Prognosis Versus Actual Outcome. III. The Effectiveness of Clinical Parameters in Accurately Predicting Tooth Survival

Michael K. McGuire and Martha E. Nunn†*

TOOTH LOSS FOR 100 TREATED PERIODONTAL PATIENTS (2,509 teeth) under maintenance care was evaluated to determine the effectiveness of commonly taught clinical parameters utilized in the assignment of prognosis in accurately predicting tooth survival. Previous studies in this series evaluated prognosis as a surrogate variable representing the condition of the tooth at a particular point. In this study, survival analysis was used to evaluate the relationship of these common clinical parameters to an actual end point, tooth loss. Robust log rank tests indicated that initial probing depth, initial furcation involvement, initial mobility, initial crown-to-root ratio, and initial root form were all associated with tooth loss. In addition, smoking and increased initial bone loss were both found to be associated with increased risk of tooth loss while fixed abutment status was associated with a decreased risk of tooth loss. A Cox proportional hazards regression model showed that initial probing depth, initial furcation involvement, initial mobility, initial percent bone loss, presence of a parafunctional habit without a biteguard, and smoking were all associated with an increased risk of tooth loss. This model suggests that patients are twice as likely to loose their teeth if there is increasing mobility, if they have a parafunctional habit and do not wear a biteguard, or if they smoke. From these data there does appear to be a relationship between the assigned prognosis and tooth loss. Teeth with worse prognosis have a worse survival rate, but the commonly taught clinical parameters used in the traditional method of assignment of prognosis do not adequately explain that relationship. Furthermore, initial prognosis did not adequately explain the condition of the tooth or accurately predict the tooth's survival. These results seem to indicate that the effect of these clinical parameters on tooth survival is only partially reflected in the assigned prognosis initially, suggesting that perhaps some of the clinical parameters should be weighed more heavily than others when assigning prognosis. Further studies are needed to develop a more accurate method for the assignment of prognosis. *J Periodontol 1996;67:666–674.*

Key Words: Decision making; dental models; periodontal diseases/diagnosis; prognosis; risk factors; tooth loss; tooth survival; treatment outcome; forecasting.

The traditional method for assigning a prognosis to a tooth involves an examiner identifying one or more commonly taught clinical parameters (Table 1) as they uniquely apply to the tooth. These factors are then recorded and weighed according to past clinical experience and a prognosis is made based primarily on the skill and judgment of the clinician. The prognosis then serves as a surrogate marker for the projected condition of the tooth at a particular time in the future. Previous studies in this series of papers[1,2] have evaluated the validity of this method for correctly assigning prognosis.

The ability to predict tooth survival accurately is the ultimate test for any system used in the development of prognosis. The utilization of a true endpoint to determine the effectiveness of the traditional way that most clini-

*Private practice, Houston, TX; Department of Periodontics, University of Texas, Dental Branch, Houston; and Health Science Center, San Antonio.
†University of Washington, School of Dentistry, Department of Dental Public Health Sciences and Department of Biostatistics, Seattle, WA.

Table 1. Factors In Assigning Prognosis

Individual Tooth Prognosis	
	Percentage of bone loss
	Probing depth
	Distribution and type of bone loss
	Presence and severity of furcations
	Mobility
	Crown-to-root ratio
	Root form
	Pulpal involvement
	Caries
	Tooth position and occlusal relationship
	Strategic value
	Therapist knowledge and skill
Overall Prognosis	
	Age
	Medical status
	Individual tooth prognosis
	Rate of progression
	Patient cooperation
	Economic consideration
	Knowledge and ability of dentist
	Etiological factors
	Oral habits and compulsions

cians have been taught to assign prognosis is appealing because it replaces much of the subjectivity that takes place when assigning one of the prognosis categories (good, fair, poor, questionable, and hopeless).

Survival analysis is commonly used in medicine for evaluating certain illnesses such as cancer as well as evaluating diagnostics and therapeutics. Survival analysis is uncommon in dentistry primarily because most data sets do not include enough lost teeth from which to draw valid conclusions and, until recently, the necessity for independence of observations has precluded the general use of the statistical techniques used in survival analysis. Recent developments, however, now allow the use of log rank tests and Cox proportional hazards regression models where there exists correlation between observations.[3,4]

Prognostic data should provide sensible answers to the questions commonly asked by the profession and our patients. The medical literature assigns questions on prognosis into one of three categories and each category requires a particular type of prognosis study to provide the answer.[5] Our patient may ask, "Are my teeth worth it—what are my chances? How likely will I suffer an adverse outcome? Over what time frame might this occur?" To answer those questions, one must look for prognostic results expressed in terms of absolute risk (event/time). Or our patient may ask, "How do my chances compare with others?" To answer this question, one must look for studies that express results in terms of relative risk (the more risk factors the greater the probability of an adverse event). The two previous papers in this series attempt to answer these types of questions.[1,2] And finally, our patient may ask "Do my chances change with time?" In most clinical situations, the chance of an outcome does change with time. Studies expressing their results in absolute or relative risk will not be able to answer this question. Instead, we must turn to studies such as this one which express their results in terms of survival data.

