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Root proximity as a risk marker for periodontal disease: a case–control study

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Abstract

Aim: The aim of this study is first, to examine the prevalence, symmetry and spread of root proximity using the measurement tools and classification as described in part I of the study, and second to examine whether root proximity is a risk marker for periodontal disease.

Material and Methods: The radiographs of 227 patients were examined. The study consisted of a study group of 197 patients with advanced periodontal disease with at least one site with bone loss more than one third of the root length and 30 controls without periodontal disease. Every inter-proximal space was assessed on the full-mouth radiographs and a score was assigned according to severity and location. Consequently prevalence of severity and location, symmetry, spread and an odds ratio and relative risk for periodontal disease was calculated.

Results: Root proximity is a symmetrical and localized but widespread phenomenon in periodontal patients and to lesser extend in the non-periodontal control group. In periodontal patients root proximity was most often encountered in the coronal and intervening part whereas subjects without periodontal disease had more root proximity in the apical and intervening part where it is less critical. Subjects with bilateral root proximity had a 3.6 times higher chance to have periodontitis.

Conclusion: Root proximity must be taken into consideration as a risk marker for periodontal disease.

Key words: location; non-periodontal patients; odds ratio; periodontal patients; prevalence; relative risk; risk marker; root proximity; severity; symmetry

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The phenomenon root proximity is well-known among clinicians, yet very little research concerning root proximity has been performed.

Two questions arise regarding the degree to which root proximity occurs and its location. First, what is the prevalence of root proximity among periodontal patients and among patients with a healthy periodontium and second, is root proximity a symmetrical phenomenon and is it generalized in the mouth or rather localized?

Årtun et al. (1986) examined patients at least 16 years after orthodontic treatment. A subjective screening without measurement tools was performed on 400 patients for the presence of root proximity. Twenty-five subjects (6%) were selected for having root proximity. The radiographs of these 25 patients were examined using a transparent grid for measuring the inter-root distances and they found inter-root distances in the sites with root proximity to vary from 0.4 to 0.8 mm. Seventy-two per cent of these root proximities occurred between the maxillary central and lateral incisors. Out of the 25 patients, eight had symmetrical sites with root proximity.

Trossello & Gianelly (1979) took a sample of 30 females, aged 18–25 years at least 2 years after fixed orthodontic treatment, and a sample of 30 comparably aged females to serve as a control. The status of bone and roots was determined using full-mouth radiographs. The measurements were taken midway between the cemento-enamel junction and the root apex using an X-ray grid scale divided into 1 mm increments. Root proximity was determined as favourable when there was more than 1 mm of bone between the roots and unfavourable when less than 1 mm was recorded. He concluded that root proximity was found in 13.4% in the control group and in 11.4% in the orthodontically treated group. In none of the previous articles was the distinction

made as to whether root proximity occurred in the coronal, middle or apical part of the inter-dental space. From a clinical point of view, root proximity occurring in the coronal part or in the intervening part seems to be more important than in the apical part.

In the first article of classification, reproducibility and prevalence of root proximity of periodontal patients (Vermylen et al. submitted) it was concluded that there was no difference in the distance cemento-enamel junction to bone crest between the root proximity sites and their contra-lateral sites without root proximity.

Since the amount of scientific literature on this subject is extremely limited, there is an obvious need for studies on the prevalence, location, symmetry and spread of root proximity and particularly whether a subject with an increased number of inter-dental spaces with root proximity is more likely to have periodontitis. A risk marker is defined as an attribute or exposure that is associated with increased probability of disease, but is not necessarily a causal factor (Last (2001)).

The aim of this study was to examine these parameters using the measurement tools and classification as described in part I of the study. The question also arose whether root proximity could be considered as a risk marker for periodontal disease.

Material and Methods

Subjects

Two hundred twenty-seven consecutive patients of several operators, working in the Catholic University of Nijmegen and in private practice, were selected. All operators were following the same philosophy and strategy in both the University and their private practice. All subjects, fulfilling the inclusion criteria, which were examined by one of the operators between September 1997 and June 2001, were included in the study. The inclusion criteria to participate in the study were the following: patients were required to have all (28) teeth in order to be included in the study, third molars could be present but were not examined in the study and no fixed orthodontic treatment should be performed in the past. For each patient a full-mouth radiographic examination was present, taken with the long cone technique, consisting of at least one radiograph of the molars in each sextant, one of the premolars in each sextant and three radiographs in the frontal area of each jaw. In the study group, patients were required to have advanced periodontal disease with bone loss more than one-third of the root length at least at one site. In the control group, only subjects that agreed with a full-mouth radiographic examination were included.

