The Effect of Occlusal Discrepancies on Periodontitis. II. Relationship of Occlusal Treatment to the Progression of Periodontal Disease

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Background: A causal relationship between occlusal discrepancies and periodontal disease has been postulated in the past. However, minimal data are available concerning the effect of treatment of occlusal discrepancies on periodontitis.

Methods: The records from a private practice limited to periodontics were reviewed to find patients who had complete periodontal examination records, including occlusal analysis, that were recorded at least 1 year apart. Patients who fit these criteria were divided into a group that had none of the recommended treatment (untreated n = 30), those who had only nonsurgical treatment (partially treated n = 18), and a control group that had completed all recommended treatment (surgically treated n = 41). The data for each tooth of each patient, including occlusal status, were placed in a database and analyzed using the generalized estimating equations method.

Results: Worsening in overall clinical condition, as measured by worsening in prognosis, indicated that teeth with no initial occlusal discrepancies and teeth with treated initial occlusal discrepancies were only about 60% as likely to worsen in overall clinical condition over time compared to teeth with untreated occlusal discrepancies. Teeth with untreated occlusal discrepancies were also shown to have a significantly greater increase in probing depth per year than either teeth without initial occlusal discrepancies or teeth with treated initial occlusal discrepancies ($P < 0.001$). In addition, teeth with untreated occlusal discrepancies had a significant increase in probing depth per year ($P < 0.001$), whereas teeth without initial occlusal discrepancies and teeth with treated initial occlusal discrepancies had no significant increase in probing depth per year ($P > 0.05$).

Conclusions: This study provides strong evidence of an association between untreated occlusal discrepancies and the progression of periodontal disease. In addition, this study shows that occlusal treatment significantly reduces the progression of periodontal disease over time and can be an important adjunct therapy in the comprehensive treatment of periodontal disease. *J Periodontol 2001;72:495-505.*

KEY WORDS

Dental occlusion; malocclusion; periodontal diseases/etiology.

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The role of trauma from occlusion and the effect of occlusal discrepancies in the progression and treatment of periodontal disease have been a source of controversy. When trauma from occlusion was considered to be a primary etiologic factor in the progression of periodontal disease, occlusal adjustment was often considered an integral part of periodontal treatment.[1,2] Glickman and Smulow, who felt that occlusion was a codestructive factor in periodontal disease, wrote several articles on the diagnosis and treatment of occlusal discrepancies/occlusal trauma.[3-5] As the concept of the pathogenesis of periodontal disease shifted to one based on dental plaque, the use of occlusal adjustment as a routine part of periodontal treatment was less prevalent.[6,7] The proceedings of the 1989 World Workshop in Clinical Periodontics reported that the relationship between occlusion and periodontal disease was controversial and there was no long-term evidence of the effectiveness of occlusal adjustment as a treatment for periodontal disease.[8] Despite the lack of published evidence supporting the use of occlusal adjustment in periodontal treatment, many periodontists perform some amount of occlusal adjustment in the management of periodontal patients.

A single clinical study has lent support to the use of occlusal adjustment as a part of periodontal treatment.[9] This study evaluated the attachment levels of

patients who had completed periodontal therapy. The patients who had occlusal adjustment as part of their periodontal treatment showed a significant improvement in attachment levels over a similar group of patients who did not receive this therapy. This study is often cited as justification for performing occlusal adjustment as part of periodontal therapy.

Several studies have evaluated the effect of tooth mobility on periodontal destruction. Two studies found a relationship between mobility and increased probing depths, attachment loss, and diminished bone support.[10,11] Another study found that greater attachment loss was present on mobile teeth with furcation involvement as compared to teeth with furcation involvement but with no mobility.[12] It has been reported that mobile teeth did not respond as well to periodontal therapy as non-mobile teeth.[13] Others have reported that it may not be necessary to treat mobility during active periodontal therapy due to the lack of association between mobility and inflammatory periodontitis.[14] This same group advocated the use of occlusal adjustment and splinting only in the presence of permanently increased mobility following periodontal therapy.[15] Despite the seeming relationship between mobility and periodontal disease, the efficacy of occlusal adjustment to treat periodontal disease by reducing mobility has not been demonstrated. However, logic would seem to indicate that if mobility is associated with increased probing depths and attachment loss, some effort to minimize occlusal stresses may be justified for the treatment of periodontal disease in patients with demonstrable mobility.

A comprehensive literature review on the role of occlusal trauma in periodontal disease was included in the 1996 World Workshop in Periodontics.[16] The proceedings of this workshop point out that there has been very little recent research on the role of occlusion in periodontal destruction. There have been no prospective controlled studies on the role of occlusion in the progression of untreated periodontal disease or the potential benefits of occlusal adjustment in the management of periodontal disease. The World Workshop also noted that ethical considerations make such a prospective, controlled clinical trial unacceptable and, due to this, it is unlikely that such a study will be performed. Another exhaustive review of the literature in this area is contained in the Occlusal Trauma section of the International Workshop for a Classification of Periodontal Diseases and Conditions.[17]

Taking into account the ethical considerations that preclude a controlled clinical trial, a retrospective epidemiological study was conducted to investigate the relationship of occlusal trauma to the severity of periodontal disease as reflected in commonly measured clinical parameters and to investigate possible effects of occlusal treatment on the progression of periodontal disease. In this paper, the effect of occlusal adjustment on the progression of treated and untreated periodontal disease is evaluated.

