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Original Article

Baseline probing depth and interproximal sites predict treatment outcomes of non-surgical periodontal therapy



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Received 18 June 2019; Final revision received 26 August 2019

Available online 15 November 2019

KEYWORDS

Non-surgical periodontal therapy;
Radiographic defect angle;
Interproximal site;
Probing depth;
Treatment outcome

Abstract *Background/purpose:* The efficacy of non-surgical periodontal therapy (NSPT) has been well discussed. The aim of this study was to investigate whether the baseline clinical periodontal parameters, radiographic defect angle, and interproximal site predict the treatment outcome of NSPT.

Materials and methods: A total of 39 patients who were diagnosed with generalized chronic periodontitis and met the inclusion criteria were enrolled in this study. All patients received full-mouth periodontal examination by two well-trained periodontists. Clinical periodontal parameters, including probing depth (PD), recession (Rec), and clinical attachment level (CAL), were recorded, and vertical bitewing radiographs were taken as baseline data. Reevaluation was performed after 4 weeks of non-surgical periodontal treatment. Pearson's correlation coefficient and multivariate logistic regression were performed to examine the association between favorable treatment outcome (PD reduction ≥ 3 mm) and various clinical parameters.

Results: A significant improvement was observed in PD reduction and CAL gain after NSPT. The radiographic defect angle was strongly correlated with baseline Rec, baseline CAL, and interproximal sites in teeth with a deeper PD. Baseline PD and interproximal sites emerged as

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significant prediction factors for favorable treatment outcome with a PD reduction of ≥ 3 mm. **Conclusion:** Our study is the first to report that distal sites show wider radiographic angles with shallow infrabony defects and that pocket reduction is more obvious at distal sites than at mesial sites. These data provide evidence that baseline PD and interproximal sites may predict the treatment outcome of NSPT.

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Introduction

Chronic periodontitis is a chronic inflammatory disease caused by pathogenic microflora in the biofilm, affecting the supporting tissues of the teeth, resulting in the destruction of connective tissues and bone, and tooth loss in severe cases.^{1,2} A recent epidemiological survey reported that 46% of U.S. adults had chronic periodontitis, among whom 8.9% had severe periodontitis.³ A nationwide population-based database revealed that the prevalence of periodontitis significantly increased from 11.5% in 1997 to 19.59% in 2013 in a Taiwanese population, and the mean age of patients with periodontitis showed a decreasing trend.⁴ Periodontitis is highly prevalent among adults and represents a clear public health problem.

The treatment goal of chronic periodontitis is to remove the calculus and inflamed cementum and arrest the inflammatory disease response. Periodontal treatment is divided into a non-surgical or hygienic phase and a surgical or corrective phase.⁵ Non-surgical periodontal therapy (NSPT), known as scaling and root planing, is the most common procedure and remains the gold standard of successful periodontal therapy.^{6,7} The non-surgical phase involves the mechanical removal of supra- and subgingival calculus and plaque to establish periodontal health. In general, scaling and root planing considerably reduce Gram-negative microbes such as *Porphyromonas gingivalis*, *Bacteroides forsythus*, and *Treponema denticola*.^{8–10} The shift toward a more dominant population of Gram-positive microbes is typically associated with gingival health.¹⁰

The major goal of periodontal therapy is to reduce the quantity of bacterial plaque and achieve equilibrium between residual microbes and host response.¹¹ Non-surgical periodontal therapy, combined with effective oral hygiene, can reduce tissue inflammation and pocket depth and improve the clinical attachment level (CAL).^{12,13} Clinical parameters including probing depth (PD), CAL, and recession (Rec) are commonly used to assess periodontal status. The reduction in PD following mechanical instrumentation results from a combination of gain in CAL and gingival Rec.^{14,15} Morrison et al. was the first to demonstrate improvement in clinical parameters of periodontitis 4 weeks after the non-surgical phase when patients received scaling and root planing and performed effective oral hygiene.¹⁶ The evaluation of periodontium after scaling and root planing should be performed no earlier than 4 weeks following treatment.¹⁵ For patients with mild or moderate periodontal disease, non-surgical treatment is often sufficient when patients maintain effective oral hygiene. For patients with advanced

periodontal disease or osseous defects, periodontal surgery may be necessary to reduce the pocket depth and regenerate the lost attachment tissues.

