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The association between clinical and radiographic periodontitis measurements during periodontal maintenance

Jeffrey B. Payne, D.D.S., M.Dent.Sc.^{*}, Pirkka V. Nummikoski, D.D.S., M.S.[†], David M. Thompson, Ph.D.[‡], Lorne M. Golub, D.M.D., M.Sc.[§], and Julie A. Stoner, Ph.D.[‡]

^{*}Department of Surgical Specialties, University of Nebraska Medical Center College of Dentistry, Lincoln, Nebraska, USA

[†]Longitudinal Radiographic Assessment Facility, University of Texas Health Science Center San Antonio Dental School, San Antonio, Texas, USA

[‡]Department of Biostatistics and Epidemiology, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, USA

[§]Department of Oral Biology and Pathology, School of Dental Medicine, Stony Brook University, Stony Brook, New York, USA

Abstract

Background—To examine the association between clinical and radiographic periodontitis measurements during two years of periodontal maintenance.

Methods—Secondary analyses were performed from a two-year, double-blind, placebo-controlled, randomized clinical trial evaluating the efficacy and safety of subantimicrobial dose doxycycline (SDD) in 128 postmenopausal osteopenic women with moderate to severe chronic periodontitis. Relative clinical attachment level (RCAL) and probing depth (PD) measures were made. Posterior vertical bite-wings were taken for alveolar bone density (ABD) and alveolar bone height (ABH) measurements. Generalized estimating equations were used to model associations.

Results—One-year ABD changes and one-year RCAL/PD changes did not predict two-year ABH changes and ABH/ABD changes, respectively. Baseline RCAL and PD were positively associated with baseline ABH loss ($p < 0.0001$) and baseline probing depths were associated with subsequent ABD and ABH loss ($p < 0.05$ for each). Among placebo (but not SDD) participants, RCAL changes were associated with concurrent ABD loss ($p = 0.027$) when considering one- and two-year changes combined. The odds of ABH loss were higher among sites with concurrent one-year ABD loss versus no change ($OR = 3.15$, $p < 0.0001$) or concurrent PD increases versus no change ($OR = 1.88$, $p = 0.0025$) when considering one- and two-year changes combined.

Conclusions—In postmenopausal osteopenic women undergoing periodontal maintenance, baseline PD was associated with subsequent ABD and ABH loss. Although no longitudinal change preceded another measurement change, changes in probing depths and relative clinical attachment levels appeared to reflect changes in the underlying alveolar bone over time.

^{*}Full contact information for corresponding author: Dr. Jeffrey B. Payne, Associate Dean for Research, Professor, F. Gene and Rosemary Dixon Endowed Chair in Dentistry, University of Nebraska Medical Center, College of Dentistry, 40th and Holdrege, Lincoln, NE 68583-0740, Telephone Number: (402) 472-1318, Fax Number: (402) 472-6668, jbpayne@unmc.edu.

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MeSH Key Words

alveolar bone loss; doxycycline; osteopenia; periodontal attachment loss; periodontitis; postmenopause

INTRODUCTION

Periodontal maintenance is an essential component of periodontal therapy and has been shown to reduce progressive attachment loss and tooth loss¹ when compared to less frequent periodontal maintenance² or none at all.³ Periodontal maintenance appointments include an independent assessment of clinical changes via measurement of probing depths and attachment levels, and radiographic changes via evaluation of alveolar bone height (ABH), in addition to oral hygiene instructions and supragingival and subgingival debridement.

The association between clinical (soft tissue) measurements and alveolar bone loss has been explored in untreated periodontitis patients⁴⁻⁶ and in the absence of periodontitis.⁷ In a study of postmenopausal women in the absence of periodontal disease, changes in ABH and changes in attachment level were only weakly associated based on site-level data over a two-year follow-up period.⁷ In untreated, general periodontitis populations, clinical attachment levels and baseline crestal bone height were significantly correlated, but changes in these measures over a one-year period beyond a defined threshold did not demonstrate good agreement.⁶ In contrast, probing attachment loss and crestal bone height loss, based on one-year changes, were significantly, but weakly, correlated based on site-level data from 57 untreated adults with established periodontitis.⁵ A small study of patients with untreated destructive periodontal disease monitored for one year suggested that significant attachment loss preceded oral bone loss.⁴ The association between oral bone loss and clinical periodontal measures, such as attachment level, appears to be complex and there is some suggestion that there may be a time lag between changes in oral radiographic measures and changes in clinical periodontal measures.⁷ However, the temporal association between clinical and radiographic periodontitis measurements during periodontal maintenance has not been explored.