MATERIALS AND METHODS

The data for this study were obtained from the clinical records of a private periodontal practice. All available records from 24 years of practice were searched for patients who fit the following criteria. All patients had to be seen for a complete periodontal examination with data recorded for each tooth. These data consisted of at least 6 sites of probing depths measured with a non-automated Michigan type probe, bifurcation involvement (Glickman) measured with a Nabor's bifurcation probe, measurement of the width of keratinized gingiva, measurement of mobility (Miller), and analysis of occlusal relationships. Occlusal analysis included notation of initial contact, discrepancies between initial contact in a retruded position (centric relation) and maximum intercuspation (centric occlusion), and working and balancing contacts in lateral and protrusive movements. All patients had non-surgical and surgical periodontal treatment recommended for them at their initial appointment as part of their comprehensive treatment plan and failed to complete all of the recommended periodontal treatment. Additionally, all patients had to have a second examination at least 12 months after the initial examination that included the recording of another complete set of data that duplicated the data recorded at the first examination. All patients for whom this information was available were included in this study. All examinations and data collection were performed by the same examiner.

The patients who fit these criteria were then divided into 2 groups. An untreated group consisted of patients who had none of the recommended periodontal treatment performed between the 2 examinations. A partially treated group consisted of patients who had completed the non-surgical portions of their treatment but had not completed the recommended surgical treatment, and a control group consisted of patients who had completed all of the recommended periodontal treatment for at least 12 months and had been compliant with the periodontal maintenance schedule recommended for them. The control group was formed by the first 41 patients who were seen during routinely scheduled periodontal maintenance visits and who fit the criteria specified for inclusion in the 2 study groups.

All patients who met the specified criteria for these 3 groups were entered into a database which included the following patient information: age, smoking status (smoker or non-smoker), presence or absence of a medical condition such as diabetes or medication known to negatively affect the periodontium (negative health history), gender, oral hygiene (good, fair, poor), compliance with treatment recommendations (com-

pliant, partially compliant, and non-compliant), and the date of each examination where complete clinical records were recorded. The following information was recorded for each tooth for each visit: prognosis (good, fair, poor, hopeless), probing depth (PD) in millimeters, bifurcation involvement (Glickman class I, II, III), the presence of occlusal discrepancies (premature contact with a vertical slide ≥1 mm or balancing contact in lateral movement), presence or absence of a mucogingival defect, and mobility (Miller 1, 2, and 3). The treatment performed for each tooth was recorded as a yes or no response for the following categories: root planing, occlusal adjustment, osseous surgery, osseous regenerative procedure, and soft tissue grafting.

The prognosis for each tooth was assigned based on the projected treatment outcome. A tooth with a good prognosis was projected to be retained as a functional unit with little or no treatment. A tooth with a fair prognosis was projected to be retained as a functional unit after treatment was completed. Teeth with a good or fair prognosis were expected to have probing depths of 2 to 4 mm following treatment. A tooth with a poor prognosis was projected to be lost within 1 to 2 years following treatment. A tooth with a hopeless prognosis was projected to be extracted during the course of treatment. A diagnosis of fair to poor was given to those teeth where the treatment outcome was in question and where probing depths were projected to be greater than 5 mm after treatment.[18]

The data were placed in a database where they could be evaluated for the effect of presenting factors, non-treatment, partial treatment, and complete treatment on the progression and/or resolution of periodontal disease. The current paper presents the relationship between periodontal treatment or lack of treatment and the progression of periodontal disease over time as measured by probing depth, mobility, and clinical prognosis.

Statistical Methods

Summary statistics or frequencies were computed for initial patient characteristics, including gender, health history, smoking status, oral hygiene status, treatment status (surgical, non-surgical, untreated), age, and time of follow-up with patients classified according to occlusal treatment status: 1) patients without initial occlusal discrepancies; 2) patients with treated initial occlusal discrepancies; and 3) patients with untreated initial occlusal discrepancies. Possible associations between occlusal treatment status and initial patient characteristics were tested using chi-squared tests of independence for categorical patient characteristics (such as gender, health history, smoking status, parafunctional habit, etc.) and 1-way analysis of variance (ANOVA) for continuous patient characteristics (such as age and follow-up time). Summary statistics or frequencies were also computed for initial clinical parameters, including initial probing depth, initial prognosis, initial mobility, and initial furcation involvement, for teeth classified according to occlusal treatment status (no occlusal discrepancy, treated occlusal discrepancy, untreated occlusal discrepancy). Because of the lack of independence of teeth within each patient's mouth, comparisons of each initial clinical parameter by occlusal treatment status were made by using the method of generalized estimating equations (GEE) while assuming an exchangeable working correlation structure. The method of GEE is used in place of traditional ANOVA or regression analysis when there is a lack of independence among observations, as is the case with tooth-level data collected for this study.