The study group consisted of 197 periodontal patients with advanced periodontal disease and the control group of 30 patients without periodontal disease. The patients in the study group were aged between 18 and 66 years (average of 42 years). Eighty-two were men and 115 were women.

The control group was derived from 200 new patients that presented at the private practice of the author for general dental treatment. After clinical examination, 67 patients, in whom it was justifiable to take more extensive radiographs for caries detection and endodontic follow-up (in accordance with FDA guidelines), remained. Thirty of them gave their informed consent to participate in the study. These patients were comparable for age, gender, smoking status and approximal caries (DFS-index) with the test group. In the control group, 18 were women and 12 were men and their age varied between 20 and 67 years (average of 41 years).

Radiographic measurement and classification

Every inter-dental space of every patient was assessed on the full-mouth radiographs and a score was assigned according to severity and location, which were classified according to the new classification as described in part I of the study.

Prevalence

After the examination of the radiographs, the number of times that root proximity was found per subject, per inter-dental space and per category was calculated. The average number of inter-dental spaces with root proximity for the periodontal study group and the non-periodontal control group was calculated for the different severities and locations. The odds ratio and relative risk was calculated between the periodontal study group and the non-periodontal control group.

Statistical analysis

The prevalences of root proximity were expressed in percentage and the standard error was calculated for the study and the control group. The *t*-test was used to calculate whether there was a statistically significant difference in the amount of inter-dental spaces with root proximity between the study group and the control group. Odds ratios and relative risk were calculated with logistic regression analysis.

Results

The full-mouth radiographs of 227 patients were examined and classified according to the new classification. In the study group, affected by periodontal disease, 5.6% of the subjects had no inter-dental space with root proximity (Table 1). In the control group, 36% of the subjects had no inter-dental space with root proximity and 70% had no root proximity severity 3. In the periodontal study group, only 25% of the subjects had no severity 3. Most of the subjects had 1–4 inter-dental spaces with root proximity. In the study group 32.5% of the subjects had five or more inter-dental spaces with root proximity whereas none of the subjects in the control group had root proximity in five or more inter-dental spaces.

For both study and control group, root proximity was found most frequently between the second and first molars in the maxilla and between the central and lateral incisors in the

Table 1. The amount of inter-dental spaces with their consequent prevalence of root proximity expressed as a percentage of prevalence per subject for different severities of root proximity

Inter-dental space	Severity 1/2/3		Severity 2/3		Severity 3	
	Perio	Control	Perio	Control	Perio	Control
0	5.6	36	8.6	36	24.4	70
1–4	61.9	64	68.1	64	64.5	30
5 or more	32.5	0	23.3	0	11.1	0

Table 2. The prevalence of root proximity per inter-dental space (average of the two contra lateral inter-dental spaces) in percentage (± standard error (SE)) for the maxilla and the mandible for different severities and for different groups