Previous papers have emphasized changes in microbial species and clinical periodontal parameters after non-surgical periodontal treatment.^{8–11,16} McGuire et al. studied factors including initial PD, furcation involvement, tooth mobility, plaque index, and bleeding scores, which may predict tooth prognosis and survival rate.^{17,18} Smoking, the presence of subgingival plaque, gingival bleeding, and pocket depth at multi-rooted teeth have been reported as significant factors in determining the short term clinical outcome of non surgical periodontal treatment.^{19–21} The baseline radiographic defect angle has been correlated with the clinical outcomes of infrabony defects treated with access flap or regeneration surgery,^{22–25} and it has been used as a factor for predicting the success of regenerative approaches. Nevertheless, the role of the radiographic defect angle in predicting the treatment outcomes of NSPT has not been well discussed. The aim of this study was to investigate whether the baseline clinical periodontal parameters, radiographic defect angle, and interproximal site predict the treatment outcome of NSPT.

Materials and methods

Study design and patients

Patients were recruited from the Dental Clinic of National Taiwan University Hospital between July 2016 and June 2017. All patients provided informed consent. The protocol was approved by the Ethics Committee of National Taiwan University Hospital (NTUH-201804058RIND). A flow chart of this study is shown in Fig. 1. The diagnosis of periodontitis was based on the consensus of the International Workshop of the American Academy of Periodontology.²⁶ Patients were over 18 years old and generally healthy, without a history of smoking, and had at least 16 teeth after extraction of hopeless teeth. Patients had not received any periodontal treatment nor been prescribed systemic antibiotics in the previous 3 months. The sample size necessary for a power of 90% ($\alpha = 0.05$) was calculated based on a difference of 20% in CAL before and after treatment, and the variation was 30%.

Periodontal examination

Clinical periodontal examination, including PD, CAL, and gingival Rec, were performed at six sites of each tooth by

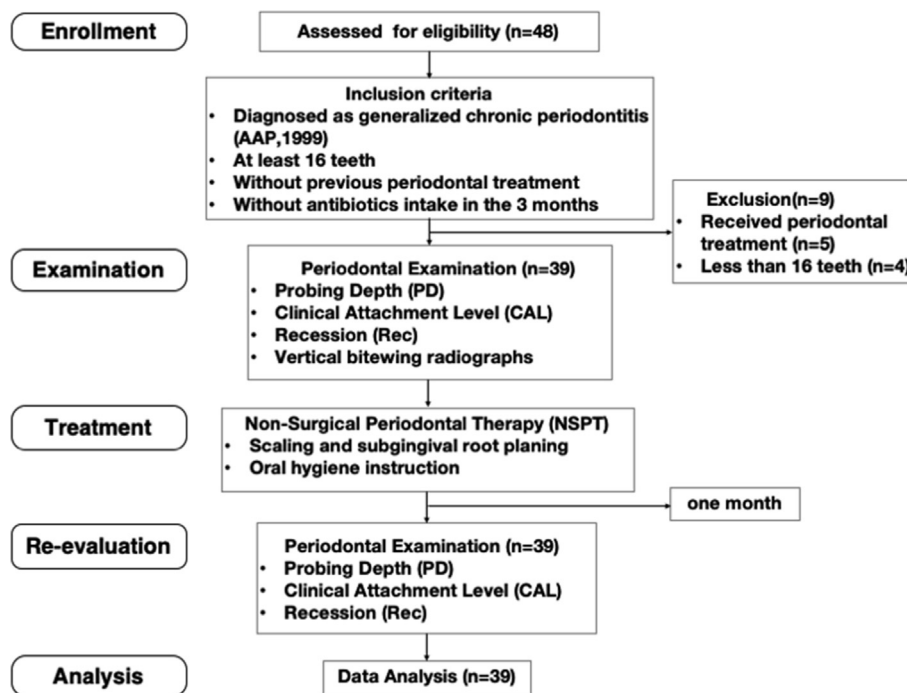


Figure 1 A flow chart of this study.

two well-trained and calibrated periodontists before and after NSPT. The calibration was performed with 10 volunteers before the study began. The reproducibility of the clinical measurements was calculated by means of the index, and a value of 0.857 was obtained for the CAL, with a difference of 1 mm.

