J Clin Periodontol 2009; 36: 1035–1042 doi: 10.1111/j.1600-051X.2009.01486.x

Journal of Clinical Periodontology

The association of occlusal contacts with the presence of increased periodontal probing depth

Stephen K. Harrel[1] and Martha E. Nunn[2]

[1]Private Practice, Baylor College of Dentistry, Dallas, TX, USA; [2]Department of Health Policy and Health Services Research, Goldman School of Dental Medicine, Boston University, Boston, MA, USA

Harrel SK, Nunn ME. The association of occlusal contacts with the presence of increased periodontal probing depth. J Clin Periodontol 2009; 36: 1035–1042. doi: 1486 10.1111/j.1600-051X.2009.01486.x

Abstract

Aim: This study evaluates relationships in humans between various occlusal contacts and the presence of deeper probing depths, reduced width of keratinized tissue, and less than favourable initial prognosis.

Materials and Methods: The tooth level relationship between various occlusal contacts and pocket probing depths, width of keratinized gingiva, and prognosis at the time of initial examination was evaluated (multivariate model) in a group of patients (85 patients, 2219 teeth) with active periodontal disease.

Results: The following were noted to be associated with significantly deeper pocket probing depths: premature contacts in centric relation (0.89 mm, $p < 0.0001$), posterior protrusive contacts (0.51 mm, $p < 0.0001$), balancing contacts (1.01 mm, $p < 0.0001$), combined working and balancing contacts (1.13 mm, $p < 0.0001$), and the length of slide between centric relation and centric occlusion. Protrusive contacts on anterior teeth were significantly associated with shallower probing depths (– 0.18 mm, $p = 0.0076$) and a wider zone of keratinized tissue (0.16 mm, $p = 0.0065$). Balancing contacts with and without working contacts and centric prematurities were all associated with an increased incidence of a less than ''Good'' prognosis

Conclusions: Multiple types of occlusal contacts were shown to be associated with deeper probing depths and the increased assignment of a less than ''Good'' initial prognosis.

Key words: disease progression; occlusal discrepancies; periodontal treatment; periodontitis; risk indicators

Accepted for publication 30 August 2009

Occlusal forces have been associated with the progression of periodontal disease for over a century (Karolyi 1901). Early publications describing a relationship between occlusion and periodontal disease were based on patient observation only (Stillman 1917, 1926). Towards the middle of the 20th century, multiple studies that evaluated human autopsy specimens were performed with conflicting conclusions. In evaluating autopsy specimens, Weinmann concluded that the inflammation of periodontal disease progressed along blood vessels in the alveolar bone and the progression of the inflammation seemed to be unrelated to occlusal contacts on the teeth (Orban & Weinman 1933, Weinman 1941). Reviewing similar autopsy specimens, Glickman observed that teeth undergoing occlusal trauma seemed to demonstrate a progression of periodontal tissue loss that was different from teeth that were not undergoing occlusal trauma (Glickman & Smulow 1962, 1969). He termed the progression of inflammation associated with occlusal trauma as following an ''altered pathway of inflammation'' and felt this process led to specific forms of osseous degeneration such as vertical bone defects. Reviewing very similar autopsy material, Waerhaug did not observe any differences in disease progression between teeth with occlusal trauma when compared with teeth that were not undergoing occlusal trauma. He did not see any evidence for an ''altered pathway of inflammation'' and saw no relationship between occlusal trauma

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests.
This study was partially supported by a NIH/NIDCR grant R03DE16924.

and specific types of periodontal degeneration. Waerhaug felt that all periodontal degeneration was associated with the ''plaque front'' in close proximity to the periodontal attachment (Waerhaug 1979a, b).

All descriptive studies, whether on living patients or on autopsy specimens, are subject to observer bias. With living patients, the condition observed is the result of the action of many factors often acting over many years. Autopsy specimens are even more difficult to interpret and the observed findings can be more problematical. Often knowledge of the cadaver's medical history, life habits, and other factors are very limited. After death it is difficult to accurately evaluate the occlusal relationship that existed during life. All of these factors make the descriptions and conclusions drawn from autopsy observations subject to question.

In an attempt to answer the questions inherent in descriptive studies, animal studies were performed to evaluate and measure whether occlusal forces were or were not a factor in the progression of periodontal disease in animals. Two major series of animal studies were performed (Lindhe & Svanberg 1974, Polson 1974, Lindhe & Ericsson 1976, 1982, Polson et al. 1974, Polson et al. 1976a, b, Ericsson & Lindhe 1982, Polson & Zander 1983). Despite the fact that the animals used in these studies were different and the types of occlusal forces used on the animals varied dramatically, the conclusions drawn from these studies were similar. Both groups of researchers found that while excessive occlusal forces caused mobility and changes in the alveolar bone, occlusal forces alone did not cause loss of attachment. When inflammation was induced by plaque accumulation and excessive occlusal forces were applied to the teeth, one group found that no attachment loss occurred in the squirrel monkey model while the other group found that some attachment loss occurred in a surgically altered beagle dog model. Both research groups determined that occlusal forces alone do not cause attachment loss in animals and it was only in special circumstances that inflammation from plaque in the presence of excess occlusal forces may cause increased attachment loss.

