group A (*t*-test = 3.58, p = 0.0005) and in group B (*t*-test = 5.56, p < 0.0001; *Table 1)*. *Table 2* presents the comparison of the number of RPs per patient (RP distribution) by group, sex and jaw. The RP distribution was different between men and women overall (p = 0.032) and in groups A (p = 0.009) and B (p = 0.02) and between maxilla and mandible overall and for group B (p = 0.001 for both). For the maxilla, there was a difference in RP distribution between groups A and B (p = 0.02, *Table 2)*.

Analysis per interdental space

The number of interdental spaces examined was 8,580. In total, 969 interdental spaces with RP (11.3%) were detected, 232 (11.1%) in group A and 737 (11.3%) in group B, with RP being more frequent in women (67.2%) and in the mandible (76.1%, *Figure1*). For the maxilla, the most frequent unilateral and bilateral RPs were located between central and lateral incisors and between first and second molars (*Figure 2*). For the mandible, the most frequent unilateral RPs were found between central and lateral incisors, between central incisors and between first and second molars. The most

Table 4. Width, position, location and severity of root proximity by type of bone loss.

Measurements	Horizontal bone loss mean ± SD	Angular bone loss mean ± SD	Parametric methods *p*-value	Linear regression analysis[c] OR (95%CI)
Width RP	5.5 ± 1.3	5.2 ± 1.3	0.0009[a]	0.80* (0.71 - 0.92)
Position RP	44.7 ± 11.1	45.4 ± 11.7	0.47[a]	1.00 (0.99 - 1.02)
Location RP				
Coronal	44 (11.1%)	15 (6.9%)		--
Middle	329 (82.6%)	189 (86.2%)	0.23[b]	1.69 (0.19 - 3.11)
Apical	25 (6.3%)	15 (6.9%)		1.76 (0.74 to 4.19)
Severity RP				
S-1	179 (45%)	71 (32.4%)		--
S-2	189 (47.5%)	128 (58.5%)	0.01[b]	1.71* (1.20 - 2.43)
S-3	30 (7.5%)	20 (9.1%)		1.68 (0.90 - 3.15)

[a]Student's *t*-test; [b]χ^2; [c]odds ratio (OR) – confidence interval (CI); *statistical significance; RP, root proximity

frequent bilateral RP was found between central and lateral incisors *(Figure 3)*.

Distribution of location ($p < 0.01$) and severity ($p < 0.001$) of RPs differed between maxilla and mandible. Differences in RP location between jaws were mainly due to RPs located in the middle root third, which were more frequent in the mandible. Differences in RP severity between the jaws were found for S-2 severity, which was more frequent in the mandible *(Table 3)*. For group A, RP location differed between the jaws ($p < 0.01$). This was mainly attributed to the higher number of RPs located in the middle ($Z = 3.88$) and apical ($Z = 4.28$) root third for the mandible *(Table 3)*. For group B, distribution of location and severity of RP differed between maxilla and mandible ($\chi^2 = 9.05$, $p < 0.01$ and $\chi^2 = 13.01$, $p < 0.001$, respectively). Root proximities located in the middle root third were more frequent in the mandible than maxilla ($Z = 7.56$, $p < 0.001$). Category S-2 ($Z = 6.85$, $p < 0.0001$) and S-3 ($Z = 4.38$, $p < 0.001$) severity RPs were more frequent in the mandible *(Table 3)*.

For group B, RP width was higher in sites with horizontal rather than angular bone loss ($p = 0.0009$). The RP position and location did not differ between horizontal and angular bone loss sites ($p = 0.47$), however, the distribution of RP severity differed between horizontal and angular bone loss sites ($p = 0.01$). Logistic regression models were used with the width, position, location and severity of RP as independent variables and the morphology of bone loss (horizontal and angular) as dependent variables to further examine the previously mentioned associations. The probability to identify defects with angular bone loss decreased by 20% per unit increase in RP width (OR = 0.80, 95%CI 0.71 to 0.92) compared to horizontal bone loss. The presence of an S-2 severity RP increased, by 71%, the probability of identifying defects with angular rather than horizontal bone loss as compared to S-1 severity (OR = 1.71, 95%CI 1.20 to 2.43; *Table 4)*.

Discussion

The present retrospective study analyzed root proximity. Nine hundred sixty-nine interdental spaces with RP were detected and studied in 250 patients with periodontitis and 80 control patients. The RP prevalence in this study was lower than that found by Vermylen *et al.* (2005a; 2005b) in patients with advanced chronic periodontitis and greater than that reported by Artun *et al.* (1986) in patients with a history of orthodontic treatment. This might partly be explained by the different methodology used for determining RP. Linear measurements from digitized radiographs were used in this study, measurements with a modified Shei ruler and transparent grid scale were taken by Vermylen *et al.* (2005a; 2005b) and the transparent grid scale was used by Artun *et al.* (1986). The RP prevalence in this study was similar for patients with and without periodontitis.

In the present study, RP distribution was affected by sex and jaw. Jaw location influenced RP location along the root and RP severity. Most maxillary unilateral and bilateral RPs were between central and lateral incisors and between first and second molars;

while in the mandible most unilateral RPs were between central and lateral incisors, central incisors, and between first and second molars; the bilateral RPs were mainly between central and lateral incisors. The present study agrees with Vermylen *et al.* (2005b) in the distribution pattern of the majority of RPs, in that a great percentage of RPs is observed between central and lateral mandibular incisors and in that no RP was found between the maxillary central incisors.

In the present study, RP location along the root and severity were affected by jaw location. For both patient groups the great percentage of RPs were located at the middle root third, specifically 84.01% for the former and 70.27% for the latter group. The RP location along the root was not related to the existence of periodontitis. The width and severity of RP significantly differed between sites with horizontal and angular bone loss. Root proximities had significantly greater width in horizontal than angular bone loss sites. Therefore, the width and severity of RP affected the type of interproximal alveolar bone loss (horizontal or angular). In the presence of periodontitis, a unit (pixel) increase in RP width decreased the probability of detecting angular bone defects by 20%, while a unit decrease in RP severity increased the possibility of detecting angular bone loss by 71%. Therefore, the slightly increased width of RP reduced the chances of angular bone loss and the slightly lessened severity of RP elevated the chances of angular bone loss. Only indirect comparison of this finding with previous research data is feasible: Tal (1984) previously found that the prevalence of angular bone defects was higher in sites with increased interproximal distance.

Within its limits, the present study demonstrated that the width and severity of root proximity are significantly different between horizontal and angular bone loss sites, with root proximities in horizontal bone loss sites having greater width. The possibility of presenting with an angular bone defect was decreased by the increase in root proximity width and increased by the decrease in root proximity severity.

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