Radiographic assessment

All patients received four vertical bitewing films for posterior teeth. At baseline, all vertical bitewing radiographs were screened to detect the presence of infrabony defects. If restorations were present, the apical margin of the restoration was substitute to the CEJ as a fixed reference point.²³ In addition, the tooth with ill-fitting prosthesis or restoratives that might interfere biological width and lead to alveolar bone resorption had been ruled out. Most teeth showed radiographically visible calculus. Radiographs were taken with the long cone paralleling technique, using Rinn holders. The measurements were performed with the assistance of DICOM Viewer (Uniweb, version 10.1, EBM Technologies, Taipei, Taiwan), which is a customized software program. Radiographic defect angle was defined by the (A) cemento-enamel junction of the diseased tooth; (B) bottom of the radiographic defect; and (C) bone crest of the adjacent tooth on the radiographs based on the criteria set by Bjorn et al.²⁷ and Schei et al.²⁸ (Fig. 2) Measurement of the baseline radiographic defect angle was defined by the two lines that represent the root surface of the involved tooth (AB) and the bone defect surface (CB), essentially as previously described.²⁹ Besides, teeth with dilacerated root were excluded in case any variation of the radiographic defect angle. Furthermore, the bottom of the radiographic defects was apical to the nearby alveolar crest which represented all of the defects were infrabony defects.³⁰

All examinations were performed by a radiologist who was blinded to the clinical diagnosis and treatment outcome. Calibration of the radiographic measurements and finding the anatomic landmarks were performed by double measurements of 20 radiographs unrelated to this study with at least 2 weeks gap. Examiner reproducibility was calculated as the standard error of the mean difference of the duplicate measurements.²³

NSPT

Full-mouth scaling and subgingival root planing were completed within four dental visits within 1 month, with one quadrant treated at each appointment. Patients received oral hygiene instruction once a week. Four weeks after NSPT was completed, patients were re-evaluated for all of the clinical parameters. No medication or chlorhexidine was prescribed during treatment.

Statistical analysis

Descriptive statistics and statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was conducted to determine the normality of the data distribution. A two-sample t-test for paired data was used to examine the statistical differences in periodontal clinical parameters before and after NSPT. Pearson's correlation coefficient was used to identify correlations among these parameters. Multivariate logistic regression analysis was performed to examine the association between favorable treatment outcome (PD reduction ≥ 3 mm) and several clinical parameters. The significant difference was set at $p < 0.05$.

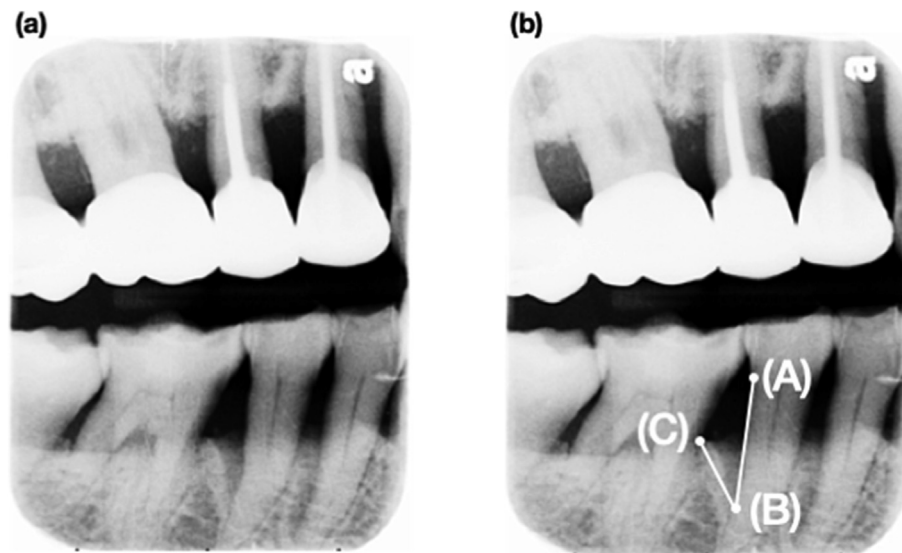


Figure 2 Assessment based on vertical bitewing radiographs. (a) Vertical bitewing radiograph showing Tooth 45 with a distal radiographic infrabony defect. (b) Radiographic defect angle defined by the (A) cemento-enamel junction of the diseased tooth; (B) bottom of the radiographic defect; and (C) bone crest of the adjacent tooth.