Animal studies allow for definitive control of variables such as occlusal forces and plaque that are acting on the teeth being studied. However, several factors limit the usefulness of animal studies. No animal model has naturally occurring periodontal disease that is consistent with that found in humans. This factor limits the ability to apply findings from animal studies to human disease. Another factor is the relatively short length of time the animals were studied. Human periodontal disease tends to progress slowly over many years, generally much longer than the animals were studied.

In order to shed light on the pathophysiology of human periodontal diseases, the effects of occlusal forces on human periodontal diseases needs to be studied in humans within the subgroup of the population who are susceptible to periodontal disease. The gold standard for any human study is the blinded-controlled clinical trial. Unfortunately, as pointed out by the 1996 World Workshop in Periodontics, a controlled clinical trial to evaluate the progression of periodontal disease in humans and the effects that occlusal forces may have on the progression of periodontal disease is not ethically acceptable (Gher 1996). All human studies on the effects of occlusion on periodontal disease progression must rely on less powerful data than the controlled clinical trial. To date, the results of human studies have shown a positive association between signs of trauma from occlusion and periodontitis (Pihlstrom et al. 1986) and a significantly greater gain of clinical periodontal attachment following periodontal therapy in patients who received an occlusal adjustment compared with those who did not (Burgett et al. 1992).

We published three studies between 2001 and 2004 on the effects of occlusal discrepancies on the progression of periodontal disease and the effect of occlusal treatment on the progression of periodontal disease (Harrel & Nunn 2001a, b, 2004, Nunn & Harrel 2001). These studies reported that defined occlusal discrepancies are an independent risk factor for the progression of periodontal disease and that the treatment of occlusal discrepancies as part of periodontal treatment resulted in improved outcomes when compared with patients with untreated occlusal discrepancies and that there was not a relationship between occlusal discrepancies and gingival recession.

The above noted publications evaluated two specifically defined occlusal parameters consisting of either an occlusal discrepancy between centric relation (retruded position) and centric occlusion (maximum intercuspation) of at least 1 mm vertical difference and/or a non-working (balancing) contact. These past studies did not individually evaluate various types of occlusal contacts. The purpose of the current study is to evaluate multiple specifically defined occlusal contacts and their association with deeper probing depths, their association with a decreased width of gingiva, their association to prognosis, and their comparison with the traditional periodontal risk factors of smoking, male gender, and poor oral hygiene.

Materials and Methods

This study further evaluates a group of patients that were reported on in previous publications (Harrel & Nunn 2001a, b, 2004, Nunn & Harrel 2001). The criteria for inclusion of patients in this database and the methods used in obtaining the information have been described previously in detail. The methods are briefly described here.

The data for this study were obtained from the clinical records of a private periodontal practice. All existing patient records were searched for patients who had two complete periodontal evaluations that including the information described below, and that were separated by at least 1 year. Additionally, the patients had to have self-selected to have no periodontal treatment between these two evaluations. For the previously reported studies this allowed for the evaluation of the progression of untreated periodontal disease. For the current study, all groups were combined and only the data from the initial evaluation were analysed. All data were collected by a single examiner.

In order to be included in the database, all patients had to have been referred for periodontal treatment and deemed to have moderate to severe periodontal destruction. All patients had to have at least one pocket probing depths of at least 6 mm and radiographic evidence of bone loss. All patients gave permission for the use of their clinical information for scientific study.

All patients had to be seen for a complete periodontal examination with data recorded for all teeth. These data consisted of at least six sites of pocket probing depths measured with a non-automated Michigan probe, bifurcation involvement (Glickman) diagnosed with a Nabor's bifurcation probe, measurement of the width of keratinized gingiva,

measurement of mobility (Miller), and analysis of occlusal relationships.

Occlusal analysis had to include notation of initial contact, discrepancies between initial contact in a retruded position (centric relation) and maximum intercuspation (centric occlusion), the amount and direction of movement in mm between the retruded and maximum intercuspation positions, working and balancing contacts in lateral movement, and contacts in protrusive movements. Occlusal analysis was performed by gently manipulating the patient into a retruded position to determine initial (centric) contact. All other contacts were evaluated from a centric occlusion relationship of the jaws. Contacts were verified by performing the analysis twice and confirming the contacts with occlusal marking ribbon. The same examiner performed all examinations.

All patients who fit the inclusion criteria were entered into a database. For the current study, the information obtained at the initial examination was analysed on a tooth-level basis as opposed to a patient-level dichotomized measure of occlusion. This method allows for the evaluation of occlusion on a continuum instead of as a patient-level dichotomized measure. A total of 85 patients with 2219 teeth were included in the current database.