	Severity 1,2,3 (SE)		Severity 2,3 (SE)		Severity 3 (SE)	
	Perio	Control	Perio	Control	Perio	Control
Maxilla						
M2–M1	19.0 (± 1.8)	7.8 (± 3.0)	16.9 (± 1.8)	7.2 (± 2.9)	12.5 (± 1.6)	5.0 (± 2.5)
M1–PM2	2.2 (± 0.6)	1.1 (± 1.1)	1.5 (± 0.5)	0.5 (± 0.5)	0.6 (± 0.3)	0.5 (± 0.5)
PM2–PM1	3.1 (± 0.8)	2.7 (± 1.8)	2.9 (± 0.7)	2.7 (± 1.8)	1.8 (± 0.5)	1.1 (± 0.7)
PM1–C	4.0 (± 0.9)	3.3 (± 2.3)	3.9 (± 0.8)	3.0 (± 2.8)	1.4 (± 0.5)	1.6 (± 1.2)
C–I2	2.8 (± 0.6)	0.0 (± 0.0)	1.8 (± 0.5)	0.0 (± 0.0)	0.8 (± 0.3)	0.0 (± 0.0)
I2–I1	27.4 (± 2.3)	2.2 (± 1.5)	23.5 (± 2.2)	2.2 (± 1.5)	14.4 (± 1.8)	0.0 (± 0.0)
I1–I1	2.7 (± 1.0)	1.1 (± 1.1)	2.4 (± 0.9)	1.1 (± 1.1)	1.0 (± 0.5)	0.0 (± 0.0)
Mandible						
M2–M1	2.2 (± 0.6)	1.1 (± 1.7)	1.2 (± 0.4)	1.1 (± 1.1)	0.5 (± 0.3)	1.1 (± 1.1)
M1–PM2	0.3 (± 0.3)	0.0 (± 0.0)	0.2 (± 0.2)	0.0 (± 0.0)	0.2 (± 0.2)	0.0 (± 0.0)
PM2–PM1	0.6 (± 0.4)	0.0 (± 0.0)	0.5 (± 0.4)	0.0 (± 0.0)	0.3 (± 0.3)	0.0 (± 0.0)
PM1–C	1.5 (± 0.5)	0.0 (± 0.0)	1.0 (± 0.4)	0.0 (± 0.0)	0.4 (± 0.2)	0.0 (± 0.0)
C–I2	5.6 (± 1.0)	1.1 (± 1.1)	4.2 (± 0.9)	0.5 (± 0.5)	2.7 (± 0.7)	0.0 (± 0.0)
I2–I1	30.9 (± 2.3)	6.7 (± 2.5)	25.1 (± 2.2)	5.6 (± 2.3)	14.6 (± 1.7)	2.2 (± 1.7)
I1–I1	25.7 (± 2.7)	3.3 (± 2.5)	21.6 (± 0.6)	3.3 (± 2.4)	12.0 (± 2.0)	0.0 (± 0.0)

mandible for all severities (Table 2). Furthermore, root proximity was frequently found in the study group in the mandible between the central incisors for all severities, and in the maxilla between the central and the lateral incisors. The prevalence of root proximity in the periodontal study group achieved a level up to five times the prevalence of the control group in the incisor region of the mandible. In the study group, inter-dental spaces associated with premolars or canines had the lowest frequency of root proximity for both the mandible and the maxilla.

The inter-dental spaces between the second and first molars of the study group in the maxilla showed that 12.5% were found to have root proximity severity 3, while approximately 19% of the inter-dental spaces had root proximity severity 1, 2 or 3. This means that 60% of the root proximities at that inter-dental space had severity class 3. This ratio was found to be 50% between the lateral and central incisor. In the mandible these percentages were 51% between the lateral and central incisors and 49% between the central incisors.

For the control group, these percentages were much lower and in many inter-dental spaces severity 3 did not even occur.

The periodontal study group had an average of 3.6 sites with root proximity compared with 1.0 site for the non-periodontal control group (Table 3.). The periodontal study group had an average of 3.0 sites with root proximity compared with 1.0 sites for the non-periodontal control group when including only the sites with root proximity severity 2 and severity 3. For root proximity severity 3, the average in the periodontal study group was 1.9 per subject and for the control group the average amount of root proximities was 0.5. For all severities the difference between the two groups was calculated with the *t*-test and was found to be highly significant ($p \leqslant 0.001$). The odds ratio for periodontal disease per one inter-dental space with root proximity was calculated with logistic regression analysis and found to be 2.6 (95% confidence interval 1.75–3.70) per inter-dental space with root proximity. The relative risk (Fig. 1) for one inter-dental space with root proximity is 2.1 and 3.6 for two inter-dental spaces with root proximity. When five or more inter-dental spaces are affected by root proximity the relative risk reaches more or less a steady state at 6.4–6.7.

In the study group, in the maxilla, 21.1% of the inter-dental spaces between the second and first molar had root proximity in the apical part (a) 28.2% in the middle part (b) and 7.9% in the coronal part (c) (Table 4). In addition, between the first molar and the second premolar and between the first premolar and the canine, most of the root proximities were located in the middle part. For all the other inter-dental spaces in the maxilla, the highest frequencies of root proximity were found in the coronal part.

In the mandible, the intervening part (b) showed the highest frequency of root proximity (3.6%) between the second and first molar. Equal distribution, as regards location, was found between the first molar and second premolar.

All the other inter-dental spaces had the highest frequencies of root proximities located in the coronal part.