Results

As Fig. 1 shows, 48 patients were enrolled in this study. Five patients who had received periodontal treatment within 3 months, and four who had fewer than 16 teeth after hopeless teeth had been extracted were excluded from this study. A total of 39 patients completed NSPT and re-evaluation. Table 1 shows the demographics and periodontal clinical parameters of all patients. A significant improvement was observed in PD reduction and CAL gain overall. The number of sites with PD ≥ 5 mm and CAL ≥ 5 mm was significantly lower after NSPT. Table 2 Shows the average reduction of PD, increase of Rec, and gain of CAL after NSPT in the anterior and posterior teeth. Similar results were obtained regarding the change of PD and Rec in the anterior or posterior buccal/facial and palatal/distal aspects. However, the posterior teeth showed more prominent CAL gain than the anterior teeth. Table 3 shows the average reduction of PD, increase of REC, and gain of CAL after NSPT at buccal/facial and palatal/lingual sites. No

significant difference was observed in the changes of these parameters in the maxillary or mandibular buccal/facial and palatal/lingual aspects.

Table 4 shows change in the sites with PD ≥ 5 mm or CAL ≥ 5 mm after NSPT. Both the anterior and posterior teeth showed significant improvement in the number of sites with PD or CAL ≥ 5 mm. The results were similar at the buccal/facial and palatal/lingual sites. The treatment outcomes of the different initial PD groups are shown in Fig. 3. The average PD reduction was significantly higher in the group with initial PD ranges of 4–6 mm and ≥ 7 mm. After NSPT, the number of sites with PD ≥ 5 mm was significantly lower in the three groups.

Table 5 shows the associations between the radiographic defect angle ($n = 102$) and initial or final PD, CAL, and Rec, and the changes in PD, CAL, and Rec. The radiographic defect angle was significantly associated with the initial Rec/CAL and final Rec/CAL, indicating that wider radiographic angles are correlated with a larger amount of initial and final Rec/CAL. The correlations among various clinical

Table 1 Geographic characteristics of the study subjects.

	initial	Re-evaluation	Change	<i>p</i> value
N	39	39	—	—
Age	53.67 \pm 11.32	53.67 \pm 11.32	—	—
Gender (M/F)	19/20	19/20	—	—
Tooth Number	25.86 \pm 3.37	25.86 \pm 3.37	—	—
PD (mm)	3.24 \pm 0.61	2.75 \pm 0.41	-0.49 \pm 0.54	0.000*
CAL (mm)	4.09 \pm 0.92	2.98 \pm 0.88	-0.25 \pm 0.25	0.000*
Rec (mm)	0.86 \pm 0.79	1.21 \pm 0.83	0.22 \pm 0.36	0.000*
Site Number (total)	155.2 \pm 20.2	155.2 \pm 20.2	—	—
Sites with PD ≥ 5 mm(%)	19.2 \pm 13.9	6.19 \pm 6.09	—	0.000*
Sites with CAL ≥ 5 mm(%)	18.64 \pm 15.57	11.55 \pm 5.47	—	0.000*

PD: Probing Depth; CAL: Clinical Attachment Level; Rec: Recession.

* $p < 0.05$.

Table 2 Comparisons of treatment outcomes at anterior and posterior teeth.

	PD reduction	<i>p</i> value	Rec change	<i>p</i> value	CAL gain	<i>p</i> value
Anterior	-0.97 ± 1.32	0.119	0.30 ± 0.74	0.136	-0.91 ± 1.88	0.047*
Posterior	-1.14 ± 1.27		-0.06 ± 0.61		-1.18 ± 1.75	
Anterior	-0.98 ± 1.30	0.849	0.06 ± 0.73	0.263	-0.93 ± 1.82	0.762
Buccal/Facial						
Anterior	-0.96 ± 1.41		-0.00 ± 0.79		-0.90 ± 2.01	
Palatal/Lingual						
Posterior	-1.13 ± 1.22	0.860	-0.02 ± 0.53	0.274	-1.13 ± 1.69	0.503
Buccal/Facial						
Posterior	-1.15 ± 1.38		-0.10 ± 0.74		-1.22 ± 1.90	
Palatal/Lingual						

PD: Probing Depth; CAL: Clinical Attachment Level; Rec: Recession.