The following patient information derived from the health history was entered for each patient: age, smoking status (smoker or non-smoker), presence or absence of a medical condition such as diabetes mellitus or medications, such as Phenytoin, known to negatively effect the periodontium (negative health history), gender, and past diagnosis of parafunctional habits. At the initial examination an assessment of oral hygiene was made (good, fair, poor). The following information was recorded for each tooth of each patient: prognosis (good, fair, poor, hopeless), pocket probing depth in millimeters, bifurcation involvement (Glickman class I–III), presence or absence of a mucogingival defect, width of keratinized tissue, and mobility (Miller 1–3). The occlusal contacts on each tooth were recorded including: contacts in centric relation, any contacts between centric relation and centric occlusion including direction and distance of movement, working contacts, non-working contacts, and protrusive contacts.

The initial prognosis for each tooth was also entered into the database. 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 pocket-probing depths of 2–4 mm following treatment. A tooth with a poor prognosis was projected to be lost within 1–2 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 pocket probing depths were projected to be 5 mm or greater after treatment (McGuire & Nunn 1996a, b).

The relationship of all occlusal contacts to initial pocket probing depth, prognosis, and width of keratinized gingiva was evaluated. All comparisons were made on a tooth-by-tooth basis as opposed to a patient-by-patient comparison of patient means.

Statistical Methods

Descriptive statistics in the form of summary statistics for continuous measures and frequency distributions for categorical measures were computed for initial patient characteristics, including gender, health history, smoking status, oral hygiene status, age, and measures of occlusal discrepancies. Measures of occlusal discrepancy included centric prematurity (present, absent), contact in protrusive movement (present, absent), type of contact (balancing only, working only, balancing and working, no excursive contact), centric vertical slide (no slide, 1, 2, $\geqslant$3 mm), centric horizontal slide (no slide, 1, 2, $\geqslant$3 mm), and lateral slide (no slide, 1, 2 mm). Because of the lack of independence of teeth within each patient's mouth, comparisons of initial clinical parameters by measures of occlusal discrepancy were conducted 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 the tooth-level data collected for this study.

In order to more fully evaluate the relationship of each measure of initial occlusal discrepancy to initial probing depth, a multiple regression model for each measure of initial occlusal discrepancy using GEE was fit in order to adjust for potential confounders such as age, gender, health history, smoking status, oral hygiene status, initial parafunctional habit, and parafunctional habit without an occlusal splint. Similarly, multiple logistic regression models using GEE were constructed for evaluating the relationships of measures of initial occlusal discrepancy to likelihood of an initial prognosis that was less than ''Good'' while accounting for potential confounders. Adjusted means and confidence intervals (CI) were obtained for both initial probing depth and initial prognosis by measures of initial occlusal discrepancy while adjusting for significant confounders in the multiple GEE regression models.

All models were tested for effect modification with smoking and all other significant confounders. No significant effect modification was detected. Parafunctional habit and parafunctional habit without an occlusal splint were not included in the final modeling because they were not significant confounders and did not affect estimation of the primary exposure variables dealing with occlusal discrepancies.

All statistical analyses were conducted using SAS statistical software version 9.1 (SAS Institute Inc., Cary, NC, USA).

Results

A total of 85 patients with 2219 teeth were included in the study. Descriptive statistics were calculated for the study participants and are shown in Table 1.

Frequency distributions of teeth with various measures of initial occlusal discrepancy were tabulated and are shown in Table 2. Twelve per cent of teeth demonstrated a centric prematurity. When distribution of contacts was tabulated by type, 57% were found to have no contact except in maximum intercuspation, 32% had working contacts only, and the remaining 11% had balancing contacts with or without working contacts.

A multiple GEE regression model was fit to test the association of centric prematurity to initial probing depth while adjusting for significant confounders with the final regression model

Table 1. Descriptive statistics for study population

Variable	Descriptive statistics
Age	
Mean ± SD	46.0 ± 11.4
Median	44.4
Range	24–82.3
Number of teeth	
Mean ± SD	26.1 ± 3.21
Median	27
Range	15–32
Gender	
Male	44.7% (38/85)
Female	55.3% (47/85)
Diabetes	
No	94.1% (80/85)
Yes	4.9% (5/85)
Smoking status	
Non-smoker	56.5% (48/85)
Smoker	43.5% (37/85)
Compliance	
Non-compliance	32.9% (28/85)
Partial compliance	36.5% (31/85)
Full compliance	30.6% (26/85)
Oral hygiene	
Unsatisfactory	30.6% (26/85)
Satisfactory	69.4% (59/85)
Parafunction	
No habit	81.9% (68/83)
Bruxer with nightguard	7.2% (6/83)
Bruxer without nightguard	10.8% (9/83)

shown in Table 3a. Adjusted mean probing depths with corresponding 95% CI for the fitted multiple GEE regression model were computed by centric prematurity status and are shown in Table 3b. On average, teeth with centric prematurities had 0.9 mm greater probing depth than teeth without centric prematurities ($p<0.0001$). The relative effect of centric prematurity compared with other factors associated with probing depth is depicted in Fig. 1. As can be seen from the figure, a centric prematurity results in over twice as much increase in probing depth as smoking or poor oral hygiene.