In order to evaluate the effect of occlusal treatment on the progression of periodontal disease over time, 3 different outcome measures were evaluated: 1) change in probing depth per year for each tooth; 2) change in mobility over time (worsening in mobility versus no worsening in mobility); and 3) change in clinical prognosis over time (worsening in prognosis versus no worsening in prognosis). GEE regression models were constructed to evaluate the effect of occlusal treatment on these 3 outcome measures. In all modeling, corresponding baseline clinical parameters were included as covariates in order to adjust for baseline differences within each group.

To more fully evaluate the relationship of initial occlusal status to initial probing depth, a multiple regression model using GEE was constructed to adjust for potential confounders such as age, gender, health history, smoking status, treatment status, oral hygiene status, initial parafunctional habit, parafunctional habit without an occlusal splint, etc. A confounder is any variable that may be associated with the outcome of interest and may also be associated with the variable under investigation, which, in this case, is initial occlusal status. Similarly, a multiple regression model using GEE was constructed for evaluating the relationship of initial occlusal status to initial prognosis while accounting for potential confounders. Adjusted means and confidence intervals were obtained for both initial probing depth and initial prognosis by initial occlusal status while adjusting for statistically significant confounders in the multiple GEE regression models.

All statistical analyses were conducted using a statistical software program.‡

RESULTS

Exploratory Analysis

Data were collected retrospectively on 89 patients who had sought consultation and/or treatment for moder-

‡ Version 8.0, SAS Institute Inc., Cary, NC.

ate to severe chronic adult periodontitis in the private practice of one periodontist. Non-surgical periodontal treatment and periodontal surgery were indicated and recommended to all 89 patients in the study. However, through self-selection, only 41 patients completed all treatment recommended (control group), another 18 patients consented to some non-surgical treatment (partially treated group), and 30 patients refused any treatment whatsoever (untreated group). Those patients refusing treatment voluntarily returned to the office at a future date for a complete re-evaluation and recharting. Of the 59 patients who were treated either fully or partially, 26 received some form of occlusal adjustment (17 out of 41 [39%] fully treated patients received occlusal treatment, and 9 out of 18 [50%] partially treated patients) in order to correct occlusal discrepancies and to alleviate potential occlusal trauma. In addition, there were 30 patients who had occlusal discrepancies who were not treated for this condition. Of these 30 patients, 5 were in the partially treated group (non-surgical treatment) and 25 in the untreated group.

Table 1 shows the distribution of patient characteristics by occlusal treatment status. Associations between patient characteristics and occlusal treatment status were tested using chi-squared tests of independence. No statistically significant association between gender and occlusal treatment status ($P = 0.51$), between health history and occlusal treatment status ($P = 0.52$), between smoking status and occlusal treatment status ($P = 0.57$), between oral hygiene status and occlusal treatment status ($P = 0.28$), or between parafunctional habit and occlusal treatment status ($P = 0.87$) was found. However, as would be expected from the design of the study, there was a significant association between treatment group (fully treated, partially treated, untreated) and occlusal treatment status ($P < 0.0001$). This result was an obvious expectation, since all patients who were fully treated received occlusal adjustments where indicated and none of the untreated patients received occlusal adjustments, with some of the partially treated patients receiving occlusal adjustments and some of the partially treated patients failing to receive occlusal adjustments. Average age and average time of follow-up were calculated according to occlusal treatment status. The mean age of subjects with no occlusal discrepancies was compared to the mean age of subjects with treated occlusal discrepancies and to the mean age of subjects with untreated occlusal discrepancies using 1-way ANOVA. Based on the 1-way ANOVA, it was found that there was a significant difference in age among occlusal treatment groups ($P = 0.0026$). Scheffe's test of multiple comparisons was conducted post hoc to find which occlusal treatment groups differed with respect to age. It was found that subjects without occlusal discrepancies were significantly older than subjects with untreated occlusal discrepancies. The mean follow-up time of the occlusal treatment groups was also compared using 1-way ANOVA. A significant difference in follow-up time was found among the occlusal treatment groups ($P = 0.0003$). Again, Scheffe's test of multiple comparisons was conducted post hoc to determine where these differences in follow-up time were significant. It was found that subjects with treated occlusal discrepancies and patients with no occlusal discrepancies had significantly longer follow-up times

Table 1.