In the control group 16.7% of the inter-dental spaces between the first and second molar, had root proximity in the apical part and 5% had it in the intervening part (b). For the other inter-dental spaces in the maxilla, root proximity was found most frequently in the apical part (a) or to an equal extent in the apical and intervening part (b). In the mandible, root proximity was found to an equal extent (1.7%) at the apical and intervening part between the first and second molar and between the canine and lateral incisor. Root proximity was not present between the first molar and the canine. In the incisor region of the control group, root proximity was most frequently found in the apical part.

The periodontal study group had an average of sites with root proximity that was always larger than in the control group (Table 5). When expressed as a percentage, one can see that most of the root proximities in the non-periodontal control group where located in the apical part while in the periodontal study group the root proximities were mostly located in the between or the coronal part.

Per inter-dental space, the average root proximity score of the subjects of the study group was calculated. The Pearson correlation coefficient between the average proximity score of the inter-

Table 3. Average amount (and standard deviation) of inter-dental spaces with root proximity per subject in the periodontal study group or in the non-periodontal control group

	N	Severity 1/2/3 mean (SD)		Severity 2/3 mean (SD)		Severity 3 mean (SD)	
Control	30	1.0 (1.1)	*	1.0 (1.0)	*	0.5 (0.9)	*
Perio	197	3.6 (2.1)		3.0 (2.0)		1.9 (1.7)	

* $p<0.001$.

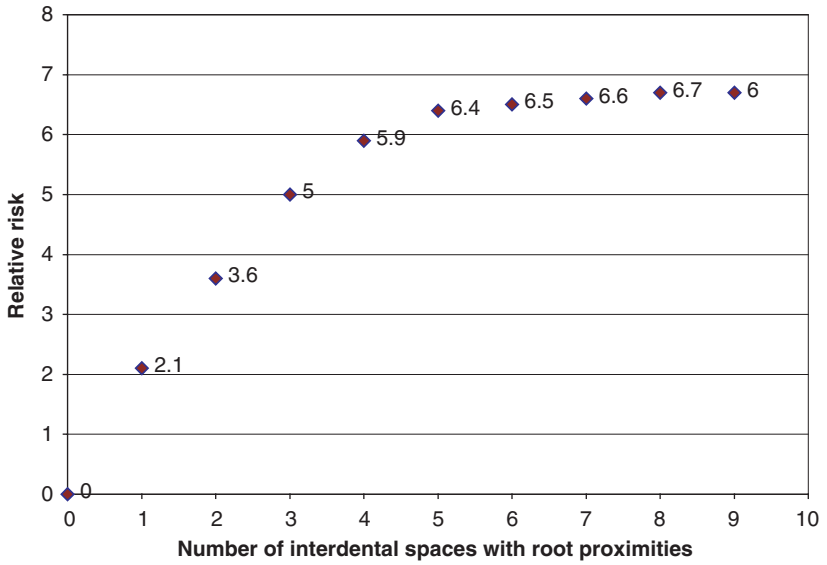

Fig. 1. The calculated relative risk for periodontal disease for the number of additional inter-dental spaces with root proximity.

Table 4. The prevalence of root proximity per inter-dental space (average of the two contra lateral inter-dental spaces) in percentage (± Standard error (SE)) for the maxilla and the mandible and per location and group