We recently published the results of a clinical trial examining the efficacy and safety of subantimicrobial dose doxycycline (SDD) as an adjunctive treatment of periodontitis in postmenopausal women with systemic osteopenia and moderate to severe chronic periodontitis who were undergoing periodontal maintenance therapy.^{8,9} In this clinical trial, SDD reduced alveolar bone loss in subgroups and reduced progressive relative clinical attachment loss based on intent-to-treat analysis. Our hypotheses for the current study were: 1) alveolar bone density (ABD) loss precedes ABH loss and 2) relative clinical attachment loss and probing depth (PD) increases precede ABD loss and ABH loss over a 2-year period among postmenopausal osteopenic women. Therefore, the purpose of this two-year longitudinal study was to examine the temporal association between clinical periodontitis measurements (relative clinical attachment level [RCAL] and PD) and radiographic measurements (ABD and ABH) over time during periodontal maintenance.

MATERIALS and METHODS

Study Design

The study described in this paper represents secondary data analyses from the clinical trial. The design of this clinical trial, including the flow of participants from screening through analysis, has been described extensively elsewhere.⁸ Briefly, one hundred twenty-eight eligible postmenopausal women with osteopenia and moderate to severe chronic

periodontitis (defined as at least two sites, on different posterior teeth, with probing depths and clinical attachment loss ≥ 5 mm with bleeding on probing) participated at the two study centers (University of Nebraska Medical Center [UNMC] College of Dentistry and Stony Brook University School of Dental Medicine). The study protocol was reviewed and approved by the UNMC and Stony Brook University Institutional Review Boards and all participants provided written informed consent. Eligible individuals were randomized to either SDD (20 mg doxycycline hyclate; $n=64$) or placebo ($n=64$). The clinical trial was double-blind and patients were instructed to take SDD or placebo tablets twice daily for two years. Participants also were provided calcium (1200 mg daily, divided into two doses) and vitamin D supplements (400 IU daily, divided into two doses) based on the standard of care at the time this clinical trial was conducted. Patients were recruited and randomized on a rolling admission basis beginning in June 2002 and ending in October 2003. The last participant completed the clinical trial in October 2005. All patients received periodontal maintenance every three to four months during the two-year clinical trial by their own dental care provider and at no cost to the patient.

Inclusion and exclusion criteria have been published.⁸ Briefly, participants were between 45 and 70 years of age at telephone screening, osteopenic (defined as a T-score, as determined by dual-energy x-ray absorptiometry, between -1.0 and -2.5 inclusive) at either the lumbar spine or femoral neck, and not receiving any medications that would influence bone remodeling (e.g., bisphosphonates or hormone replacement therapy). All patients had moderate to severe chronic periodontitis and no individuals had osteoporosis at either the lumbar spine or femoral neck (T-score less than -2.5).

Clinical Periodontal Measurements

Clinical measurements were made at posterior interproximal sites.⁹ RCAL measurements were made with a Florida Disk Probe^{||} every six months for two years. PD measurements were recorded every six months for two years using a UNC-15 probe.[¶] Calibration studies were performed as described by Reinhardt et al.⁹ Replicate clinical measures were made at 6 and 18 month visits on 12 (PD measures) and 13 (RCAL measures) randomly-chosen patients to estimate the standard deviation of replicate measures, which were used to define thresholds of change for statistical analysis purposes.

Alveolar Bone Measurements

Four posterior vertical bite-wing radiographs were taken at baseline, one-year and two-year visits. Standardized radiographic projection geometry and bite-wing holders were used in exposure of the radiographs, and the one-year or two-year follow-up radiograph was aligned with the baseline image such that measurement locations were the same in the baseline and follow-up films. The alveolar bone measurement methodology has been described previously.⁸ ABD was measured by computer-assisted densitometric image analysis (CADIA) at crestal and subcrestal areas of interest. ABH was measured by the method of Hausmann et al.¹⁰ ABH measurements were made between a fixed reference point (cemento-enamel junction or restoration margin) and the alveolar crest. All alveolar bone measurements for the clinical trial were made by a single examiner (PVN) at the Longitudinal Radiographic Assessment Facility. Replicate radiographic measures were made at one and two year visits on 13 randomly-chosen participants to estimate the standard deviation of replicate measures.