Statistics of Patient Characteristics by Occlusal Treatment Status

	No Occlusal Problem	Treated Occlusal Problem	Untreated Occlusal Problem
Gender			
Female	61% (20)	50% (13)	47% (14)
Male	39% (13)	50% (13)	53% (16)
Health			
No negative history	91% (30)	92% (24)	83% (25)
Negative health history	9% (3)	8% (2)	17% (5)
Smoking status			
Non-smoker	64% (21)	50% (13)	57% (17)
Smoker	36% (12)	50% (13)	43% (13)
Oral hygiene			
Satisfactory	67% (22)	62% (16)	80% (24)
Unsatisfactory	33% (11)	38% (10)	20% (6)
Parafunctional habit			
No bruxism	91% (30)	69% (18)	90% (27)
Bruxism	9% (3)	31% (8)	10% (3)
Treatment group			
Surgical treatment	73% (24)	65% (17)	0% (0)
Non-surgical treatment	12% (4)	35% (9)	17% (5)
Untreated	15% (5)	0% (0)	83% (25)
Age			
Mean (±SD)	58.2 (±12.7)	53.8 (±9.6)	47.3 (±12.5)
Median	58.8	55.2	47.6
Range	35.9 to 80.5	33.8 to 69.8	24.9 to 88.1
Follow-up time (years)			
Mean (±SD)	7.0 (±4.2)	8.2 (±5.4)	3.8 (±2.7)
Median	8.7	6.6	2.7
Range	0.8 to 14.5	1.3 to 21.2	0.9 to 10.6

when compared to patients with untreated occlusal discrepancies.

Table 2 shows statistics for initial clinical parameters by occlusal treatment status with data collected for each tooth. Associations between initial clinical parameters in Table 2 and occlusal treatment status were tested using simple GEE regression models with an exchangeable working correlation matrix. Teeth with no occlusal discrepancies were found to have significantly shallower initial probing depths than either teeth with treated occlusal discrepancies (P <0.0001) or with untreated occlusal discrepancies (P <0.0001). However, there was not a significant difference in initial probing depth between teeth with treated occlusal discrepancies and those with untreated occlusal discrepancies (P = 0.69). Similarly, teeth with no occlusal discrepancies were found to have significantly better initial prognoses than teeth with treated occlusal discrepancies (P <0.0001) or teeth with untreated occlusal discrepancies (P <0.0001). However, there was not a significant difference in initial prognosis between teeth with treated occlusal discrepancies and those with untreated occlusal discrepancies (P = 0.51). No significant differences in initial mobility were noted among the three occlusal treatment groups (no discrepancy versus treated discrepancy: P = 0.13; no discrepancy versus untreated discrepancy: P = 0.11; treated discrepancy versus untreated discrepancy: P = 0.71). For comparison of initial furcation involvement, only molars were included in the analysis since other teeth are extraneous to this measure. No significant differences in initial furcation involvement among the three occlusal treatment groups were found (no discrepancy versus treated discrepancy: P = 0.15; no discrepancy versus untreated discrepancy: P = 0.61; treated discrepancy versus untreated discrepancy: P = 0.06), although the difference in furcation involvement between teeth with treated occlusal discrepancies and those with untreated occlusal discrepancies approached significance.

Table 3 shows the distribution of the categorized changes in probing depth, prognosis, mobility, and furcation over time and also the mean change in probing depth per year. Because of the disparity in the follow-up time of the patients included in the study, very limited inference can be drawn from this table. However, inspection of the distribution of categorized change in probing depth, prognosis, mobility, and furcation involvement would appear to indicate that teeth with untreated occlusal discrepancies do worsen over

Table 2.

Statistics for Initial Clinical Parameters by Occlusal Treatment Status

	No Occlusal Problem	Treated Occlusal Problem	Untreated Occlusal Problem
Initial probing depth	(n = 1991)	(n = 156)	(n = 151)
Mean (±SD)	4.77 (±1.31)	5.53 (±1.51)	5.59 (±1.29)
Median	5.0	5.0	6.0
Range	2.0 to 9.0	3.0 to 9.0	3.0 to 9.0
Initial prognosis	(n = 1993)	(n = 156)	(n = 151)
Good	45% (896)	28% (43)	19% (28)
Fair	51% (1012)	57% (89)	72% (109)
Fair to poor	2% (41)	9% (14)	4% (6)
Poor	2% (36)	5% (8)	4% (6)
Hopeless	<1% (8)	1% (2)	1% (2)
Initial mobility	(n = 1894)	(n = 151)	(n = 130)
0	77% (1467)	68% (103)	68% (89)
1	20% (382)	26% (40)	26% (34)
2	2% (34)	3% (5)	5% (7)
3	1% (11)	2% (3)	0% (0)
Initial furcation	(n = 461)	(n = 90)	(n = 110)
0	42% (192)	34% (31)	45% (49)
1	40% (184)	31% (28)	39% (43)
2	14% (64)	28% (25)	16% (17)
3	5% (21)	7% (6)	<1% (1)

Table 3.