**p* < 0.05.

Table 3 Comparisons of treatment outcomes at buccal/facial and palatal/lingual sites.

	PD reduction	<i>p</i> value	Rec change	<i>p</i> value	CAL gain	<i>p</i> value
Buccal/Facial	-1.07 ± 1.21	0.967	0.01 ± 0.59	0.205	-1.06 ± 1.70	0.713
Palatal/Lingual	-1.08 ± 1.35		-0.06 ± 0.72		-1.10 ± 1.89	
Maxillary	-1.10 ± 1.21	0.708	0.03 ± 0.64	0.610	-1.09 ± 1.74	0.863
Buccal/Facial						
Maxillary	-1.13 ± 1.35		0.00 ± 0.65		-1.07 ± 1.79	
Palatal/Lingual						
Mandibular	-1.05 ± 1.33	0.792	0.00 ± 0.60	0.139	-1.03 ± 1.78	0.502
Buccal/Facial						
Mandibular	-1.02 ± 1.42		-0.12 ± 0.85		-1.13 ± 2.07	
Palatal/Lingual						

PD: Probing Depth; CAL: Clinical Attachment Level; Rec: Recession.

**p* < 0.05.

Table 4 Comparisons of treatment outcomes in aspect of sites with PD ≥ 5 mm(%) or CAL ≥ 5 mm(%)

		Sites with PD ≥ 5 mm(%)	<i>p</i> value	Sites CAL ≥ 5 mm(%)	<i>p</i> value
Anterior Teeth	Initial	8.48 ± 14.26	0.002*	10.69 ± 13.84	0.046*
	Re-evaluation	1.25 ± 3.21		7.09 ± 13.78	
Posterior Teeth	Initial	23.61 ± 13.45	0.000*	18.53 ± 14.55	0.000*
	Re-evaluation	8.27 ± 8.23		6.22 ± 8.94	
Buccal/Facial	Initial	17.51 ± 12.46	0.000*	19.17 ± 14.98	0.000*
	Re-evaluation	5.73 ± 6.66		9.03 ± 12.45	
Palatal/Facial	Initial	21.13 ± 16.06	0.000*	22.06 ± 18.48	0.000*
	Re-evaluation	6.75 ± 7.51		8.72 ± 14.70	

**p* < 0.05.

parameters, including age, radiographic defect angle, interproximal sites, initial PD, Rec, and CAL, are shown in Table 6. In the group with an initial PD < 3 mm (Table 6(a)), initial Rec was positively correlated with age, radiographic defect angle, initial PD, and initial CAL. In the group with an initial PD of 4–6 mm (Table 6(b)), initial Rec was positively correlated with age, radiographic defect angle, and initial CAL. A positive correlation was observed between the radiographic defect angle and initial CAL. The wider the radiographic angle was, the larger the initial Rec and CAL were. In the group with an initial PD ≥ 7 mm (Table 6(c)), initial REC was positively correlated with age and initial

CAL. The radiographic defect angle was strongly correlated with interproximal sites. This result suggests that the distal root surface showed a wider radiographic defect angle (shallow bony defect) than the mesial surface.

We defined the treatment outcome as favorable based on a PD reduction or CAL gain ≥ 3 mm. Table 7 shows the clinical parameters associated with a favorable treatment outcome based on multivariate logistic regression. In the PD model, baseline PD and interproximal sites emerged as significant factors for predicting favorable treatment outcome with a PD reduction ≥ 3 mm. When the initial PD was larger, the amount of PD reduction is more prominent.