Multiple GEE regression models were also fit for effect of vertical slide from centric, horizontal slide from centric, and lateral slide from centric on probing depth. Adjusted means and 95% CI for probing depth by amount of vertical slide from centric, amount of horizontal slide from centric, and amount of lateral slide from centric were calculated from the three multiple GEE regression models for each of these slides considered individually and are given in Table 4. While the amount of lateral slide seems to depict a linear association to probing depth, the association between the amount of vertical slide to probing depth and the association between the amount of horizontal slide to probing depth are more quadratic (i.e. non-linear) in nature with increases in the amount of horizontal and vertical slides only having a small impact above an initial threshold of 1 mm.

Table 2. Frequency distribution for occlusal variables

Occlusal variable	% (frequency)
Centric relation	
No prematurity	87.7% (1945/2219)
Prematurity	12.4% (274/2219)
Centric vertical slide (mm)	
No slide	88.1% (1955/2219)
1	6.4% (143/2219)
2	3.9% (87/2219)
3 mm or more	1.5% (34/2219)
Centric horizontal slide (mm)	
No slide	88.2% (1957/2219)
1	7.1% (157/2219)
2	3.8% (85/2219)
3 mm or more	0.9% (20/2219)
Centric lateral slide (mm)	
No slide	98.6% (2187/2219)
1	0.8% (18/2219)
2	0.6% (14/2219)
Protrusive movement (anterior teeth)	
No contact	47.8% (461/965)
Contact	52.2% (504/965)
Protrusive movement (posterior teeth)	
No contact	87.7% (1100/1254)
Contact	12.3% (154/1254)
Contact type (lateral movement)	
No contact	57.0% (1264/2219)
Working contact only	32.3% (717/2219)
Balancing contact only	4.4% (98/2219)
Working and balancing contact	6.3% (140/2219)

In order to investigate the effect of contact in protrusive movement, separate multiple GEE regression models were fit for anterior teeth and posterior teeth separately to test the association of protrusive contacts to initial probing depth while adjusting for significant confounders for anteriors and posteriors separately. Results of multiple regression models are shown in Table 5a. Adjusted mean probing depths with corresponding 95% CI were computed from multiple regression models by protrusive contact status with stratification by tooth position (anteriors and posteriors) and are shown in Table 5b. On average, anterior teeth with contact

Table 3a. Generalized estimating equations multiple regression for relationship of centric prematurity to initial pocket probing depth with adjustment for confounders

Regression parameter	Estimate	SE	*p*
Intercept	4.32	0.10	<0.0001
Centric prematurity	0.89	0.09	<0.0001
Smoker	0.41	0.15	0.0043
Male	0.30	0.14	0.0327
Unsatisfactory oral hygiene	0.33	0.15	0.0314

SE, standard error.

Table 3b. Average initial probing depth by centric prematurity adjusted for significant confounders

	Adjusted mean	95% CI
No centric prematurity	4.85	4.69–5.01
Centric prematurity	5.74	5.50–5.98

CI, confidence interval.

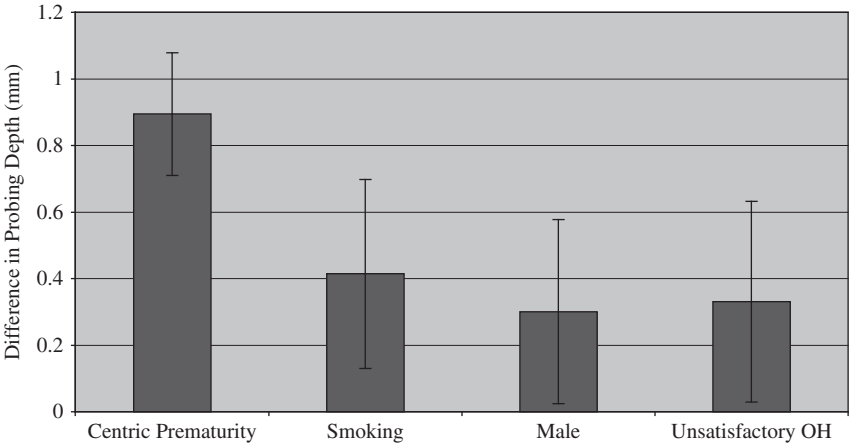

Fig. 1. Difference in probing depth of teeth with a centric prematurity compared with traditional risk factors associated with increased probing depth.

on protrusive movement had a *decrease* of 0.18 mm in probing depth compared with anterior teeth without contact on protrusive movement ($p = 0.0076$), and posterior teeth with contact on protrusive movement had an *increase* of 0.51 mm in probing depth compared with posterior teeth without contact on protrusive movement ($p < 0.0001$).