Categorized Changes in Clinical Parameters Over Time by Occlusal Treatment Status

	No Occlusal Problem	Treated Occlusal Problem	Untreated Occlusal Problem
Change in PD	(n = 1991)	(n = 156)	(n = 151)
Improvement	45% (904)	60% (94)	9% (14)
No change	27% (543)	16% (25)	39% (59)
Worsening	27% (544)	24% (37)	52% (78)
Change in PD (per year)			
Mean	–0.048	–0.122	0.066
95% CI	(–0.124,9.027)	(–0.223,–0.020)	(–0.045,0.176)
Change in prognosis	(n = 1993)	(n = 156)	(n = 151)
Improvement	24% (483)	33% (51)	3% (4)
No change	63% (1246)	51% (80)	66% (100)
Worsening	13% (264)	16% (25)	31% (47)
Change in mobility	(n = 1993)	(n = 156)	(n = 151)
Improvement	7% (134)	17% (26)	0% (0)
No change	85% (1684)	69% (107)	77% (117)
Worsening	9% (175)	15% (23)	23% (34)
Change in furcation	(n = 430)	(n = 79)	(n = 107)
Improvement	13% (54)	16% (13)	0% (0)
No change	75% (321)	63% (50)	63% (67)
Worsening	13% (55)	20% (16)	37% (40)

time compared to both teeth with treated occlusal discrepancies and without occlusal discrepancies initially.

GEE Regression Analysis

Table 4 shows the relationship of occlusal treatment to worsening in prognosis, mobility, and furcation involvement over time while adjusting for significant confounders. For worsening in each of these parameters, a GEE multiple logistic regression model was fit with inclusion of follow-up time and significant confounders included in the model. When considering worsening in prognosis over time, teeth with no initial occlusal discrepancies were slightly less likely to worsen in prognosis over time (odds ratio = 0.94), although this was not statistically significant. Both teeth with treated occlusal discrepancies and teeth without initial occlusal discrepancies were found to be only about 60% as likely to worsen in prognosis over time compared to teeth with untreated occlusal discrepancies, although only teeth without initial occlusal discrepancies were shown to be significantly less likely to worsen in prognosis over time ($P = 0.020$).

Table 4.

Odds Ratios for Categorized Changes in Clinical Parameters Individually Over Time While Adjusting for Time Followed and Significant Confounders

	Odds Ratio	95% CI	*P*
Worsening in prognosis (n = 2238)			
Treated discrepancy versus untreated discrepancy	0.64	0.27,1.52	0.308
No discrepancy versus untreated discrepancy	0.60	0.39,0.92	0.020
No discrepancy versus treated discrepancy	0.94	0.43,2.07	0.878
Worsening in mobility (n = 2293)			
Treated discrepancy versus untreated discrepancy	1.32	0.72,2.43	0.368
No discrepancy versus untreated discrepancy	0.60	0.35,0.86	0.008
No discrepancy versus treated discrepancy	0.41	0.25,0.68	<0.001
Worsening in furcation (n = 594)			
Treated discrepancy versus untreated discrepancy	1.00	0.39,2.55	0.998
No discrepancy versus untreated discrepancy	0.69	0.35,1.39	0.300
No discrepancy versus treated discrepancy	0.69	0.34,1.43	0.319

For worsening in mobility over time, teeth with no initial occlusal discrepancies were significantly less likely to worsen in mobility compared to treated occlusal discrepancies or untreated occlusal discrepancies. Specifically, teeth with no initial occlusal discrepancies were only about 60% as likely to worsen in mobility compared to teeth with untreated occlusal discrepancies, while teeth with no initial occlusal discrepancies were about 40% as likely to worsen in mobility compared to teeth with treated occlusal discrepancies. In addition, teeth with treated occlusal discrepancies were about 1.3 times as likely to worsen in mobility compared to teeth with untreated occlusal discrepancies, although this was not statistically significant.

When considering worsening in furcation over time, there were no significant differences in the odds among any of the occlusal treatment groups.

Table 5A shows the results for the multiple GEE regression model for average change in probing depth per year, while Table 5B shows the adjusted mean change in probing depth per year by occlusal treatment group. There was no significant difference in the mean change in probing depth per year between teeth with no initial occlusal discrepancies and teeth with treated initial occlusal discrepancies. In addition, the adjusted mean changes in probing depth per year for these 2 groups indicated that there is not a significant change in probing depth per year for either teeth without occlusal discrepancies or teeth with treated discrepancies. However, the mean increase in probing depth per year among teeth with untreated occlusal discrepancies was statistically significant and significantly greater than either teeth with no occlusal discrepancies or those with treated occlusal discrepancies ($P < 0.001$). Figure 1 shows the projected changes in probing depth for each occlusal treatment group over time based on this regression model.

Change in probing depth per year was also analyzed for each of the periodontal treatment groups separately (surgical, non-surgical, and untreated) with the results summarized in Tables 6, 7, and 8. Tables 6A and 6B show the results for the surgical treatment group. Because all patients who received surgical treatment also complied with all recommended treatment, the only two occlusal treatment groups shown are "treated occlusal discrepancies" and "no occlusal discrepancies." For the surgical group, both teeth with no occlusal discrepancies and teeth with treated occlusal discrepancies showed a mean reduction in probing depth of about 0.3 mm per year, with this reduction in probing depth being statistically significant ($P < 0.001$), although there was no significant difference in the reduction in probing depth per year between teeth with no occlusal discrepancies and teeth with treated occlusal discrepancies ($P = 0.905$).

