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The infrabony defect and its determinants

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Background and Objective: The purpose of this study was to assess the defect width of infrabony defects in a cross-sectional study and to evaluate whether the defect width is a function of defect depth.

Material and Methods: Complete sets of intra-oral radiographs of patients with severe periodontitis, which exhibited at least one infrabony defect, were digitised and evaluated. The following parameters were measured: depth and width of the infrabony defect, defect angle, and width of the interdental spaces.

Results: Fifty-one patients (26 women), ranging from 21 to 73 yr of age (48.5 ± 13.4 yr), contributed a total of 1272 teeth with 135 infrabony defects (10.6%). Seventeen infrabony defects were located at sites without a neighboring tooth. Infrabony defects were statistically more prevalent in the mandible ($n = 82$) than in the maxilla ($p = 0.013$), and more prevalent at mesial sites ($n = 92$) than at distal sites ($p < 0.001$). At infrabony defects, the width of interdental spaces at the most coronal extension of the alveolar crest could be measured only at sites with neigboring teeth 2.67 ± 0.78 mm (range: 1.19–5.70 mm). Analysis failed to reveal a statistically significant difference between defect width at sites with (2.64 ± 0.82 mm) and sites without (2.76 ± 0.70 mm) a neighboring tooth. Multilevel regression analysis revealed narrow defect angles to be related to deep infrabony defects, whereas width of the interdental space and distal location were related to wide defects.

Conclusion: Defect angle depended on defect depth and defect width was not different at sites with or without a neighboring tooth. Even in severe periodontitis, infrabony defects are found only at a minority of teeth.

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In periodontal diagnosis, intra-oral peri-apical radiographs are used to image the interproximal alveolar crest. The amount of interproximal bone loss can be assessed by measuring the distances between the landmarks cemento–enamel junction or restoration margin and alveolar crest or the most apical extension of an intrabony defect) (1–5). Bony fill within infrabony defect may be assessed by measuring these distances in consecutively obtained radiographs (3–5). There is some evidence that besides depth (4–7) and number of walls, the width of infrabony defects may influence the success of regenerative therapy (4–7). The width of infrabony defects may be assessed in radiographs as the distance between the most coronal margin of the infrabony pocket and the root surface, or as the angle between the root surface and a line through the infrabony defect and the most coronal margin (4–7).

Periodontal destruction is found in a radius of 0.5–2.7 mm (8) and 1.5–2.5 mm (9) around bacterial plaque: the so-called radius of action. Further observations from our group have shown that the width of infrabony defects, assessed as the distance between the most coronal margin of the bony defect and the root surface perpendicularly to the tooth axis, were quite consistently found to be between 2 and 4 mm. If the defect widths were determined by the sphere of action of bacterial plaque, the presurgical defect angle would be a function of the depth of infrabony defects and not an independent prognostic factor (4) (Fig. 1).

Thus, the aim of the present study was to assess the defect width of infrabony defects in a cross-sectional study and to evaluate whether the defect angle is a function of defect depth.