Table 4. Average initial pocket probing depth by amount of vertical slide from centric, amount of horizontal slide from centric, and amount of lateral slide from centric, respectively, adjusted for significant confounders[§]

	Adjusted mean	95% CI	P[¥]
Vertical Slide (mm)			
No Slide	4.85	4.69–5.01	
1	5.73	5.40–6.06	
2	5.67	5.36–5.98	
⩾3	5.95	5.47–6.42	<0.001
Horizontal slide (mm)			
No slide	4.85	4.69–5.01	
1	5.62	5.31–5.93	
2	5.89	5.56–6.21	
⩾3	6.03	5.50–6.55	<0.001
Lateral slide (mm)			
No slide	4.94	4.79–5.10	
1	5.46	4.73–6.18	
2	6.16	5.52–6.80	0.120

[§]Significant confounders for the models in the table included oral hygiene, gender, and smoking status.

[¥]*p*-values are for the overall effect of each factor (e.g. vertical slide, horizontal slide, lateral slide). In the case of lateral slide, a 2 mm slide was statistically significant ($p < 0.001$), although the overall effect of that factor was not statistically significant.

CI, confidence interval.

A multiple GEE regression model was fit to test the association of contact type to initial probing depth while adjusting for significant confounders with the final regression model shown in Table 6a. Teeth with working contacts only did not have significantly different probing depths from teeth without any contacts except during maximum intercuspation ($p = 0.5543$). Teeth with balancing contacts with or without working contacts had 1.1 ($p < 0.0001$) to 1.0 mm ($p < 0.0001$) greater probing depth, respectively, compared with teeth with no contacts outside of maximum intercuspation. Figure 2 shows the relative effect of contact type on probing depth compared with other factors that are significant predictors of probing depth. Balancing contacts, with or without working contacts demonstrates a greater impact on probing depth than smoking, poor oral hygiene, and being male combined.

In order to investigate the association of occlusal contact type to initial width of keratinized tissue, the GEE regression analyses presented for initial probing depth were repeated for initial width of keratinized tissue. These results are shown in Table 7a and b. The only significant association found was for contact in protrusive movement for anterior teeth with contact in protrusive movement associated with an *increased* width of keratinized tissue initially (0.16 mm, $p = 0.0065$). Although no statistically significant association was found between amount of vertical slide ($p = 0.5193$), amount of horizontal slide ($p = 0.5416$), or amount of lateral slide ($p = 0.0805$) and initial width of keratinized tissue, width of keratinized tissue did seem to decrease slightly with greater amounts of slide, particularly lateral slide.

In addition to fitting multiple GEE regression models for predicting initial probing depth and initial width of keratinized tissue, multiple GEE logistic regression models were also fit for predicting the likelihood of an initial prognosis of less than ''Good''. Table 8 shows odds ratios for each occlusal factor that was fit in a multiple GEE logistic regression model for predicting less than ''Good'' initial prognosis. Slides from centric relation of any vertical distance was associated with over three times the probability of having an initial prognosis less than ''Good''. In contrast, increasing the horizontal distance of a slide from centric from 1 to 2 to 3 mm or more resulted in an incremental increase in the likelihood of an initial prognosis less than ''Good'' of 2.7, 4.7, and 5.1, respectively. Contact in protrusive movement for anterior teeth resulted in a 34% *reduced* likelihood of less than ''Good'' initial prognosis while contact in protrusive movement for posterior teeth resulted in over double the likelihood of less than ''Good'' initial prognosis. When type of contact was considered, working contact only was not associated with the likelihood of less than ''Good'' initial prognosis while balancing contact, with and without working contact, was associated with 5.1 to 5.9 times the likelihood of less than ''Good'' initial prognosis, respectively.

Table 5a. Generalized estimating equations multiple regression for relationship of contact in protrusive movement to initial pocket probing depth with adjustment for confounders with stratification by tooth position (posterior *versus* anterior teeth)

Regression Parameter	Posterior teeth			Anterior teeth		
	estimate	SE	*p*	estimate	SE	*p*
Intercept	4.81	0.10	<0.0001	4.02	0.13	<0.0001
Protrusive contact	0.51	0.11	<0.0001	−0.18	0.07	0.0076
Smoker	0.41	0.15	0.0053	0.32	0.17	0.0663
Male	0.35	0.14	0.0155	0.22	0.17	0.1973
Unsatisfactory oral hygiene	0.32	0.14	0.0218	0.35	0.20	0.0755

Table 5b. Average initial probing depth by contact in protrusive movement adjusted for significant confounders with stratification by tooth position (posterior *versus* anterior teeth)

	Posterior teeth		Anterior teeth	
	adjusted mean	95% CI	adjusted mean	95% CI
No protrusive contact	5.35	5.20–5.50	4.46	4.25– 4.68
Protrusive contact	5.86	5.61–6.11	4.28	4.07– 4.49

CI, confidence interval.

Discussion

The data presented here seems to confirm our findings from previous publications that occlusal discrepancies between centric relation and centric occlusion (centric slide) and non-working (balancing) contacts are associated with deeper probing depths. This data also appears to indicate that protrusive contacts on posterior teeth are also associated with deeper probing depths.