Tables 7A and 7B summarize the results for the mul-

Table 5A.

Multiple Regression for Change in Probing Depth Per Year (n = 2,237)

Parameter	Estimate	SE	*P*
Intercept	0.25	0.062	<0.001
Periodontal treatment			
Untreated	0.48	0.066	<0.001
Non-surgical treatment	0.40	0.061	<0.001
Surgical treatment	0.00	—	—
Occlusal treatment			
Untreated occlusal discrepancy	0.17	0.048	<0.001
Treated occlusal discrepancy	–0.02	0.034	0.485
No occlusal discrepancy	0.00	—	—
Initial probing depth	–0.12	0.017	<0.001
Initial mobility	0.05	0.025	0.038
Initial furcation	0.13	0.059	<0.001

Table 5B.

Change in Probing Depth Per Year by Occlusal Treatment Status Adjusted for Significant Confounders

Treatment Group	Adjusted Change in Probing Depth Per Year	95% CI
Untreated occlusal discrepancy*	0.167	0.069, 0.265
Treated occlusal discrepancy	–0.027	–0.101, 0.047
No occlusal discrepancy	–0.004	–0.055, 0.048

* Statistically significant increase in probing depth per year (P <0.001).

tiple GEE regression model for the change in probing depth among subjects receiving only non-surgical treatment. Comparisons made for these patients is particularly compelling, because all 3 occlusal treatment statuses are represented, and the group is fairly homogeneous in terms of non-surgical periodontal treatment and baseline clinical parameters. All 3 groups had a mean increase in probing depth per year, although the only statistically significant increase in probing depth per year was for teeth with untreated occlusal discrepancies, with the average increase in probing depth for these teeth being about 0.27 mm per year. In addition, the teeth with untreated occlusal discrepancies had a significantly greater increase in probing depth per year than either teeth with no occlusal discrepancies (P = 0.006) or teeth with treated occlusal discrepancies (P = 0.042). However, the increase in probing depth per year among teeth with treated occlusal discrepancies was not significantly greater than teeth with no occlusal discrepancies (P = 0.605). Figure 2 shows the projected increases in probing depth for each occlusal treatment group for patients in the non-surgical treatment group only.

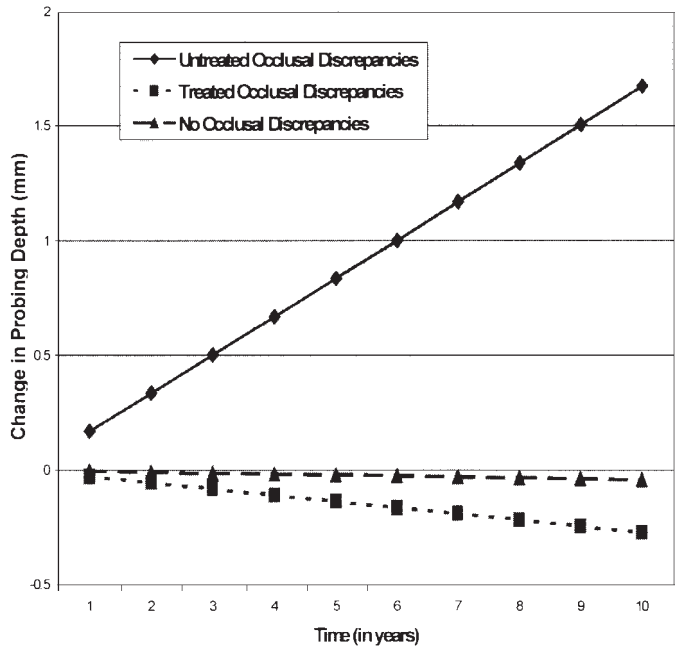

Figure 1.
Change in probing depth over time by occlusal treatment group.

Tables 8A and 8B show the results for the change in probing depth per year for untreated patients only. Both teeth with no occlusal discrepancies and teeth with untreated occlusal discrepancies had significant increases in probing depth per year (P <0.001). Although there was not a significant difference in the increase in probing depth per year between teeth with no occlusal discrepancies and teeth with untreated occlusal discrepancies, there appeared to be a trend for teeth with untreated occlusal discrepancies to show greater increases in probing depth over time (mean increase in probing depth among teeth with no occlusal discrepancies of 0.206 mm versus 0.286 mm for teeth with untreated occlusal discrepancies).

DISCUSSION

If prognosis is considered as being representative of the clinical condition of a tooth at any point, then the prognosis at any time point should give a good indication of the overall clinical condition of that tooth. Hence, by evaluating the change in prognosis over time by comparing the worsening in prognosis over time with adjustment for baseline clinical parameters and time

Table 6A.

Multiple Regression for Change in Probing Depth Per Year for Surgical Treatment Group (n = 1,003)

Parameter	Estimate	SE	*P*
Intercept	0.421	0.078	<0.001
Occlusal treatment			
Treated occlusal discrepancy	–0.004	0.034	0.905
No occlusal discrepancy	0.000	—	—
Initial probing depth	–0.154	0.025	<0.001
Initial mobility	0.021	0.021	0.311
Initial furcation	0.058	0.020	0.004

Table 6B.