^{||}Florida Probe Corporation, Gainesville, FL

[¶]Hu-Friedy, Chicago, IL

Statistical Analysis

Associations between baseline measures were investigated using linear regression modeling applied to tooth-site level measures. Changes in ABH, RCAL and PD from baseline at one and two years were calculated, whereas the CADIA measure itself represents a relative change from baseline and therefore, no further calculation was performed. Categories (disease progression, no change, improvement) were coded as previously described^{8,9} using thresholds, based on two times the standard deviation of replicate measures, of ± 2 mm for PD, ± 1.5 mm for RCAL, ± 17 at crestal or ± 14 at subcrestal locations for ABD (tooth site-level code reflecting more extreme crestal/subcrestal CADIA value), and ± 0.4 mm for ABH. Changes equal to or beyond the stated threshold values were coded as progression or improvement depending on the sign of the change. Positive changes indicated disease progression for ABH, PD, and RCAL; negative ABD changes indicated progression. Logistic regression was used to investigate the association between concurrent and time-lagged changes in oral bone and soft tissue measures using a dichotomous outcome variable, indicating disease progression based on alveolar bone values, and two independent variables, indicating progression and no change with reference to improvement, based on soft tissue values. A third contrast, between sites demonstrating progression versus no change in the soft tissue measures, was then estimated. Overall, two degrees of freedom (df) Wald tests are reported, comparing the odds of alveolar bone loss among all three categories of the independent factor, followed by pair-wise contrasts to determine which pairs differ significantly. Models were adjusted for the baseline outcome measure (except for ABD, a relative change), randomized treatment, visit, and smoking. To determine if associations differed by time, treatment, smoking status, and years post-menopausal, interactions were fit. Stratified models were fit for significant time and treatment interactions; interactions with smoking status and years postmenopausal were non-significant and are not presented. As in previous publications, results based on combined one- and two-year changes are presented when significant modification by study visit was not detected.⁸⁻⁹ Similar models were fit to investigate the association between ABD changes (independent variable) and ABH loss (outcome) and the association between baseline measures (independent variable coded as 2 dummy variables indicating probing depths of 5–6 mm or 7mm with reference to 1–4 mm probing depths, with a contrast between probing depths of 5–6 mm versus 7mm subsequently estimated) and concurrent or time-lagged changes in oral bone (outcome). All regression models were fit using generalized estimating equations to account for tooth-site measurement correlation. A two-sided 0.05 alpha level was used, except for pair-wise comparisons, which were based on a 0.0167 level (Bonferroni adjustment).

RESULTS

Among the 128 randomized patients, 117 participants completed at least one annual follow-up visit and were analyzed. Patients were, on average, 58 years old (range 45–70 years), 91% were non-Hispanic White, 38% were within 5 years of menopause, and 21% were current smokers. A descriptive summary of baseline and one- and two-year changes in alveolar bone and clinical measures is provided in Table 1.

Lagged Associations

One-year RCAL changes did not predict either two-year ABD (overall, two df test, $p=0.39$) or ABH changes (overall, two df test, $p=0.87$). Likewise, one-year PD changes did not predict either two-year ABD (overall, two df test, $p=0.64$) or ABH changes (overall, two df test, $p=0.20$). Results were similar when 6-month lags between soft tissue changes and alveolar bone changes were considered (data not shown). One-year changes in ABD did not predict two-year ABH loss (overall, two df test, $p=0.57$).

Concurrent Associations

There was a concurrent association between ABD and ABH loss at one year (overall, two df test, $p=0.0002$), but not at two years (overall, two df test, $p=0.58$) (Table 2). The odds of progressive ABH loss at one year were significantly higher among sites that showed a loss of ABD (OR=3.15, 95% CI: 1.84 to 5.39, $p<0.0001$) compared to sites that demonstrated no change in density and also higher, although not significantly, compared to sites that showed a gain in density (OR=2.65, 95% CI: 0.93 to 7.55 $p=0.069$). Results were similar when ABD changes at only the crestal site were considered (data not shown).