The purpose of this study is two-fold: to further evaluate the data derived from the longitudinal investigation used in the previous papers, and to perform survival analysis based on tooth loss to determine the actual relationship of prognosis to tooth survival and to determine what clinical parameters are related to tooth survival and which of these parameters are not adequately reflected in the assignment of prognosis.

MATERIALS AND METHODS

As reported earlier, 100 consecutive patients with at least 5 years of maintenance care were selected from one clinician's appointment book over a 2-month period. All had been initially diagnosed as having chronic generalized moderate to severe adult periodontitis and were treated by the same clinician. Patients in the study were under maintenance regimens of 2- or 3-month intervals with the majority under a 3-month interval. Additional information regarding the study population, therapy, and assignment of prognoses can be found in the initial reports.[1,2] In this paper, statistical analysis was accomplished by using MULCOX2, a Fortran program developed for the analysis of correlated survival data. Proportional hazards assumptions were checked using S-Plus software.

Determining the Actual Outcome

Teeth lost during the initial active phase of periodontal therapy were documented, along with the prognosis assigned each tooth following active therapy and prior to maintenance care. The same set of criteria were used for assigning prognoses at 5 and 8 years. Subsequent prognoses were determined by charted clinical data accumulated between initial and 5 years and 5 years and 8 years, rather than on information recorded only at the 5-year and 8-year examinations. A more accurate projection of prognosis was intended by this method. All assessments were blind to previous assessments and conducted by the same examiner. The prognoses initially, at 5 years, and at 8 years were then compared.

Third molars that were lost during the study were not included in this analysis. Also, teeth extracted for orthodontic purposes were treated as censored at the time that these teeth were extracted, since the loss was clearly not related to periodontal disease. Teeth lost because of periodontal disease, restorative purposes, endodontic involvement, and caries were all treated as failures for this analysis. In most cases where teeth were lost for reasons other than impaction and orthodontics, history of these teeth indicated that they were periodontally involved so that separating them out would not be appropriate for this study. In an effort to include as many teeth as possible in

Table 2. Clinical Characteristics of Teeth

	Lost Teeth (131)		Surviving Teeth (2,378)	
Parameter	Mean (Range)	SD	Mean (Range)	SD
Probing depth	7.00 (3.0 to 10.0)	1.89	4.62 (3.0 to 10.0)	1.86
Bone loss (%)	49.58 (10.0 to 75.0)	20.90	34.87 (10.0 to 75.0)	15.89
Mobility	Number	%	Number	%
0	91	69.5	2261	95.1
1	13	9.9	63	2.6
2	15	11.5	40	1.7
3	12	9.2	14	0.6
Furcation				
0	71	54.2	2043	85.9
1	14	10.7	164	6.9
2	27	20.6	126	5.3
3	19	14.5	45	1.9

the data set, the maximum study time was extended to 16 years. The results of increasing the study period increased the number of teeth lost from 51 to 131. Patients who became inactive during the course of the study were treated as censored observations at the time of the inactivation. All teeth remaining at the last data collection period were treated as censored at that time.

Exploratory Results

Of the 2,509 teeth that were initially included in the study, 131 were lost. The average time of follow-up was 9.97 years with a range of 0.33 years to 15.17 years. The average time of survival for teeth that were lost was 5.79 years with a range of 0.33 years to 12.33 years (median = 6.25 years). The characteristics of the initial clinical parameters found to be significantly related to lost teeth and surviving teeth during the follow-up period are given in Table 2. When comparing the characteristics of lost teeth and surviving teeth, one can see that lost teeth had greater average probing depths initially, greater bone loss initially, and higher proportions of greater degrees of furcation involvement and mobility. It was also found that 63.4% of lost teeth had unsatisfactory crown-to-root ratios initially, compared with only 17.7% of teeth that survived. Poor root form was found in 19.1% of teeth lost whereas only 7.3% of surviving teeth had poor root form. Root proximity was about the same for both groups with only about 2.3% exhibiting significant root proximity. None of the lost teeth had initial caries or endodontic involvement, whereas 8 of the surviving teeth were carious and 19 were endodontically involved. Three of the lost teeth (2.29%) were fixed abutments initially and seven (5.34%) were removable abutments initially. Of the 2,378 surviving teeth, 108 (4.54%) were fixed abutments while 47 (1.98%) were removable abutments. Of the teeth lost, 75 (57.3%) were from patients with parafunctional habits. Of the surviving teeth, 957 (40.24%) were from patients with parafunctional habits. There were 58 (44.27%) teeth lost where the patient had a parafunctional