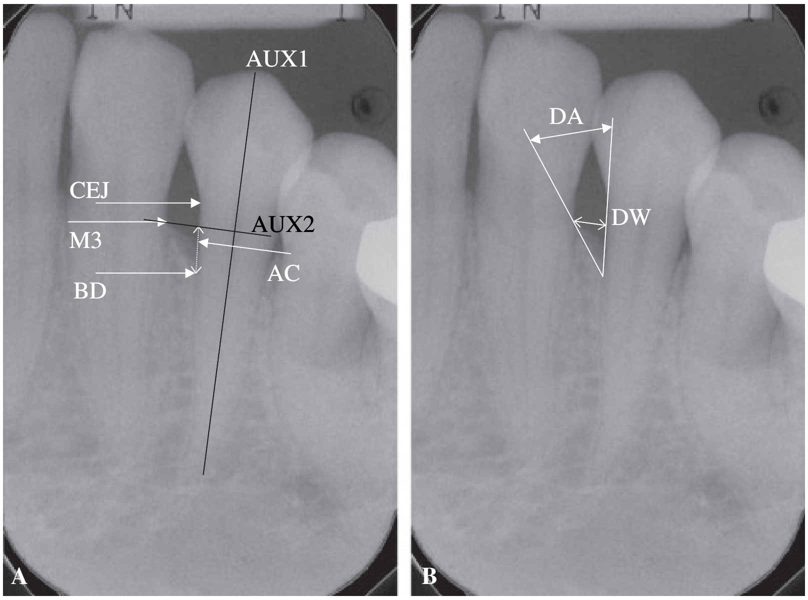

Fig. 1. Mandibular left first premolar of patient no. 26 exhibiting a mesial infrabony defect. (A) AC, alveolar crest; AUX1, auxiliary line 1 representing the tooth axis; AUX2, auxiliary line 2, perpendicular to AUX1 and running through M3; BD, the most apical extension of the bony defect; CEJ, cemento–enamel junction; M3, the most coronal margin of the bony defect; dotted double ended arrow: depth of the infrabony defect. (B) DW, defect width as the distance from M3 to the root surface perpendicular to AUX1, DA, defect angle between the root surface and a straight line from DB to M3.

Material and methods

Patients and clinical examinations

Beginning in 2003, the journal documenting all radiographs that had been produced at the Section of Periodontology, Department of Conservative Dentistry, Clinic for Oral, Dental, and Maxillofacial Diseases, University Hospital Heidelberg, Germany, was searched antichronologically for patients who had undergone a complete status of peri-apical radiographs. Qualifying patients had to fulfil the following criteria: untreated severe chronic or aggressive periodontitis and a complete periodontal examination with probing pocket depths and vertical probing attachment levels at six sites per tooth measured to the nearest mm using a simple manual periodontal probe (PCPUNC 15; Hu Friedy, Chicago, IL, USA). All patients were classified as having severe chronic or aggressive periodontitis, according to the following criteria.

1 Aggressive periodontitis: patient is clinically healthy (i.e. systemic diseases predisposing for periodontitis are not reported), and radiographic bone loss is $\geq 50\%$ at a minimum of two different teeth and age $\leq$ 35 yr at the time of diagnosis.
2 Severe chronic periodontitis: attachment loss ≥ 5 mm at a minimum of one tooth; age $>$ 35 yr.

Patients with post-treatment or incomplete radiographic status, or mild or moderate chronic periodontitis, were excluded from analysis. For qualifying patients, all interproximal infrabony defects were assessed and measured on the peri-apical radiographs.

Radiographic evaluation

All radiographs were digitalized using a flatbed scanner (Epson 1680 pro; Seiko Epson Corp., Nagano-Ken, Japan) and evaluated using the computer program FRIACOM, version 2.0 (Friadent AG, Mannheim, Germany). When scanning each radiograph, a transparent ruler with mm markings was placed on the vertical edge of the radiograph. The markings of the ruler were used to calibrate the PC program.

All radiographic measurements were performed by two experienced examiners (CKK, SHC) who were blinded to the clinical measurements. Both examiners watched the radiographs and identified the infrabony defects. The actual measurements were made by CKK (moving the PC mouse and clicking on the respective landmarks) after he had agreed on the landmarks with SHC. All radiographic measurements were repeated after 14 d (repeated measurements). If an interproximal infrabony defect was shown on more than one radiograph, the radiograph with the better orthoradial projection was chosen for evaluation. If one or more interproximal sites could not be evaluated within a radiographic status (e.g. as a result of overlapping) the number of sites that could not be evaluated per status was documented.

The radiographic landmarks were defined as follows: if the cemento-enamel junction was destroyed by restorative treatment, the margin of the restoration was taken as a landmark. The most apical extension of the bony defect was defined as the most coronal point where the periodontal ligament space showed a continuous width. If no periodontal ligament space could be identified, the point where the projection of the AC crossed the root surface was used as the landmark (2). If both structures could be identified at one defect, the point defined by the periodontal ligament was used as the bony defect, and the crossing of the silhouette of the alveolar crest with the root surface was defined as the alveolar crest. If several bony contours could be identified, the most apical one that crossed the root was defined as the bony defect and the most coronal one as the alveolar crest (3). For all infrabony defects, the distances cemento-enamel junction/restoration to alveolar crest and cemento-enamel junction/restoration to bony defect were measured. Using the measurement tool, a first auxiliary line was drawn to represent the tooth axis (auxiliary line 1, AUX1). Perpendicular to this first auxiliary line, a second one was drawn (AUX2) that ran through the most coronal margin of the infrabony defect (M3). The depth of the infrabony defect was measured as distance between the bony defect and AUX2 (5) (Fig. 1A). The width of the infrabony defect was measured as distance from the coronal margin of the bony pocket (M3) to the root surface perpendicular to AUX1 (tooth axis). Furthermore, the distance between the adjacent root surfaces was measured on the level of width. Using the function 'angle', the angle (defect angle: DA) between the root surface and a straight line from DB to M3 was assessed (4,5) (Fig. 1B).