When examining the association between concurrent RCAL and ABD changes (Table 3), there was a significant difference between the two treatment groups (test of interaction, $p=0.037$). Among SDD patients, there was no significant indication that changes in RCAL were associated with changes in ABD (overall, two df test, $p=0.66$). However, among placebo patients, there was a significant association between changes in RCAL and changes in ABD (overall, two df test, $p=0.027$). Based on combined one-and-two-year changes, sites that demonstrated a loss of attachment ($p=0.090$) or no change in attachment ($p=0.0074$) had increased odds of ABD loss compared to sites that demonstrated a gain in attachment (odds ratios were between 2.0 and 2.5). Unlike the association with ABD, the odds of progressive ABH loss were not significantly associated with concurrent RCAL change (overall, two df test, $p=0.58$).

However, there was a significant positive association between baseline RCAL and baseline ABH loss measures. When comparing between randomly chosen tooth sites, a 1 mm higher baseline RCAL measurement was associated with a 0.41 mm higher baseline ABH measure (95% CI: 0.37 to 0.44, $p<0.0001$) based on a linear regression model.

There also was a significant positive association between baseline PD and baseline ABH loss. When comparing between randomly chosen tooth sites, a 1 mm higher baseline manual PD measure was associated with a 0.22 mm higher baseline ABH measure (95% CI: 0.18 to 0.27, $p<0.0001$) based on a linear regression model.

When examining the association between concurrent PD and ABH changes (Table 4), the odds of progressive ABH loss were significantly associated with concurrent PD measures (overall, two df test, $p=0.0089$). Based on combined one- and two-year changes, the odds of ABH loss were higher among sites that demonstrated PD increases (disease progression) (OR=1.88, 95% CI: 1.25 to 2.82, $p=0.0025$) compared to sites that demonstrated no change. Unlike the association with ABH, there was no significant association between concurrent PD changes and ABD changes (overall, two df test, $p=0.11$).

Associations between Baseline Probing Depths and Subsequent Alveolar Bone Changes

The odds of progressive ABH loss over the two-year study were significantly associated with baseline PD measures (overall, two df test, $p=0.042$) where the odds of ABH loss were significantly higher among sites with baseline probing depths of 7+ mm (OR=2.29, 95% CI: 1.20 to 4.39, $p=0.012$), but not among sites with baseline probing depths of 5–6 mm ($p=0.26$), versus probing depths of 1–4 mm (Table 5).

The association between baseline PD and subsequent ABD changes differed between the one-year and two year visits (test of interaction, $p=0.046$) where the association was not significant at the one-year visit (overall, two df test, $p=0.11$) but was significant at the two-year visit (overall, two df test, $p=0.0019$). At two years, the odds of ABD loss were significantly increased for baseline probing depths of 5–6 mm (OR=1.76, 95% CI: 1.27 to 2.44, $p=0.0006$) and not significantly increased for baseline probing depths of 7+ mm relative to sites with probing depths of 1–4 mm ($p=0.77$) (Table 6).

DISCUSSION

To our knowledge, our study is the first to examine the temporal association between periodontal soft tissue changes, as measured by PD and RCAL, and hard tissue changes, as measured by ABD and ABH, in participants undergoing periodontal maintenance. One-year RCAL and PD changes did not predict two-year ABD and ABH loss in postmenopausal osteopenic women with moderate to severe chronic periodontitis receiving periodontal maintenance and, furthermore, one-year ABD loss did not predict two-year ABH loss. However, site-level baseline probing depths, based on manual probing, were associated with subsequent ABD and ABH loss, respectively, which is in agreement with Machtei et al.,¹¹ who similarly showed, although at the patient level, that mean baseline probing depths ≥ 3.2 mm were at greater risk for future ABH loss at one year (ABD loss was not assessed). In addition, among all participants, ABD changed concurrently with ABH at one year and, among placebo patients only, RCAL changes over time were significantly associated with ABD loss. Furthermore, the odds of progressive ABH loss were significantly associated with concurrent PD changes. Finally, baseline RCAL and PD were positively associated with baseline ABH loss.