	A(pical) (SE)		B(etween) (SE)		C(oronal) (SE)	
	Perio	Control	Perio	Control	Perio	Control
Maxilla						
M2–M1	21.1 (± 2.5)	16.7 (± 6.0)	28.2 (± 2.8)	5.0 (± 2.8)	7.9 (± 1.5)	1.7 (± 1.7)
M1–PM2	1.0 (± 0.5)	1.7 (± 1.7)	4.1 (± 1.2)	1.7 (± 1.7)	1.5 (± 0.6)	0.0 (± 0.0)
PM2–PM1	2.5 (± 0.9)	3.3 (± 2.3)	3.3 (± 1.0)	1.7 (± 1.7)	3.6 (± 1.1)	3.3 (± 2.3)
PM1–C	2.8 (± 0.9)	5.0 (± 3.7)	5.3 (± 1.2)	3.3 (± 2.3)	4.1 (± 1.0)	1.7 (± 1.7)
C–I2	1.8 (± 0.8)	0.0 (± 0.0)	1.5 (± 0.7)	0.0 (± 0.0)	5.1 (± 1.2)	0.0 (± 0.0)
I2–I1	16.2 (± 2.2)	3.3 (± 2.3)	32.7 (± 2.7)	3.3 (± 2.3)	33.3 (± 2.9)	0.0 (± 0.0)
I1–I1	1.0 (± 0.7)	3.3 (± 3.3)	3.1 (± 1.2)	0.0 (± 0.0)	4.1 (± 1.4)	0.0 (± 0.0)
Mandible						
M2–M1	1.3 (± 0.7)	1.7 (± 1.7)	3.6 (± 1.1)	1.7 (± 1.7)	1.8 (± 0.7)	0.0 (± 0.0)
M1–PM2	0.3 (± 0.3)	0.0 (± 0.0)	0.3 (± 0.3)	0.0 (± 0.0)	0.3 (± 0.3)	0.0 (± 0.0)
PM2–PM1	0.5 (± 0.4)	0.0 (± 0.0)	0.5 (± 0.4)	0.0 (± 0.0)	0.8 (± 0.4)	0.0 (± 0.0)
PM1–C	0.8 (± 0.4)	0.0 (± 0.0)	1.5 (± 0.6)	0.0 (± 0.0)	2.3 (± 0.8)	0.0 (± 0.0)
C–I2	2.3 (± 0.9)	1.7 (± 1.7)	5.6 (± 1.3)	1.7 (± 1.7)	8.9 (± 1.5)	0.0 (± 0.0)
I2–I1	24.1 (± 2.6)	11.7 (± 4.6)	33.8 (± 2.8)	5.0 (± 2.8)	35.0 (± 2.7)	3.3 (± 2.3)
I1–I1	16.8 (± 2.7)	6.7 (± 4.6)	28.9 (± 3.2)	3.3 (± 3.3)	30.0 (± 3.3)	0.0 (± 0.0)

dental space and the contra lateral site was calculated. Root proximity at the three levels (apical, between and coronal) was found to be symmetrical at a significance level of $p<0.01$ for all the inter-dental spaces in the maxilla and the mandible between the first and second molar and between the lateral and central incisor. This indicated that root proximity is symmetrical to a certain point. For the control group the data pool was too small to draw conclusions concerning symmetry.

Discussion

One of the criteria to participate in the study group was to have a full dentition (28 teeth) at the moment of intake in the practice and to have advanced periodontal disease. This is not a rare finding since Hirshfield & Wasserman (1978) found that in their study 29% of the patients had 28 or more teeth present at the completion of the initial therapy. Besides, root proximity cannot be studied correctly if the patients would not have a full dentition. Nevertheless, because of this criterium, it is possible that patients with very severe periodontitis were excluded from the study since they would have undergone extractions before they were referred to the periodontist. However, the field of interest of root proximity lies in prevention. In this perspective, the inclusion criterium of a full dentition is valid.

Another drawback of the study is examination bias since the examiner while examining the radiographs for root proximity could also see whether the subject belonged to the study group or the control group.

The fact that only 30 subjects were included in the control group as compared with 197 in the test group is because because of ethical reasons it was not possible to justify full-mouth radiographs in more patients within the time limit of the study.

The relationship of roots relative to each other is a function of the shape of the crown and divergence of the roots. This confirms the high prevalence of root proximity between the first and second molar in the maxilla and between the lateral and central incisors in the maxilla and between all the incisors in the mandible. Similar results were reported by Årtun et al. (1986). In the control group, root proximity was also most prevalent between the first and second molar in the maxilla but to a lesser extend than in the study group.

The results showed that root proximity is a very common phenomenon.

Molars in the maxilla and incisors in the maxilla and the mandible are teeth that are most often lost and canines were the teeth that were least frequently lost in downhill or extreme downhill cases during maintenance (Hirshfield & Wasserman (1978)). Besides, in a longitudinal study of Laurell et al. (2003) it was shown that maxillary molars and lower incisors were the sites that were most prone-to-bone loss. It cannot be denied that there is a striking similarity with root proximity patterns. Therefore root proximity might be used as a risk marker (Last 2001) in a way that its presence can downgrade the prognosis of teeth (Mc Guire 1991).