The data indicates that the greater the distance of the lateral discrepancy in mm between centric relation and centric occlusion, the greater the increase in probing depth while the increase in vertical and horizontal slides from centric beyond 1 mm only increased prob-

Table 6a. Generalized estimating equations multiple regression for relationship of contact type to initial probing depth with adjustment for confounders

Regression parameter	Estimate	SE	*p*
Intercept	4.36	0.11	<0.0001
Contact type			
Working contact only	− 0.04	0.07	
Balancing contact only	1.01	0.16	
Working and balancing contact	1.13	0.12	<0.0001¥
Smoker	0.36	0.15	0.0132
Male	0.30	0.14	0.0370
Unsatisfactory oral hygiene	0.31	0.16	0.0478

¥*p*-value is for overall effect of the factor ''Contact Type''. For ''Working Contact Only'' compared with no contact, $p = 0.554$ while $p < 0.001$ for both ''Balancing Contact Only'' compared with no contact and ''Working and Balancing Contact'' compared with no contact.

Table 6b. Average initial probing depth by contact in contact type adjusted for significant confounders

	Adjusted mean	95% CI
No contact	4.85	4.68–5.01
Working contact only	4.80	4.61–4.99
Balancing contact only	5.86	5.53 –6.19
Working and balancing contact	5.97	5.73–6.21

CI, confidence interval.

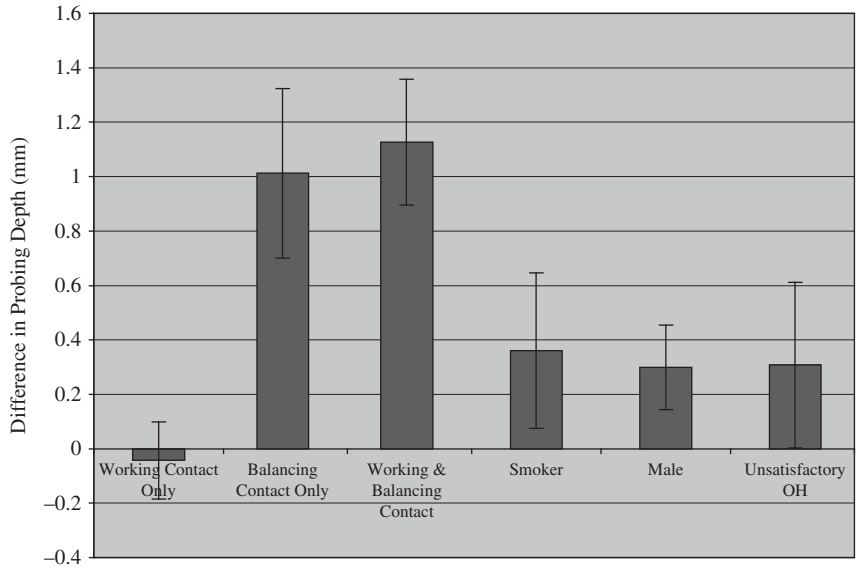

Fig. 2. Difference in probing depth of teeth with contact type (working only, balancing only, working and balancing) compared with traditional risk factors associated with increased probing depth.

ing depth marginally. Additionally, the direction of movement involved in the centric relation to centric occlusion discrepancy appears to be a factor in increased probing depth. Lateral movement between centric relation and centric occlusion is more likely to lead to deeper probing depths than either horizontal or vertical movement. Our previously published findings that followed patients over time showed that a discrepancy between centric relation and centric occlusion was a risk factor for deeper probing depths. Our current data appear to confirm this finding but also show that the distance and direction of centric discrepancies is also related to deeper probing depths, although those associations are somewhat complex.

Our previously published findings indicated that non-working (balancing) contacts were a significant risk factor for deeper periodontal probing depths. Our current data have confirmed this association but also show that teeth that have both working and non-working contacts are also associated with deeper probing depths. Teeth that have both working and non-working contacts are often associated with clinically detectable fremitus. While fremitus is often viewed as a negative clinical finding, we are unaware of any previously reported data showing a relationship between the occlusal contact most often associated with fremitus and deeper pocket depths. Our data appear to support the clinical observation that teeth with both working and non-working contacts are associated with deeper pocket probing depth and that this type of occlusal contact is associated with periodontal destruction.

Our data indicates that protrusive contacts on the anterior teeth are not associated with deeper probing depths. In fact, protrusive contacts on anterior teeth are associated with significantly *reduced* probing depths ($p = 0.0076$). In contrast, protrusive contacts on posterior teeth were associated with significantly *greater* probing depths ($p < 0.0001$). This appears to support the clinical observation that protrusive contacts on anterior teeth are generally non-damaging while protrusive contacts on posterior teeth may be damaging.

In the analysis of various occlusal contacts, a comparison was made with the traditional risk factors for periodontal disease of smoking, male gender, and unsatisfactory oral hygiene. Within the studied group, the occlusal contact between centric relation and centric occlusion (centric prematurity), non-working contacts, and protrusive contacts on posterior teeth were more strongly associated with deeper probing depths than were the traditional risk factors of smoking, male gender, or unsatisfactory oral hygiene. Because the data for smoking was self-reported by the patient on the medical history form, it is not possible to correlate the amount of smoking only the dichotomous data of smoker or non-smoker.