Change in Probing Depth Per Year for Surgical Treatment Group by Occlusal Treatment Status Adjusted for Significant Confounders

Treatment Group	Adjusted Change in Probing Depth Per Year	95% CI
Treated occlusal discrepancy*	–0.301	–0.406, –0.197
No occlusal discrepancy*	–0.297	–0.390, –0.205

*Statistically significant decrease in probing depth per year (P <0.001).

Table 7A.

Multiple Regression for Change in Probing Depth Per Year for Non-Surgical Treatment Group (N = 474)

Parameter	Estimate	SE	*P*
Intercept	0.54	0.122	<0.001
Occlusal treatment			
Untreated occlusal discrepancy	0.19	0.070	0.006
Treated occlusal discrepancy	0.03	0.055	0.605
No occlusal discrepancy	0.00	—	—
Initial probing depth	–0.11	0.030	<0.001
Initial mobility	0.19	0.055	<0.001
Initial furcation	0.12	0.045	0.007

Table 7B.

Change in Probing Depth Per Year for Non-Surgical Treatment Group by Occlusal Treatment Status Adjusted for Significant Confounders

Treatment Group	Adjusted Change in Probing Depth Per Year	95% CI
Untreated occlusal discrepancy*	0.271	0.142, 0.400
Treated occlusal discrepancy	0.105	–0.015, 0.226
No occlusal discrepancy	0.077	–0.002, 0.156

* Statistically significant increase in probing depth per year (P <0.001).

followed, we should obtain a good indication of the impact of occlusal treatment on the progression of periodontal disease as measured by the overall clinical condition of the tooth at any point in time. Based on the analysis of worsening in prognosis over time, teeth with untreated occlusal discrepancies were shown to have a significantly greater likelihood of a worsening in clinical condition over time compared to teeth without occlusal discrepancies. In addition, the progression of periodontal disease among teeth with treated occlusal discrepancies, as measured by worsening in prognosis, was not significantly different from teeth with no initial occlusal discrepancies. However, it should be noted that no significant difference in the likelihood of worsening in prognosis was found between teeth with untreated occlusal discrepancies and teeth with treated occlusal discrepancies, although those teeth with treated occlusal discrepancies were only about 64% as likely to worsen in prognosis compared to teeth with untreated occlusal discrepancies. This figure is similar to the 60% reduction in the likelihood of worsening in prognosis for teeth with no initial occlusal discrepancies compared to teeth with untreated initial discrepancies, suggesting that one reason for the lack of a significant difference is a lack of power introduced by the limited number of teeth with treated and untreated occlusal discrepancies. There are some sources of potential bias, including differences in the assessment of prognosis over time as well as the subjective nature of the assignment of prognosis that could contribute indirectly to the differences noted. However, since only one examiner assigned all of the prognoses of teeth included in this study, assessment bias should be minimized. Hence, these results give evidence that the overall clinical condition of a tooth with an occlusal discrepancy is negatively

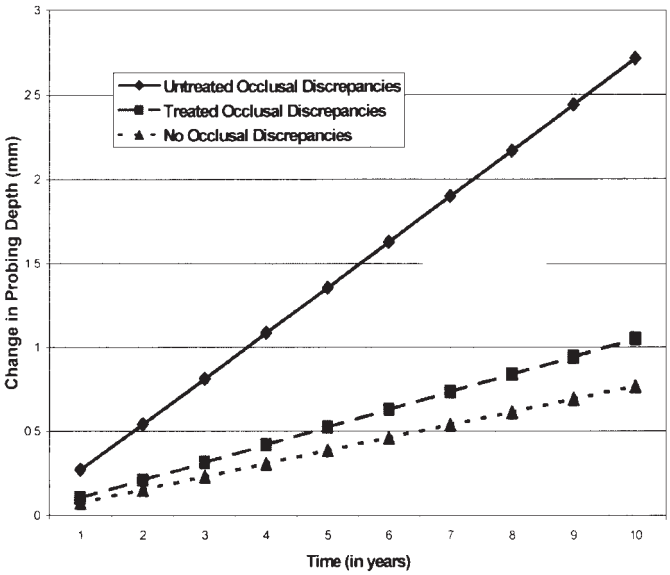

Figure 2.
Change in probing depth over time by occlusal treatment group for non-surgical treatment group only.

impacted when the occlusal discrepancy is left untreated.

The risk of worsening in mobility was significantly lower among teeth with no initial occlusal discrepancies when compared to teeth with untreated occlusal discrepancies and to teeth with treated occlusal discrepancies. No significant difference in the likelihood of worsening in mobility was found between teeth with treated initial occlusal discrepancies and teeth with untreated initial occlusal discrepancies. The reason for these results is unclear, but it may be related to the differences in follow-up time, which may not be completely discounted, although follow-up time was included in the model. It also may be related to the relatively small number of teeth with treated and untreated occlusal discrepancies.