Before measuring the radiographs, the examiner (CCK) had been trained to identify these landmarks correctly by viewing 25 radiographs several times and discussing the landmarks with the clinical examiner (PE) until common agreement was achieved.

Statistical analysis

The prevalence of infrabony defects in the sample under investigation was calculated. Using chi-square tests, the distribution of infrabony defects according to jaw and location (mesial/distal) was compared. The replicate assessments of radiographic parameters for all infrabony defects were used to estimate the intra-examiner reproducibility, which was expressed as the standard deviation of single measurements (10). To reduce the measurement error, the mean values of the replicate measurements were entered into the analysis. For each interproximal site, two clinical measurements were obtained (mesial: mesiobuccal, mesiolingual; distal: distobuccal, distolingual). For descriptive statistics, the measurements (probing pocket depths, vertically probing attachments levels) of the site with the most profound attachment loss were used in the analysis. The means and standard deviations of the clinical and radiographic parameters were also calculated. The mean width was calculated for all interproximal infrabony defects and for infrabony defects with neighboring tooth and without neighboring tooth separately. The width of infrabony defects with and without neighboring teeth were compared and the test power calculated.

Table 1. Distribution of age and number of remaining teeth as well as number of infrabony defects, according to gender

	Gender/*n*		
	Female/26	Male/25	*p*-value
Age (yr)	43.6 ± 12.8	53.7 ± 12.3	0.006
Teeth (*n*)	24.9 ± 3.1	25.0 ± 4.2	0.972
Infrabony defects (*n*)	2.7 ± 1.4	2.6 ± 1.4	0.673

Multilevel regression analysis was used to identify parameters related to defect angle (11,12). For all analyses, the basic level 'defect' was nested in the upper level 'patient', and patient effects on the outcome were assumed to be fixed. This accounted for the fact that patients contributed more than one defect to the analysis.

Models were fitted including the following independent variables: jaw (maxilla/mandible), site (mesial/distal), tooth type (anterior/premolar/molar), depth, and width of interdental space at the most coronal extension of the alveolar crest. A probability (p) of < 0.05 was required for parameters to be kept within the models.

Results

Patients

Fifty-one patients (26 women) ranging from 21 to 73 yr of age (48.5 ± 13.4) contributed a total of 1272 teeth, of which 135 exhibited infrabony defects (10.6%). Eight patients were diagnosed as suffering from aggressive periodontitis and 43 as having severe chronic periodontitis. Only 17 infrabony defects were located at sites without a neighboring tooth. On average, the male patients were 10 yr older than the female patients (Table 1). Infrabony defects were statistically more prevalent in the mandible ($n = 82$) than in the maxilla ($p = 0.013$) as well as more prevalent as at mesial sites ($n = 92$) than at distal sites ($p < 0.001$).

Table 2. Mean ± standard deviation and measurement error [standard deviation of single measurements (s)] of radiographic parameters

Parameter	Mean	SD	s
CEJ-AC/mm	4.60	2.19	0.74
CEJ-BD/mm	8.19	2.60	0.51
INFRA/mm	5.19	2.00	0.85
Defect width/mm	2.65	0.81	0.30
Defect angle/°	28.03	9.14	5.21

AC, alveolar crest; CEJ, cemento–enamel junction; BD, most apical extension of bony defect; SD, standard deviation.

Clinical and radiographic parameters

At all 135 infrabony defects, a mean probing pocket depth of 6.5 ± 2.4 mm and a vertically probing attachment level of 7.4 ± 2.5 mm were observed. A total of 68% of all assessed sites bled on probing, and 39% exhibited plaque at examination. At infrabony defects, the width of interdental spaces at the most coronal extension of the alveolar crest could be measured only at sites with neigboring tooth: 2.67 ± 0.78 mm (range: 1.19–5.70 mm). Table 2 gives the means ± standard deviations and measurement error of the radiographic parameters. Analysis failed to reveal a statistically significant difference between defect width at sites with (2.64 ± 0.82 mm) and sites without (2.76 ± 0.70 mm) neighboring teeth. The test power for the observed difference of 0.12 mm (95% confidence interval: −0.27 to 0.50 mm), a type 1 error $\alpha < 0.05$, is

Table 3. Multilevel linear regression analysis: dependent variable: defect angle, n = 51 patients, 118 defects (135 minus 17 without a neighboring tooth)

	Estimate	SE	*z*-value	*p*-value
Intercept	25.059	1.754	14.289	0.000
Width of interdental space	7.411	0.509	14.557	0.000
IBD depth	−3.378	0.222	−15.224	0.000
Distal location	1.763	0.860	2.051	0.040

IBDs, infrabony defects; SE, standard error.