The width of keratinized tissue showed no negative association with any of the occlusal contacts evaluated. Our data appears to *not* support the clinical observation that occlusal contacts are associated with recession of gingival tissues. In fact, the only significant relationship between occlusal contacts and the width of keratinized tissue was an *increased* width of kerati-

Table 7a. Generalized estimating equations multiple regression for relationship of contact in protrusive movement to initial width of keratinized tissue with adjustment for confounders with stratification by tooth position (posterior *versus* anterior teeth)

Regression parameter	Posterior teeth			Anterior teeth		
	estimate	SE	*p*	estimate	SE	*p*
Intercept	3.06	0.06	<0.0001	3.23	0.07	<0.0001
Protrusive contact	0.05	0.06	0.4645	0.16	0.06	0.0065
Smoker	0.13	0.07	0.0740	0.11	0.08	0.1685
Male	0.11	0.08	0.1628	−0.01	0.09	0.8663
Unsatisfactory oral hygiene	−0.01	0.08	0.8738	0.23	0.10	0.0171

SE, Standard error.

Table 7b. Average initial width of keratinized tissue by contact in protrusive movement adjusted for significant confounders with stratification by tooth position (posterior *versus* anterior teeth)

	Posterior teeth		Anterior teeth	
	adjusted mean	95% CI	adjusted mean	95% CI
No protrusive contact	3.17	3.09–3.25	3.40	3.29–3.51
Protrusive contact	3.22	3.09–3.34	3.56	3.45–3.68

CI, confidence interval.

Table 8. Odds ratios (OR) from multiple logistic regression models for predicting less than ''Good'' initial prognosis while accounting for significant confounders (smoking, gender, oral hygiene) – each occlusal factor analyzed in separate regression models

Occlusal factor	OR	95% CI	*p*
Centric prematurity			
No prematurity	Reference	–	
Prematurity	3.53	2.39–5.20	<0.0001
Vertical slide from centric			
No slide	Reference	–	
1 mm	3.30	1.85–5.88	
2 mm	3.43	1.87–6.27	
3 mm or more	3.29	1.28–8.45	<0.0001
Horizontal slide from centric			
No slide	Reference	–	
1 mm	2.71	1.65–4.44	
2 mm	4.66	2.23–9.73	
3 mm or more	5.07	1.69–15.2	<0.0001
Protrusive contact (anterior)			
No contact	Reference	–	
Contact	0.66	0.50–0.86	0.0025
Protrusive contact (posterior)			
No contact	Reference	–	
Contact	2.18	1.22–3.87	0.0082
Contact type			
No contact	Reference	–	
Working contact only	1.03	0.82–1.28	
Balancing contact only	5.91	2.17–16.1	
Balancing and working contact	5.13	2.78–9.48	<0.0001

CI, confidence.

nized tissue on anterior teeth with protrusive contacts when compared with anterior teeth without protrusive contacts.

There are limitations to our study. Firstly, the data were collected from only one practice so that inference is limited. Secondly, because attachment levels were not available for this group of patients, probing depths were analysed. While analysis of attachment levels would be preferable, probing depths allow for some clinical comparisons between teeth. Thirdly, this is a retrospective epidemiological study with all the biases and limitations associated with any retrospective epidemiological study. Unfortunately, because of ethical considerations raised by the 1996 World Workshop, a clinical trial, which would provide the strongest evidence, cannot be conducted. Future prospective epidemiological studies that include data from multiple sources should be conducted to confirm the findings presented here.

Conclusions

Our data appear to indicate that occlusal discrepancies between centric relation and centric occlusion, non-working contacts, and posterior contacts in protrusive movements are associated with deeper pocket probing depths and a prognosis of less than ''Good''. Based on these findings, the treatment of occlusal discrepancies as a routine part of periodontal treatment may be indicated.

Acknowledgement

The authors would like to thank Drs. Thomas G. Wilson Jr. and William W. Hallmon for their review and assistance with the preparation of this manuscript.

References

Burgett, F., Ramfjord, S., Nissle, R., Morrison, E. C., Charbeneau, T. D. & Caffesse, R. G. (1992) A randomized trial of occlusal adjustment in the treatment of periodontitis patients. *Journal of Clinical Periodontology* **19**, 381–387.

Ericsson, I. & Lindhe, J. (1982) Effect of long-standing jiggling on experimental marginal periodontitis in the beagle dog. *Journal of Clinical Periodontology* **9**, 497–503.

Gher, M. (1996) Non-surgical pocket therapy: dental occlusion. *Annals of Periodontology* **1**, 567–580.

Glickman, I. & Smulow, J. (1969) The combined effects of inflammation and trauma from occlusion in periodontitis. *International Dental Journal* **39**, 101–105.

Glickman, I. & Smulow, J. B. (1962) Alterations in the pathway of gingival inflammation into the underlying tissues induced by excessive occlusal forces. *Journal of Periodontology* **33**, 7–13.