No significant association between occlusal treatment and worsening in furcation involvement was found. Considering the limited number of molars in this study, the lack of significance is not surprising.

The changes in probing depth per year for the 3 occlusal treatment groups provide the most compelling evidence of an association between occlusal treatment and the progression of periodontal disease. When all teeth were considered together, only teeth with untreated occlusal discrepancies demonstrated a significant increase in probing depth over time. In addition, when only patients who were partially treated were considered, teeth with untreated occlusal discrepancies were, again, the only teeth that were shown to have a significant increase in probing depth over time. This is particularly compelling because patients

Table 8A.

Multiple Regression for Change in Probing Depth Per Year for Untreated Group (n = 760)

Parameter	Estimate	SE	*P*
Intercept	0.657	0.158	<0.001
Occlusal treatment			
Untreated occlusal discrepancy	0.079	0.072	0.269
No occlusal discrepancy	0.000	—	—
Initial probing depth	–0.091	0.026	<0.001
Initial mobility	0.027	0.039	0.493
Initial furcation	0.239	0.107	0.026

Table 8B.

Change in Probing Depth Per Year for Untreated Group by Occlusal Treatment Status Adjusted for Significant Confounders

Treatment Group	Adjusted Change in Probing Depth Per Year	95% CI
Untreated occlusal discrepancy*	0.286	0.134, 0.437
No occlusal discrepancy*	0.206	0.114, 0.299

* Statistically significant increase in probing depth per year (P <0.001).

who were partially treated provide a fairly homogeneous group for comparison. Although there was not a statistically significant difference between the increase in probing depth of teeth with no initial occlusal discrepancies and teeth with untreated initial occlusal discrepancies, there was a trend for teeth with untreated initial occlusal discrepancies to have greater increases in probing depth over time. Again, the sample size of patients who were untreated is relatively small, so that failing to obtain a significant difference in the change in probing depth is not surprising. Another analysis was also conducted which included only patients with good oral hygiene, and similar results were obtained as those reported here, so that the notion that occlusal trauma has a negative impact on the periodontium only in the presence of other etiological factors, such as poor oral hygiene, is questionable. Based on the results obtained in this study, there is evidence that

untreated occlusal trauma is certainly a catalyst for the progression of periodontal disease.

Another interesting finding was the failure of the presence of a parafunctional habit without an occlusal splint to be significantly associated with an increase in probing depth, worsening in prognosis, increased mobility, or increased furcation involvement over time as is implicated in the study by McGuire and Nunn.[19] However, there are some important differences. They investigated the association of parafunctional habits without an occlusal splint to tooth loss over time, whereas the current study looks only at the association of parafunctional habits without an occlusal splint to disease progression. In addition, the McGuire and Nunn[19] study covered a long period of time, so that it was more likely to detect and treat parafunctional habits. In this study, patients in the untreated and partially treated groups were not followed as closely or for as long a time, and many simply denied having a problem. In this study, we had only 14 individuals who admitted to having a parafunctional habit (9 who were subsequently treated with an occlusal splint), which may indicate that we did not have many subjects with parafunctional habits who were not treated with an occlusal splint or that some patients were reluctant to admit that they might have a problem. Hence, some patients with a parafunctional habit initially may have gone undetected through the course of treatment. Or, it is quite possible that some of these patients who did have a parafunctional habit initially that was undetected had the problem corrected through occlusal treatment. It should also be noted that an earlier study by McGuire and Nunn,[20] which looked at the progression of periodontal disease over 5 years, also failed to produce a significant association between a parafunctional habit without an occlusal splint and the progression of disease. Further long-term studies would be useful in addressing this issue more fully.

A major factor in the success of all forms of periodontal treatment is the level of patient compliance with maintenance procedures. It has been shown that a much higher success rate can be obtained following several types of periodontal treatment if the patient follows the recommended periodontal maintenance schedule versus when the patient is non-compliant.[21-25] It is inherent within the design of this study that those patients who did not follow through with the recommended periodontal treatment were also not compliant with a periodontal maintenance schedule; the partially treated group was non-compliant with periodontal maintenance; and most of the fully treated group was compliant. Since the change in probing depth was analyzed separately for each of these groups, the compliance issue was at least partially addressed, and since patients who were partially treated showed the same significant increase in probing depth for teeth with untreated occlusal discrepancies as did all patients considered together, the negative impact of occlusal trauma on the periodontium cannot be discounted by the compliance issue.

In conclusion, this study provides strong evidence that the issue of occlusal treatment in the course of fully treating the periodontal patient should be further investigated. Previous studies have almost exclusively focused on occlusion as a patient-level variable, and the results presented here demonstrate that it is critical that we begin to evaluate occlusion on a tooth level. In addition, further research should be conducted to develop an evidence-based approach to occlusal treatment that is reproducible among clinicians so that occlusal treatment can be standardized for optimal results and we can be reasonably confident that each clinician has the tools to provide such treatment.

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