Our study was unable to detect any lagged effect in observed changes in soft tissue and alveolar bone measures, as no longitudinal change preceded change in another measurement. Goodson et al.⁴ reported that attachment loss preceded radiographic evidence of alveolar crestal bone loss. In their study, attachment levels were measured monthly, and radiographic measurements were made at baseline, six and twelve months, unlike our study in which relative clinical attachment level measurements were made every six months and intraoral radiographs were taken annually. In addition, in the study by Goodson et al.⁴, patients were untreated for the one-year assessment period and manifested a higher annual percentage of sites losing attachment and bone height, compared to our study participants who received periodontal maintenance every three to four months and were relatively periodontally stable overall. It is conceivable that a lagged effect could have been observed if our study participants had more active disease. Furthermore, the radiographic and clinical changes may have appeared to change concurrently due to the less frequent timing of measurements in our study. However, quarterly clinical study measurements, coupled with three to four annual periodontal maintenance visits, would have been burdensome to participants. As an additional note for further research, the sample size for this trial was driven by the primary SDD efficacy question (versus placebo) as described in earlier papers.⁸⁻⁹ The reported estimated associations can be used to justify the sample size of subsequent studies to investigate related questions with sufficient statistical power.

Unlike the Goodson et al. study,⁴ periodontal disease status in our study was relatively stable over two years of periodontal maintenance (Table 1). Patients were relatively stable periodontally for the following reasons: 1) participants received periodontal maintenance every three to four months, provided at no cost to them, and regular periodontal maintenance is effective in maintaining attachment levels;¹² 2) participants received optimal calcium/vitamin D supplementation for two years, and calcium and vitamin D supplementation has been shown to have a modest positive effect on periodontal health;¹³ and 3) participation in the study likely heightened patient interest in their oral health, thereby resulting in low periodontitis activity. This periodontal stability resulted in a relatively small number of sites that demonstrated disease progression or improvement. The small number of sites demonstrating clinical changes led to limited power to detect true associations among the periodontal and alveolar bone measures and may have contributed to the lack of consistent associations seen among categories of change. For example, more extensive disease in the soft tissue or ABD measure, considered as the independent modeling factor, did not always

correspond to more extensive disease progression in the ABD- or ABH-dependent measure when considering ordered categories of periodontal change (Tables 2 through 6).

The association between loss of soft tissue, as measured either by baseline RCAL or PD, and loss of hard tissue (ABH) at baseline is not unexpected, since baseline measurements reflect the cumulative impact of past periodontal destruction. Furthermore, the significant association between baseline clinical attachment levels and baseline ABH in our study is in agreement with Machtei et al.⁶ Associations with baseline ABD could not be assessed, as CADIA represents a relative (not absolute), semi-quantitative, measurement.¹⁴

While there was a significant association between ABD loss and ABH loss over the first year of the study, this association was not maintained over two years. It is possible that ABD and ABH change concurrently in the short-term (i.e., one year) only, but diverge over a longer period of time (i.e., two years). Although progressive ABH loss was associated with concurrent PD changes over the two-year study, progressive ABH loss was not likewise associated with RCAL changes. Since RCAL was significantly associated with ABH loss at baseline, it is conceivable that, with longer-term follow-up, RCAL and ABH would have changed concurrently. Studies of longer duration and sufficient statistical power are needed to test these hypotheses.

RCAL loss was significantly associated with ABD loss in the placebo group only. It appears that the effect of SDD “breaks” this association. Indeed, tetracyclines have been shown to inhibit osteoclast activity and bone resorption in cell culture and *in vivo*¹⁵ and inhibit alveolar bone loss during experimental periodontitis.¹⁶ This lack of association between RCAL and ABD in the SDD group also can likely be explained based on treatment effects: SDD significantly reduced alveolar bone loss in subgroups in our randomized periodontal clinical trial⁸ and SDD reduced progressive RCAL loss in the intent-to-treat population.⁹ Mechanistically, SDD reduces gingival crevicular fluid (GCF) collagenase activity (primarily MMP-8)¹⁷ and GCF ICTP, a pyridinoline-cross-link-containing degradation fragment of the C-terminal telopeptide region of type I collagen and a bone resorption biomarker.¹⁸ Since collagenase activity and ICTP were significantly and linearly correlated at baseline, one-year and two-year time periods ($r=0.62, 0.52, \text{ and } 0.50; p < 0.001$) in our human clinical trial,¹⁷ this correlation may explain SDD’s reduction of alveolar bone loss in subgroups and contribute to the lack of association between RCAL and ABD in the SDD group. These findings suggest that SDD renders the alveolus less susceptible to bone loss in the presence of the chronic inflammatory response of periodontitis.