7%. Multilevel regression analysis revealed narrow defect angles to be related to deep infrabony defects, whereas width of the interdental space and distal location were related to wide defects (wide angles) (Table 3). Thus, the defect angle is a function of depth.

Discussion

Information on the frequency of infrabony defects in samples that are representative for a population (e.g. of Germany), and even for samples of patients with periodontitis, is scarce. The present study observed an overall frequency of 10.6% for radiographically assessed infrabony defects in patients suffering from severe chronic and aggressive periodontal disease. In a study of 81 patients undergoing flap surgery and where the infrabony defects were detected and analyzed intrasurgically, an overall frequency of 31.3% was reported (13). The higher prevalence in that study may have been a result of the fact that intrasurgical examination revealed buccal and oral vertical defects that were not visible/ measurable on radiographs. However, only teeth scheduled for periodontal surgery, and thus more likely to be affected by severe periodontal disease, were analysed in that study. A cross-sectional radiographic study evaluating 531 individuals who were not selected for periodontal reasons reported a frequency of 8%, slightly less than our results. However, both studies observed infrabony defects more frequently at mesial than at distal sites (14). After examination of 100 dried mandibles from native South Africans not preselected for periodontal disease, Tal reported an 18% frequency for infrabony defects. However, he failed to observe a significant difference between mesial and distal sites (15). This is consistent with findings from another study on dried sculls from India (16). For a random sample of Swedish adult individuals, a frequency of between 1 and 3% of periodontitis severity degree 5 was reported. This severity degree reflects alveolar bone loss around the majority of teeth exceeding two-thirds of the root length, as well as the presence of angular bony defects and/or furcation defects. This study did not report the frequency of infrabony defects related to the total number of teeth (17). However, it may be interpreted that in a random sample, infrabony defects are significantly less frequent than in a group of patients with periodontitis.

Measurement error, assessed as the standard deviation of single measurements, was 0.74 mm for the distance cemento-enamel junction-alveolar crest and 0.51 mm for the cemento-enamel junction-most apical extension of the bony defect. When evaluating the reproducibility of measurements using the same image software, similar measurement errors were observed (cemento-enamel junction-alveolar crest: 0.39–0.56 mm; cemento-enamel junction-most apical extension of the bony defect: 0.7–0.82 mm) (18). Intra-individual measurement errors of 0.25–0.29 mm were reported for assessment of the distance cemento-enamel junction-alveolar crest, with half a day interval between replicate measurements (19). The more favourable measurement error may be explained by a shorter interval between the replicate measurements: 14 d (this study), and half a day (19). In addition, Hausmann *et al.* had measured all types of interproximal bone (from normal bone to infrabony defects) (19). Radiographic landmarks are more difficult to determine in infrabony defects than in normal bone or horizontal