Table 3. Initial Prognosis by Survival Status

Prognosis	N Surviving (%)	Mean Follow-up (Range)	N Lost (%)	Mean Follow-up (Range)	Total (%)
Good	1750 (73.6%)	10.11 (1.75–15.17)	37 (28.2%)	6.14 (0.33–12.08)	1787 (71.2%)
Fair	468 (19.7%)	10.31 (4.00–15.17)	40 (30.5%)	6.61 (1.33–12.33)	508 (20.3%)
Poor	136 (5.7%)	11.09 (4.00–14.67)	21 (16.0%)	6.31 (1.58–11.25)	157 (6.3%)
Questionable	16 (0.7%)	9.41 (4.67–12.92)	20 (15.3%)	5.00 (0.67–11.25)	36 (1.4%)
Hopeless	8 (0.3%)	10.01 (6.92–12.83)	13 (9.9%)	2.68 (1.17–7.26)	21 (0.8%)

habit but did not use a biteguard. There were 569 teeth (23.93%) that survived where the patient had a parafunctional habit but did not use a biteguard. Almost 90% of the teeth that were lost were in patients that had fair or poor oral hygiene (poor = 46, 35.1%; fair = 69, 52.7%). Approximately 80% of the teeth that survived were in patients that had fair or poor oral hygiene (poor = 315, 13.2%; fair = 1,573, 66.1%). In smokers, 82 teeth (62.6%) were lost while 862 teeth (36.25%) survived. Of the teeth lost, 31 (23.66%) were in patients who had excellent compliance while 650 (27.33%) of the surviving teeth were in patients with excellent compliance. There were similar proportions of teeth in diabetic patients (about 3.5%) for both lost teeth and surviving teeth (all patients in this study had well-controlled diabetes). Of the lost teeth, 41 (31.3%) were in patients with a history of periodontal disease in their families. There were 1,003 (42.18%) surviving teeth in patients with a family history of periodontal disease.

Initial prognoses for all teeth were analyzed according to survival status along with average time (in years) of follow-up (or survival for lost teeth) in Table 3. Substantially greater percentages of lost teeth had poor or worse prognoses than surviving teeth. It should also be noted that among lost teeth, teeth with initial prognoses of ques-

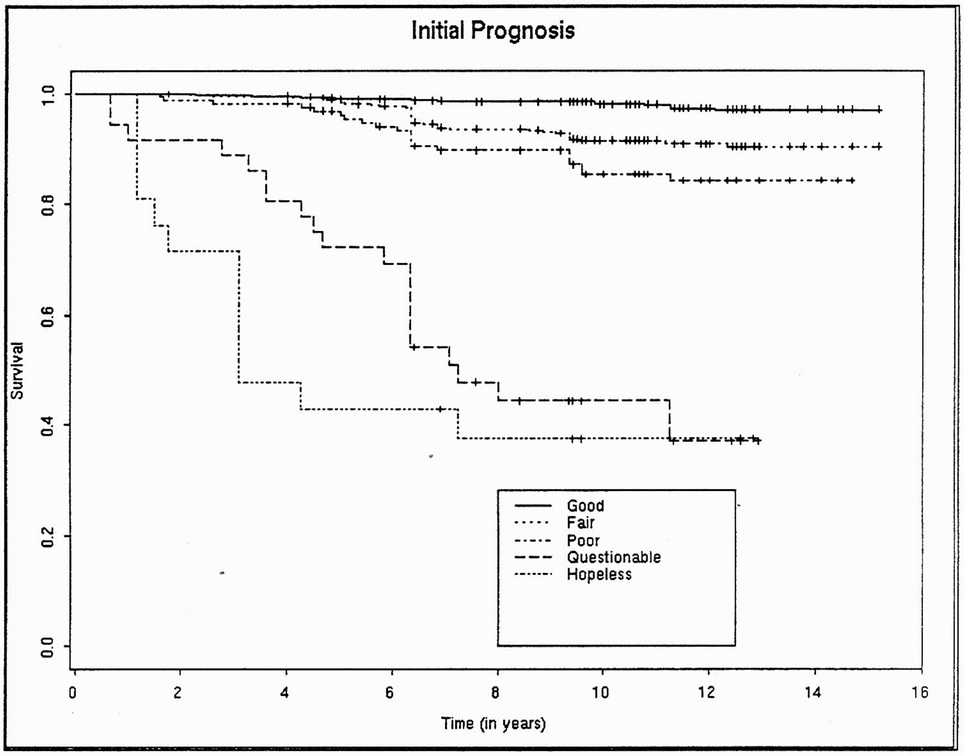

Figure 1. Unadjusted Kaplan-Meier survival plot of teeth according to initial prognosis.

tionable or poor had shorter average survival times than teeth with better prognoses. Also, note the similar survival times for lost teeth with initial prognoses of poor or better. Note also the great variability in survival times for lost teeth ranging from 4 months to 12 years.