Postmenopausal osteopenic women receiving periodontal maintenance for moderate to severe chronic periodontitis represent a significant patient cohort in a typical United States periodontal practice, as there are currently approximately 35 million women in the United States with either osteopenia or osteoporosis of the hip; this number is expected to increase to 41 million women by 2020.¹⁹ In clinical practice, dentists evaluate patients longitudinally with both clinical and radiographic measurements. While clinical measurements are made with considerable detail (each pocket site is probed and the measurement recorded), dental radiographs are reviewed more generally for the amount of bone loss (mild, moderate and severe) and the appearance of ABH change. It is not customary for radiographic measurements in clinical practice to be recorded. Thus, it is important to note that, in this study of postmenopausal women undergoing periodontal maintenance and not active periodontal treatment, although clinical changes did not predict subsequent alveolar bone loss and ABD changes did not predict subsequent loss of ABH, changes in probing depths and clinical attachment levels appeared to reflect changes in the underlying alveolar bone over time. This new information can be helpful in clinical trial and screening or diagnostic testing study design in postmenopausal women with osteopenia. Furthermore, longitudinal

assessment of periodontal health in this patient population should include both clinical and radiographic evaluations.

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Table 1

Descriptive Summary of Alveolar Bone and Clinical Measures*

Measure	Baseline (n=2336 sites) †			One-year Change from Baseline (n=2272 sites) ‡			Two-year Change from Baseline (n=2153 sites) ‡		
	Mean	SD		Improvement	No Change	Disease Progression	Improvement	No Change	Disease Progression
CADIA‡				111 (5%)	1985 (88%)	163 (7%)	126 (6%)	1776 (82%)	251 (12%)
Alveolar Bone Height (mm)	3.35	1.41		28 (1%)	2137 (94%)	107 (5%)	34 (2%)	1917 (90%)	178 (8%)
Manual Probing Depth (mm) §	3.98	1.25		271 (12%)	1850 (83%)	98 (4%)	240 (11%)	1749 (83%)	110 (5%)
Relative Clinical Attachment Level (mm) §	9.03	1.67		167 (8%)	1957 (88%)	88 (4%)	180 (9%)	1815 (87%)	97 (5%)

* Data are expressed as count (%) for categorical variables and mean and standard deviation for continuous measures. Standard deviation of alveolar bone height, relative clinical attachment, and probing depth was estimated using a linear mixed model.

† Maximum sample size across measures. Sample sizes vary slightly from measure to measure. Counts and percentages shown are calculated among non-missing values. 117 patients and 113 patients completed at least one year and two years of follow-up, respectively.

‡ CADIA (computer-assisted densitometric image analysis) is a relative change measure with no baseline value

§ Change code reflects the more extreme change at the buccal or lingual location for each tooth site

SD, standard deviation

Table 2

Concurrent alveolar bone density and alveolar bone height (ABH) changes

Summary of Regression Modeling Outcome: odds of progressive ABH loss*				
Time Points	Site-level CADIA Measure*	OR	95% CI	p-value
Overall, 2 degrees of freedom test: p=0.0002				
1-year	Decrease in Density versus No Change	3.15	1.84 to 5.39	<0.0001
	Decrease in Density versus Improvement	2.65	0.93 to 7.55	0.069
	No Change in Density versus Improvement	0.84	0.34 to 2.11	0.71
Overall, 2 degrees of freedom test: p=0.58				
2-year	Decrease in Density versus No Change	1.28	0.80 to 2.04	0.30
	Decrease in Density versus Improvement	1.25	0.55 to 2.84	0.60
	No Change in Density versus Improvement	0.98	0.47 to 2.04	0.95

* Changes in ABH were calculated by taking the one- or two-year follow-up measure and subtracting the baseline value. CADIA measures at the one- and two-year follow-up time points reflect the relative change from baseline. One- and two-year changes from baseline are presented separately, as the concurrent association differed between one year and two years (test of interaction, p=0.0087).