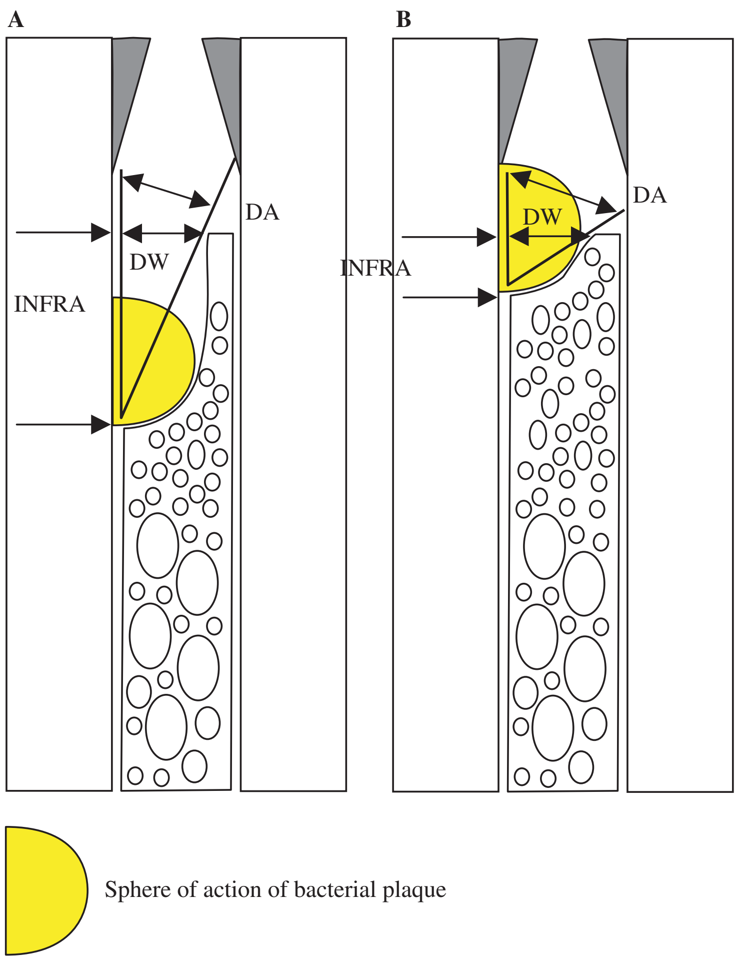

Fig. 2. Sphere of action of bacterial plaque: Within a radius/sphere of up to 2.5 mm apical and lateral to bacterial plaque, inflammatory bone loss is induced. At an interdental space wider than 2.5 mm, an infrabony defect is created. (A) For a constant width of the interdental space and defect width a deep defect is related to a narrow defect angle. (B) A shallow defect is associated with a wide DA.

bone loss. Assessing exclusively infrabony defects, the present study observed a higher variability of measurements. To our best knowledge, there is no information available on the intra-examiner reproducibility of the radiographic parameters infrabony defects, defect width and angle.

Periodontal destruction is found in a radius of 0.5–2.7 mm (8) and 1.5–2.5 mm (9) around bacterial plaque (Fig. 2). Thus, at interdental spaces that measure up to 2.5 mm, bone will be destroyed on the whole interdental width if bacterial plaque moves apically (13). The consequence, in most cases, is horizontal bone loss. In interdental spaces wider than 2.5 mm, plaque advancing apically at only one of the interproximal tooth surfaces may create an infrabony lesion. In fact, plaque advancing at both interproximal surfaces will cause horizontal bone loss, even in an interdental space up to 5 mm. If bone destruction is not limited by the radius of action of the dental biofilm, defects at sites without neighboring teeth may be expected to grow wider than interdental infrabony lesions. However, this study failed to reveal a statistically significant difference between the defect width at sites with (2.64 ± 0.82 mm) and sites without (2.76 ± 0.70 mm) neighboring teeth. As a result of the small number of infrabony defects without neighboring teeth ($n = 17$) the test power of this comparison is very low (7%). On the other hand, the observed difference is very small (0.12 mm). Which difference may be looked upon as clinically relevant? For a clinically relevant difference ($\delta = 1.0$ mm), the test power would measure 93%. Thus, despite the small test power, this observation supports the radius of action theory. Previous studies have found a strong correlation between the prevalence of infrabony defects and the width of interdental spaces (13).

Furthermore, if the defect width was determined by the radius/sphere of action of the bacterial biofilm, the baseline defect angle of an infrabony lesion would be a function of, or at least strongly dependent on, the defect depth and not an independent prognostic factor (4) (Fig. 2). Multilevel regression analysis revealed a negative association of narrow defect angles and deep infrabony defects (i.e. the deeper the defect, the narrower the defect angle). Width of the interdental space and distal location were related to wide defects (wide angles). This is plausible: up to the radius of action of bacterial plaque, the width of the defect depends on the width of the interdental space. In many patients, the axis of most posterior teeth tends to be inclined mesially. Thus, the distal root surface is also inclined mesially. If an infrabony defect develops at a distal root surface, the inclination of the distal root surface adds up to the defect angle that is measured between the lateral bony wall and the respective root surface.

Within the limitations of the present study, we may draw the following conclusions, that (i) defect angle depends on the defect depth and defect width was not different at sites with or without neighboring tooth; and (ii) even in severe periodontitis, infrabony defects are found only at a minority of teeth.

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