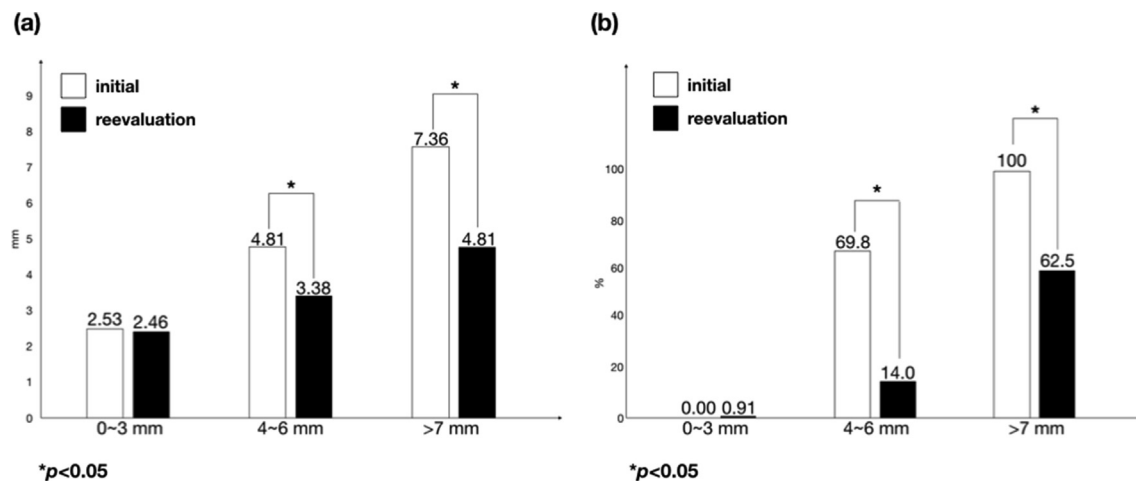


Figure 3 The efficacy of non-surgical periodontal therapy. (a) The average reduction of probing depth (PD) (mm) and (b) the change of sites with PD ≥ 5 mm (%) at initial and reevaluation timepoints in groups with different initial PDs.

Table 5 The associations between radiographic defect angle and various parameters.

	Initial PD	Final PD	PD reduction	Initial Rec	Final Rec	Rec change	Initial CAL	Final CAL	CAL gain
Radiographic defect angle (n = 102)	Pearson 0.11	0.08	-0.08	0.24	0.26	0.05	0.26	0.24	-0.04
	p value 0.257	0.453	0.435	0.014*	0.008*	0.644	0.009*	0.015*	0.676

PD: Probing depth; CAL: Clinical Attachment Level; Rec: Recession.
*p < 0.05.

NSPT was more effective at distal sites than at mesial sites. In the CAL model, the initial PD was the only significant factor for predicting a favorable treatment outcome with a CAL gain ≥ 3 mm.

Discussion

This study is the first to report a favorable treatment outcome independently correlated with interproximal sites. The distal sites showed wider radiographic angles with flatter infrabony defects, and the pocket reduction was more obvious than that at mesial sites. This phenomenon was particularly prominent at sites with an initial PD ≥ 7 mm. Kim et al. studied the correlations between defect angle and PD in 1272 teeth with 135 infrabony defects. They reported that infrabony defects were significantly more prevalent in the mandible than in the maxilla, and more prevalent at mesial sites than at distal sites.³¹ In addition, the narrow defect angle was related to deeper PD. Papananou et al. reported that angular bony defects were more prevalent on the mesial side than on the distal side in a cross-sectional study.³² Wouters et al. conducted an epidemiological study and reported that interproximal defects were more prevalent on the mesial than distal root surface in a Swedish population.³³ Our results are consistent with previous studies, suggesting that distal sites with wider radiographic angle may predict favorable treatment outcomes of NSPT. This is reasonable when the bony destruction pattern is more horizontal with wider

radiographic angles, which results in the effect of pocket reduction by NSPT being more prominent.

Infrabony defects or uneven bone architecture may contribute to residual pockets after periodontal treatment and associated with an increased risk of further periodontal breakdown.³⁴ McGuire and Nunn et al. reported that tooth survival was associated with various factors in 2509 teeth during the maintenance phase.¹⁸ Increased tooth loss was associated with deeper PD and pronounced radiographic bone destruction; however, the morphology and angle of radiographic bony defects were not discussed in their studies. Tooth sites with “angular” or “even” bony loss in patients who did not undergo periodontal therapy were studied after 10-years of follow-up.³⁵ Their results showed that the presence of angular bony defects increased the risk of further alveolar bone loss. By contrast, Pontoriero et al. failed to prove that sites with angular bony defects were more susceptible to recurrent periodontitis.³⁶ This is probably because all of the participants received active periodontal treatment and were placed in a highly strict maintenance case program that included recall appointments every 3–6 months for a period of 5–16 years.