CADIA, computer-assisted densitometric image analysis

OR, odds ratio

CI, confidence interval

Table 3

Concurrent relative clinical attachment level (RCAL) and alveolar bone density (ABD) changes

Summary of Regression Modeling Outcome: odds of progressive ABD loss*				
Treatment Group	Site-level RCAL Measure*	OR	95% CI	p-value
SDD †	Overall, 2 degrees of freedom test: p=0.66			
	Loss of Attachment versus No Change	0.92	0.34 to 2.49	0.87
	Loss of Attachment versus Gain	0.70	0.22 to 2.21	0.54
	No Change versus Gain	0.76	0.42 to 1.38	0.37
Placebo †	Overall, 2 degrees of freedom test: p=0.027			
	Loss of Attachment versus No Change	0.87	0.46 to 1.65	0.67
	Loss of Attachment versus Gain	2.13	0.89 to 5.09	0.09
	No Change versus Gain	2.45	1.27 to 4.72	0.0074

* Changes in RCAL were calculated by taking the one- or two-year follow-up measure and subtracting the baseline value. Treatment groups are presented separately, as the concurrent association differed between SDD and placebo patients (test of interaction, p=0.037). One- and two-year changes in ABD and RCAL were combined for this analysis, as the association did not differ based on time.

† Tooth site-level measures were analyzed from n = 62 placebo patients and n=55 SDD (subantimicrobial dose doxycycline) patients.

OR, odds ratio

CI, confidence interval

Table 4

Concurrent probing depth (PD) and alveolar bone height (ABH) changes

Summary of Regression Modeling Outcome: odds of progressive ABH loss *			
Site-level PD Measure *	OR	95% CI	p-value
Overall, 2 degrees of freedom test: p=0.0089			
Increases in PD versus No Change	1.88	1.25 to 2.82	0.0025
Increases in PD versus Decreases	1.45	0.87 to 2.43	0.16
No Change in PD versus Decreases	0.77	0.51 to 1.17	0.23

* Changes in ABH and PD were calculated by taking the one- or two-year follow-up measure and subtracting the baseline value. One- and two-year changes in ABH and PD were combined for this analysis, as the association did not differ based on time.

OR, odds ratio

CI, confidence interval

Table 5

Baseline absolute probing depth (PD) and subsequent alveolar bone height (ABH) changes

Summary of Regression Modeling Outcome: odds of progressive ABH loss*			
Site-level Baseline PD Measure	OR	95% CI	p-value
Overall, 2 degrees of freedom test: $p=0.042$			
5–6 mm vs. 1–4 mm	1.19	0.88 to 1.62	0.26
7+ mm vs. 1–4 mm	2.29	1.20 to 4.39	0.012
7+ mm vs. 5–6 mm	1.93	1.05 to 3.53	0.034

* Changes in ABH were calculated by taking the one- or two-year follow-up measure and subtracting the baseline value. One- and two-year changes in ABH were combined for this analysis, as the association did not differ between one and two years.

OR, odds ratio

CI, confidence interval

Table 6

Baseline absolute probing depth (PD) and subsequent alveolar bone density (ABD) changes

Summary of Regression Modeling Outcome: odds of progressive ABD loss*				
Time Points	Site-level Baseline PD Measure	OR	95% CI	p-value
Overall, 2 degrees of freedom test: p=0.11				
1-year	5–6 mm vs. 1–4 mm	1.47	0.95 to 2.25	0.081
	7+ mm vs. 1–4 mm	1.95	0.90 to 4.23	0.091
	7+ mm vs. 5–6 mm	1.33	0.63 to 2.81	0.45
Overall, 2 degrees of freedom test: p=0.0019				
2-year	5–6 mm vs. 1–4 mm	1.76	1.27 to 2.44	0.0006
	7+ mm vs. 1–4 mm	1.12	0.50 to 2.51	0.77
	7+ mm vs. 5–6 mm	0.64	0.30 to 1.37	0.25

* One- and two-year changes are presented separately for this analysis, as the association between baseline PD and subsequent ABD loss differed between one and two years (test of interaction, p=0.046).

OR, odds ratio

CI, confidence interval