A plot of survival according to initial prognosis was constructed using unadjusted Kaplan-Meier estimates and is shown in Figure 1. As was demonstrated above, teeth with worse prognoses exhibit worse survival rates, and a fairly consistent pattern over time. A log rank test was also conducted to compare the difference in survival of the five prognosis groups (good, fair, poor, questionable, hopeless). The test yielded a test statistic of 8.57 with a corresponding P value of 0.0034, indicating that there is a significant difference in survival rates between the five classes.

Kaplan-Meier plots for survival were also constructed for mobility, probing depth, age, furcation involvement, type of bone loss, percentage of bone loss, root formation (satisfactory or unsatisfactory), crown-to-root ratio (satisfactory or unsatisfactory), smoking status, root proximity, hygiene, malposed tooth status, fixed abutment, removable abutment, parafunctional habit, lack of biteguard with parafunctional habit, compliance, family history of periodontal disease, and diabetes. These plots are shown in Figures 2, 3, 4, 5, and 6. From Figure 2, we see that there appears to be decreased survival with increased mobility, increased probing depth, and increased furcation involvement. Age appears to have little effect upon tooth survival. In Figure 3, we see that there appears to be reduced survival rates with increasing bone loss, unsatisfactory root form, and unsatisfactory crown-to-root ratio. The type of bone loss appears to have little impact on the tooth survival. Figure 4 shows an apparent decrease in tooth survival for smokers and patients with poor oral hygiene or malposed teeth. Root proximity appears to have little effect on tooth survival. Figure 5 indicates that fixed abutments appear to have increased survival whereas removable abutments have decreased survival. It also shows that patients with parafunctional habits appear to have decreased tooth survival. This effect seems to be worse for patient who do not use a biteguard. In Figure 6, it appears that patient compliance, family history, and presence of controlled diabetes have little effect upon survival.

To further investigate the effect of these covariates on survival, robust log rank tests were performed (using MULCOX2) on all these covariates of interest individually, and the results of these tests are given in Table 4. From that table it can be seen that probing depth, furcation involvement, mobility, crown-to-root ratio, and root form are all significantly related to tooth survival. Smoking, percent bone loss, and fixed abutment status appear to be marginally related to tooth survival while all other factors were statistically insignificant. From the previous Kaplan-Meier plots, we note that the relationship of fixed

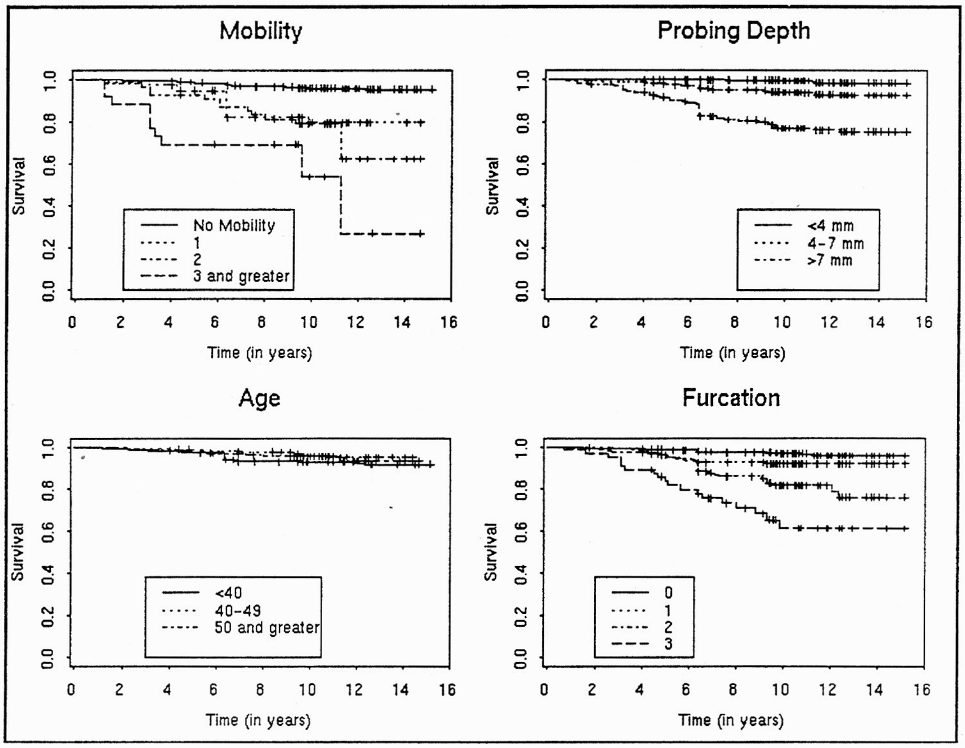

Figure 2. Unadjusted Kaplan-Meier survival plot of teeth according to mobility, probing depth, age, and furcation.