The variation of root anatomy may explain why angular radiographic defects were more prevalent on the mesial surface of premolars and molars than on the distal surface.³⁴ Nevertheless, excess chewing force from opposing tooth or unfavorable tooth alignment may also have contributed to this phenomenon. Previous studies have reported correlations between radiographic defect angle and the clinical outcomes of infrabony defects treated with

Table 6 The correlations between various clinical periodontal parameters in different initial PD groups.

		Age	Angle	Mesial/Distal	Initial PD	Initial Rec	Initial CAL
(a) Initial PD < 3 mm							
Age	Pearson	1	-0.01	-0.10	0.16	0.38	0.36
	<i>p</i> value		0.948	0.571	0.339	0.019*	0.027*
Angle	Pearson	-0.11	1	0.32	0.12	0.34	0.32
	<i>p</i> value	0.948		0.053	0.475	0.034*	0.051
Mesial/Distal	Pearson	-0.10	0.32	1	-0.27	-0.10	-0.17
	<i>p</i> value	0.571	0.053		0.100	0.543	0.307
Initial PD	Pearson	0.16	0.12	-0.27	1	0.44	0.68
	<i>p</i> value	0.339	0.475	0.100		0.005*	0.000*
Initial Rec	Pearson	0.38	0.34	-0.10	0.44	1	0.96
	<i>p</i> value	0.019*	0.034*	0.543	0.005*		0.000*
Initial CAL	Pearson	0.36	0.32	-0.17	0.68	0.96	1
	<i>p</i> value	0.027*	0.051	0.307	0.000*	0.000*	
(b) Initial PD 4~6 mm							
Age	Pearson	1	-0.17	-0.07	-0.08	0.36	0.33
	<i>p</i> value		0.219	0.637	0.544	0.006*	0.013*
Angle	Pearson	-0.17	1	0.19	0.20	0.28	0.35
	<i>p</i> value	0.219		0.169	0.151	0.037*	0.009*
Mesial/Distal	Pearson	-0.07	0.19	1	-0.10	-0.03	0.00
	<i>p</i> value	0.637	0.169		0.470	0.826	0.974
Initial PD	Pearson	-0.08	0.20	0.10	1	-0.16	0.19
	<i>p</i> value	0.544	0.151	0.470		0.238	0.169
Initial Rec	Pearson	0.36	0.28	-0.03	-0.16	1	0.94
	<i>p</i> value	0.006*	0.037*	0.826	0.238*		0.000*
Initial CAL	Pearson	0.33	0.35	0.00	0.19	0.94	1
	<i>p</i> value	0.013*	0.009	0.974	0.169*	0.000*	
(c) Initial PD ≥ 7 mm							
Age	Pearson	1	0.03	-0.46	-0.01	0.72	0.76
	<i>p</i> value		0.937	0.213	0.990	0.028*	0.017*
Angle	Pearson	0.03	1	0.67	0.59	-0.25	0.03
	<i>p</i> value	0.937		0.050*	0.092	0.513	0.940
Mesial/Distal	Pearson	-0.46	0.67	1	0.35	-0.50	-0.35
	<i>p</i> value	0.213	0.050*		0.351	0.170	0.351
Initial PD	Pearson	-0.01	0.59	0.35	1	-0.35	0.13
	<i>p</i> value	0.990	0.092	0.351		0.351	0.749
Initial Rec	Pearson	0.72	-0.25	-0.50	-0.35	1	0.88
	<i>p</i> value	0.028*	0.513	0.170	0.351		0.002*
Initial CAL	Pearson	0.76	0.03	-0.35	0.13	0.88	1
	<i>p</i> value	0.017*	0.940	0.351	0.749	0.002*	

(a) Initial PD < 3mm, n = 38.

(b) Initial PD 4 ~ 6 mm, n = 55.

(c) Initial PD > 7mm, n = 9.

PD: Probing Depth; CAL: Clinical Attachment Level; Rec: Recession.