Harrel, S. & Nunn, M. (2001a) Longitudinal comparison of the periodontal status of patients with moderate to severe periodontal disease receiving no treatment, non-surgical treatment, and surgical treatment utilizing individual sites for analysis. *Journal of Periodontology* **72**, 1509–1519.

Harrel, S. K. & Nunn, M. (2001b) The effect of occlusal discrepancies on treated and untreated periodontitis II. Relationship of occlusal treatment to the progression of periodontal disease. *Journal of Periodontology* **72**, 495–505.

Harrel, S. K. & Nunn, M. E. (2004) The effect of occlusal discrepancies on gingival width. *Journal of Periodontology* **75**, 98–105.

Karolyi, M. (1901) Beobachtungen über pyorrhea alveolaris. *Österreichische Ungarischen Vierteeljschr Zahnheilk* **17**, 275–279.

Lindhe, J. & Ericsson, I. (1976) Influence of trauma from occlusion on reduced but healthy periodontal tissues in dogs. *Journal of Clinical Periodontology* **3**, 110–122.

Lindhe, J. & Ericsson, I. (1982) The effect of elimination of jiggling forces on periodontaly exposed teeth in the dog. *Journal of Periodontology* **53**, 562–567.

Lindhe, J. & Svanberg, G. (1974) Influence of trauma from occlusion on the progression of experimental periodontitis in the beagle dog. *Journal of Clinical Periodontology* **1**, 3–14.

McGuire, M. K. & Nunn, M. E. (1996a) Prognosis versus actual outcome. II. The effectiveness of clinical parameters in developing an accurate prognosis. *Journal of Periodontology* **67**, 658–665.

McGuire, M. K. & Nunn, M. E. (1996b) Prognosis versus actual outcome. III. The effectiveness of clinical parameters in accurately predicting tooth survival. *Journal of Periodontology* **67**, 666–674.

Nunn, M. & Harrel, S. K. (2001) The effect of occlusal discrepancies on treated and untreated periodontitis: I. Relationship of initial occlusal discrepancies to initial clinical parameters. *Journal of Periodontology* **72**, 485–494.

Orban, B. & Weinman, J. (1933) Signs of traumatic occlusion in average human jaws. *Journal of Dental Research* **13**, 212–216.

Pihlstrom, B. L., Anderson, K. A., Aeppli, D. & Schaffer, E. M. (1986) Association between signs of trauma from occlusion and periodontitis. *Journal of Periodontology* **57**, 1–6.

Polson, A. (1974) Trauma and progression of marginal periodontitis in squirrel monkeys II. Co-destructive factors of periodontitis and mechanically produced injury. *Journal of Dental Research* **9**, 108–113.

Polson, A., Kennedy, J. & Zander, H. (1974) Trauma and progression of periodontitis in squirrel monkeys. I. Co-destructive factors of periodontitis and thermally produced injury. *Journal of Dental Research* **9**, 100–107.

Polson, A., Meitner, S. & Zander, H. (1976a) Trauma and progression of marginal periodontitis in squirrel monkeys. III Adaptation of interproximal alveolar bone to repetitive injury. *Journal of Dental Research* **11**, 179–289.

Polson, A., Meitner, S. & Zander, H. (1976b) Trauma and progression of marginal periodontitis in squirrel monkeys IV. Reversibility of bone loss due to trauma alone and trauma superimposed upon periodontitis. *Journal of Dental Research* **11**, 290–297.

Polson, A. & Zander, H. (1983) Effects of periodontal trauma on intrabony pockets. *Journal of Periodontology* **54**, 586–591.

Stillman, P. R. (1917) The management of pyorrhea. *Dental Cosmos* **59**, 405–414.

Stillman, P. R. (1926) What is traumatic occlusion and how can it diagnosed and corrected. *Journal of the American Dental Association* **12**, 1330–1338.

Waerhaug, J. (1979a) The angular bone defect and its relationship to trauma from occlusion and downgrowth of subgingival plaque. *Journal of Clinical Periodontology* **6**, 61–82.

Waerhaug, J. (1979b) The infrabony pocket and its relationship to trauma from occlusion and subgingival plaque. *Journal of Periodontology* **50**, 355–365.

Weinman, J. (1941) Progress of gingival inflammation into the supporting structure of the teeth. *Journal of Periodontology* **12**, 71–76.

Address:
Stephen K. Harrel
Private Practice
Baylor College of Dentistry
10246 Midway Road
#101
Dallas TX 75229
USA
E-mail: skh1@airmail.net

Clinical Relevance

Scientific rationale for the study: To determine if occlusal contacts are related to deeper pocket probing depth and a less than favourable prognosis in patients with periodontal disease.

Principle findings: Multiple types of contacts were noted to be associated with deeper pocket probing depths and a less favourable prognosis. Certain occlusal contacts are associated with the presence of deeper pocket probing depth.

Practical implications: The diagnosis and treatment of occlusal discrepancies may be a significant factor in the control of periodontal disease.