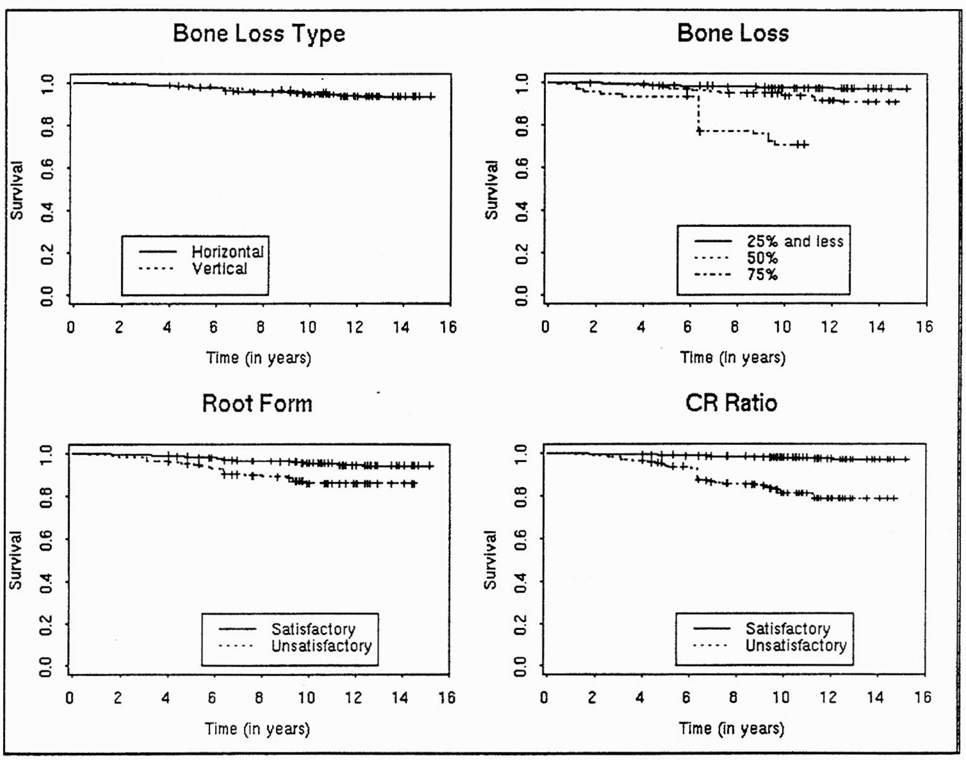

Figure 3. Unadjusted Kaplan-Meier survival plot of teeth according to bone loss type, bone loss %, root form, and crown-to-root ratio.

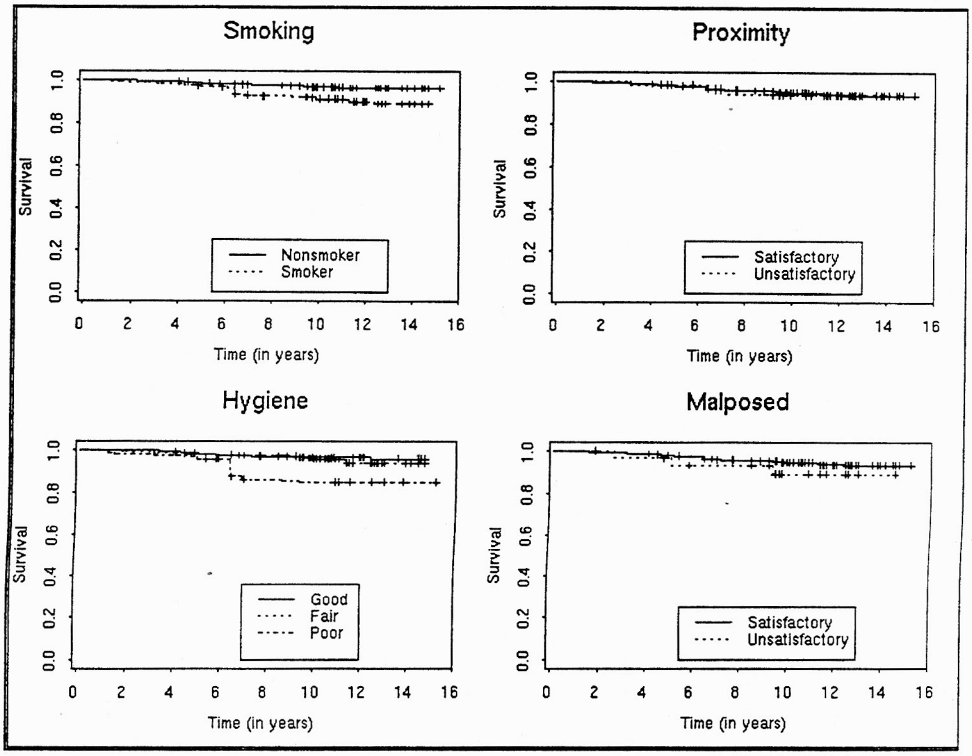

Figure 4. Unadjusted Kaplan-Meier survival plot of teeth according to smoking, root proximity, hygiene, and malposed teeth.