**p* < 0.05.

access flap or regeneration surgery.^{22–25} The findings of these studies suggested that CAL gain and bone fill are associated with narrow radiographic infrabony angles. Cortellini & Tonetti et al. studied 242 infrabony defects treated with guided tissue regeneration and found a significant difference in the CAL outcomes of narrow and wide defects, and they suggested the radiographic defect angle as a crucial factor for predicting the treatment outcome of guided tissue regeneration.³⁷ In our study, we found no positive association between radiographic defect angle and favorable treatment outcomes (PD reduction ≥ 3 mm) in a multivariate logistic model; however, the fact that PD

reduction at distal sites was more prominent than at mesial sites might explain the higher prevalence of angular bony defects at mesial sites. Wider radiographic defect angles were found to correlate with baseline Rec at sites with a PD of 4–6 mm and <3 mm, implying that when infrabony defects appear more horizontally, the baseline Rec is more obvious. In other words, the baseline PD might be shallower with a relatively narrow radiographic defect angle. The PD reduction is more prominent in a shallow infrabony defect, and the final Rec is also more prominent.

The efficacy of NSPT was proven in this study and was consistent with previous studies.^{6,38–42} In our study, the

Table 7 The factors associated with PD reduction ≥ 3 mm or CAL gain ≥ 3 mm by multivariate logistic regression analysis.

	PD reduction ≥ 3 mm				CAL gain ≥ 3 mm			
	S.E.	OR	[95%CI]	p value	S.E.	OR	[95%CI]	p value
Gender	1.34	11.03	[0.82–152.93]	0.073	1.30	6.93	[0.55–87.94]	0.135
Angle	0.05	0.95	[0.86–1.05]	0.309	0.05	0.94	[0.86–1.03]	0.182
Mesial/Distal	1.27	13.84	[1.15–166.36]	0.038*	1.21	6.55	[0.61–70.51]	0.121
Initial PD	0.37	2.38	[1.15–4.94]	0.020*	0.35	2.12	[1.07–4.21]	0.032*
Initial R	0.39	0.97	[0.45–2.09]	0.943	0.35	1.73	[0.88–3.44]	0.114

* $p < 0.05$.

amount of PD reduction was similar at the anterior, posterior, buccal, and lingual sites (Tables 2 and 3). Although the CAL gain was significantly higher in the posterior teeth than in the anterior teeth (Table 2), this may have been due to the deeper baseline PD at the posterior teeth. The amount of PD reduction and attachment level gain are reported to correlate to initial measurement and severity.^{12,16} For periodontal pockets with an initial PD of 4–6 mm, the mean reduction in pocket depth is 1.29 mm and CAL gain is 0.55 mm. For pockets with an initial PD ≥ 7.0 mm, the mean pocket depth reduction is 2.16 mm and CAL gain is 1.19 mm. Nevertheless, PDs with an initial PD ≤ 3 mm may have a net loss of 0.34 mm in CAL.¹² In this study, sites with a PD reduction or CAL gain ≥ 3 mm were positively correlated with baseline PD after adjustment of the initial Rec and interproximal sites. Our findings are in agreement with previous studies, suggesting that patients with a deeper baseline PD show more prominent PD reduction after NSPT.

This study had some limitations. First, the data of plaque index, gingival index, tooth mobility, and furcation involvement were not recorded in this study. Second, buccal and lingual defects are not measurable on radiographs, and only interproximal defects were analyzed. In addition, the interpretation of defect morphology was difficult because radiographs provide two-dimensional images. Despite on the limitations of this study, we concluded that the initial PD and interproximal sites may predict the treatment outcome of NSPT. Shallow infrabony defects with wider radiographic angles are also correlated with initial Rec, CAL, and distal tooth sites. The diagnosis of osseous defects based on clinical periodontal parameters and reestablishing their morphology with qualified radiographs are crucial in clinical treatment decisions. These data justify the specific attention that periodontists pay to clinical parameters and radiographic defect angles and provide rationale for the efficacy and predictive factors of NSPT.

Declaration of Competing Interest

The authors declare that they have no conflicts of interest related to this study.

Acknowledgements

This study was supported by grants (108-M4214,108-S4235) from National Taiwan University Hospital.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jds.2019.08.008>.

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