In the group of periodontal patients 94.4% had at least one inter-dental space with root proximity and 75% of the subjects had severe (3) root proximity. Much less root proximity was found in the control group where 64%

Table 5. Average amount and average expressed as a percentage (and standard deviation) of inter-dental spaces with root proximity per subject according to the division of location in the periodontal study group or in the non-periodontal control group

		Apical		Between		Coronal	
	N	Mean (SD)	Mean % (SD)	Mean (SD)	Mean % (SD)	Mean (SD)	Mean % (SD)
Control	30	1.0 (1.0) *	67.7 (24.5) *	0.5 (0.7) *	25.9 (21.6) *	0.2 (0.5) *	6.4 (14.1) *
Perio	197	1.7 (1.6)	23.0 (19.1)	2.7 (1.9)	41.6 (19.5)	2.4 (1.8)	35.3 (21.0)

*$p<0.001$.

of the subjects had root proximity but only 30 % had severe root proximity. Thus 36% had no root proximity at all compared with 5.6% in the study group and 70% had no severe root proximity compared with only 25% in the study group.

This contrasts with the findings of Trossello & Gianelly (1979), who concluded that root proximity was present in 11.4% of the orthodontically-treated group and 13.4% in the controls. This might have resulted from the fact that root proximity was only measured in the middle part of the roots and the periodontal status was not reported. Årtun et al. (1986) reported, after a subjective screening, 25 out of 400 patients, that had undergone orthodontic treatment in the past, had root proximity. It is logical to assume that orthodontically treated patients have much fewer sites with root proximity since orthodontic treatment would try to correct or avoid situations with root proximity.

Periodontal disease is not a rare disease. Therefore, the relative risk is considerably lower than the odds ratio. Logistic regression shows an odds ratio of 2.6 for one additional root proximity. The odds ratio for two additional root proximities is 2.6^2 etc. This implies that the influence of root proximities on periodontitis is difficult to describe. The influence, however, may better be described by the relative risk, which depends on the prevalence of the disease in the population. Data concerning the prevalence of advanced periodontal disease are difficult to compare since every study uses different criteria and classifications. It is generally accepted that the prevalence of advanced periodontal disease is approximately 10%. However, in the study of Horning et al. (1990) all teeth were screened as it was done in the present study and advanced periodontitis was found in 15% of the subjects. By accepting that 15% of the population has advanced periodontal disease, relative risk was calculated. Patients with several sites with root proximity are therefore more likely to be affected with periodontal disease. This does not mean that every person with root proximity will become a periodontal patient or that root proximity causes periodontitis. However, unfavourable conditions in this case may influence the development of periodontitis and jeopardize the ability to treat the site.

In the present study it is observed that root proximity is symmetrical for all the inter-dental spaces in the maxilla and between the first and second molar and between the central and lateral incisors in the mandible in the periodontal study group. This is in agreement with Geiger et al. (1974), who found that there is bilateral symmetry in crowding.

The more severe the root proximity, the less the number of inter-dental spaces that were affected by root proximity. Since approximately 75% of the subjects had one to five inter-dental spaces with root proximity, and less than 20% had root proximity in more than five sites, this can be considered to be a localized phenomenon.

The periodontal patients of the study group had significantly more sites with root proximity on average than the non-periodontal control group for all three different groups of severity. The subjects in the non-periodontal control group had significantly more sites with root proximity located in the apical part, whereas the subjects of the periodontal study group had significantly more sites with root proximity in the between and coronal part. This is in agreement with the findings of Heins & Wieder (1986) who performed histologic examination on human skulls of subjects that experienced periodontal disease during their life. They found that for mandibular molars and maxillary premolars, the roots are closest in the coronal part and for maxillary molars in the middle part.

Since the control group did not have periodontal disease it is not likely that the root proximity will interfere with their periodontal health. In the periodontal study group however, most of the root proximities were located in the between and coronal part and in these patients it could be hampering oral hygiene measures and treatment delivery. Therefore root proximity must be considered seriously in diagnosis and treatment planning of a periodontal patient.

In conclusion, it can be said that root proximity is a symmetrical and localized but widespread phenomenon in periodontal patients and to a lesser extent in the non-periodontal control group. In periodontal patients root proximity is most often encountered in the coronal and intervening part, whereas subjects without periodontal disease had more root proximity in the apical and intervening part where it is less critical. Patients with multiple sites with root proximity have a higher chance to be affected with periodontal disease. A subject with bilateral root proximity has 3.6 times higher chance to have periodontitis. Therefore root proximity must be considered as a risk marker and it can be used to downgrade the prognosis of teeth.

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