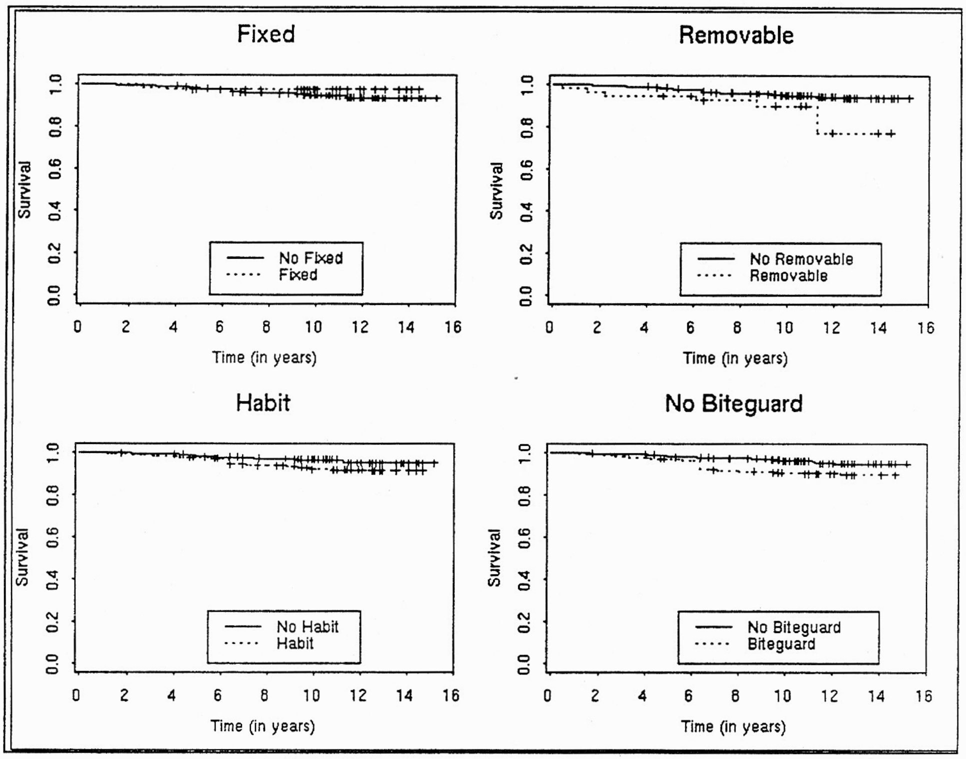

Figure 5. Unadjusted Kaplan-Meier survival plot of teeth according to fixed abutment, removable abutment, and parafunction habit with and without a biteguard.

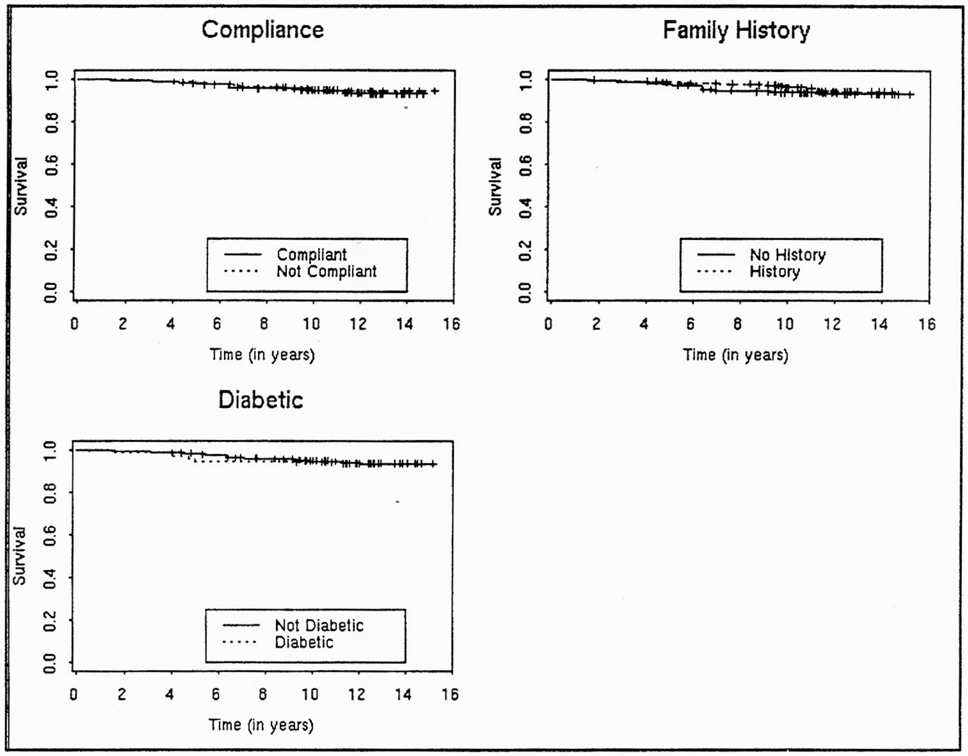

Figure 6. Unadjusted Kaplan-Meier survival plot of teeth according to compliance, family history, and diabetes.

Table 4. Logrank Tests of Commonly Used Clinical Parameters on Survival of Teeth

Parameter	Robust Statistic*	*P* Value
Age	0.38	0.5374
Family history	0.85	0.3576
Smoking	2.86	0.0909
Diabetes (controlled)	0.03	0.8729
Compliance	0.07	0.7853
Parafunctional habit	1.52	0.2182
Habit and no biteguard	1.33	0.2490
% bone loss	3.03	0.0819
Probing depth	10.05	0.0015
Bone loss type	0.10	0.7537
Furcation	19.77	<0.0001
Mobility	7.45	0.0063
Crown/root ratio	5.33	0.0209
Root form	4.26	0.0390
Root proximity	0.12	0.7325
Malposed tooth	0.26	0.6122
Fixed abutment	3.38	0.0660
Removable abutment	1.30	0.2551
Hygiene	1.64	0.2005

*Robust statistic is obtained by adjusting for correlation between multiple outcomes (multiple teeth in each patient's mouth).

abutment status to survival is that initial fixed abutments were more likely to survive.

To evaluate the effect of these commonly used factors simultaneously, a Cox proportional hazards regression model was constructed. The general form of a Cox proportional hazards regression model is given by the following equation:

$$\lambda(t) = \lambda_0(t) \exp(\beta x)$$

where β is a vector of regression coefficients corresponding to a vector of values given by x. The $\lambda_0(t)$ term corresponds to the "baseline" hazard (i.e., the hazard when x is a vector of zeroes). The hazard refers to the instantaneous probability of failure, given that a tooth has survived to this point. The term $\exp(\beta x)$ gives the relative risk which corresponds to the multiplicative increase (or decrease) in baseline hazard for given values of x.

This model was constructed by considering significantly related covariates identified from the robust log rank tests (Table 4). Initial models were constructed using standard software for fitting Cox proportional hazards regression models to determine possible significant factors. A forward step-wise procedure was then utilized to fit the robust model with each significant variable from the standard regression entered one at a time until all variables in the model reached a significance level of $x \leq 0.05$. The final model is summarized in Table 5. As can be seen in that table, increased initial probing depth (in mm), increased initial furcation involvement, increased mobility, increased initial bone loss, parafunctional habit without using a biteguard, and smoking all result in an increased risk of tooth loss. The risk ratio shows the multiplicative increase in risk by an increase of one unit of the clinical parameter. For instance, an increase in mobility by one unit doubles the increase of tooth loss as does smoking

Table 5. Cox Proportional Hazards Regression Analysis for Tooth Loss (significantly related covariates)

Variable	Estimate	Robust Error	Robust Z	P Value	Risk Ratio
Probing depth (mm)	0.2555	0.0864	2.96	0.0031	1.387
Furcation	0.3274	0.1595	2.05	0.0401	1.291
Mobility	0.7179	0.1522	4.72	<0.0001	2.050
% bone loss	0.0347	0.0095	3.65	0.0003	1.035
Habit and no biteguard	0.7223	0.3574	2.02	0.0433	2.167
Smoking	0.7733	0.3077	2.51	0.0120	2.059

Table 6. Cox Proportional Hazards Regression Analysis for Tooth Loss (initial prognosis)

Variable	Estimate	Robust Error	Robust Z	P Value	Risk Ratio
Fair or poor	0.5871	0.3013	1.95	0.0513	1.799
Questionable or hopeless	1.7783	0.4198	4.24	<0.0001	5.920
Probing depth	0.1621	0.0837	1.94	0.0527	1.176
Mobility	0.5306	0.1697	3.13	0.0018	1.700
% bone loss	0.0340	0.0085	4.00	<0.0001	1.035
Habit and no biteguard	0.6492	0.3502	1.85	0.0637	1.914
Smoking	0.7481	0.3049	2.45	0.0141	2.113

and the presence of a parafunctional habit without a biteguard.

Another Cox regression model was fit that included the initial prognosis as a variable. Furcation involvement did not add significantly to the model with initial prognosis included and therefore, was eliminated. Indicator variables for initial prognosis were used. Fair and poor prognosis categories were combined as were questionable and hopeless categories since exploratory analysis indicated little difference between each of these pairs of groups. The final model is shown in Table 6.

DISCUSSION

In order to develop an accurate system for the assignment of prognosis to teeth, the authors found it necessary to determine the relationship of various clinical parameters used in this process to tooth loss. In the past, clinicians have often used these clinical parameters to predict outcome of the tooth, that is, whether the tooth is maintained or lost. Many of these clinical parameters have also been used as surrogate markers in the evaluation of treatment efficacy as well as in the assignment of prognosis. Unfortunately, the accuracy of many of these commonly used clinical parameters as surrogate markers as well as predictors of tooth loss has been somewhat ineffective. The fact that commonly used clinical parameters (surrogate variables) often lead to false conclusions has been recently demonstrated by Hujoel and DeRouen.[6]

By evaluating the long-term survival of 100 "well-maintained" periodontal patients, the authors have attempted to determine first, which of these commonly used clinical parameters are most closely related to tooth loss, and second, the effect each has on tooth survival. There are obvious limitations to this study, some of which are addressed in the previous two papers.[1,2]

The guidelines necessary to establish a valid study on prognosis are rather straightforward.[5] This study has fulfilled most of the important requirements: 1) an inception cohort was assembled—all of the study patients were at a uniform point in their disease and data collection began immediately following definitive therapy; 2) a referral pattern was described—extrapolation from this study group to other groups would most likely hold true in comparison to other "well-maintained" periodontal maintenance patients; 3) objective outcome criteria were developed and used—the same set of objective criteria were used for the assignment of prognosis at each examination period; 4) the outcome assessment was blind to previous assessment; 5) complete follow-up was achieved. This is the only guideline that may not have been completely fulfilled. Although the study patients were followed for a relatively long period of time, the periodontal therapy rendered was very effective and only a small proportion of teeth were lost. In an effort to increase the number of teeth lost and available for evaluation the study period was extended from the original 5 to 8 years to 16 years. All members of the cohort were accounted for, but they were followed for different lengths of time. During this extended period, some patients were lost from the study group and several of these became inactive after the loss of some teeth. This may not be a fatal flaw, because the proportion of patients inactivated who suffered tooth loss was similar to the proportion of active patients that lost teeth (active patients with no teeth lost after active therapy, 34; active patients with teeth lost after active therapy, 35; inactive patients with no teeth lost following active therapy, 17; inactive patients with loss of teeth following active therapy, 14).

The Cox model that was used in this study assumed that censoring (i.e., loss to follow-up) is a random event that is unrelated to outcome. Since some patients apparently withdrew after losing some teeth, the assumption that loss to follow-up is unrelated to tooth loss may not be valid. The clinical and demographic characteristics of the patients lost to follow-up were very similar to those who completed the study. Loss to follow-up, therefore, may not be a threat to the validity of the study, but one should be aware of this potential problem. Proportional hazards assumptions were checked for each of the clinical parameters included in the model, and there did appear to be some deviation from the assumption of proportional hazards for initial prognosis, initial furcation, and initial bone loss. Specifically, there appear to be proportional hazards for fair or worse initial prognosis, but good prognoses appear to deviate somewhat from this. The largest deviation in furcation appears to occur with furcation involvement of 1 while the deviations in proportional hazards for bone loss appears with bone loss of 10% or less.

It is reasonable to assume that furcation involvement did not add significantly to this model with initial prognosis included since prognosis is partially determined by degree of furcation involvement. The proportional hazards assumption for other clinical parameters appeared to be valid.

Robust log rank tests indicated that initial probing depth, initial furcation involvement, initial mobility, initial crown-to-root ratio, and initial root form were all associated with tooth loss. Specifically, increased probing depth, increased furcation involvement, increased mobility, unsatisfactory crown-to-root ratio, and unsatisfactory root form were all associated with an increased risk of tooth loss. In addition, smoking and increased initial bone loss were both found to be associated with increased risk of tooth loss while fixed abutment status was associated with a decreased risk of tooth loss. The reasons that a fixed abutment may have greater survival may be related to the initial choice of the tooth as an abutment (i.e., only very healthy teeth would be used for a fixed abutment) or it may be related to the investment that the patient has in that tooth. In other words, after a patient has spent a great deal of money on a fixed prosthesis, he may be more cognizant of the maintenance required to retain it.

A Cox proportional hazards regression model showed that initial probing depth, initial furcation involvement, initial mobility, initial percent bone loss, parafunctional habit with no biteguard, and smoking were all related to the risk of tooth loss. In addition, increased probing depth, increased furcation involvement, increased mobility, increased bone loss, parafunctional habit without a biteguard, and smoking were all associated with an increased risk of tooth loss. This model suggested that patients are twice as likely to lose their teeth if there is increasing mobility, if they have a parafunctional habit and do not wear a biteguard, or if they smoke. In addition, all these factors except furcation involvement were found to significantly add to the regression model in the presence of initial prognosis. This would seem to indicate that the effect of these clinical parameters on tooth survival is not completely reflected in the initially assigned prognosis and perhaps that they should be weighed more heavily than the other clinical parameters when prognosis is assigned.

The previous papers in this series[1,2] on prognosis have concluded that commonly taught clinical parameters are useful in the assignment of prognosis for teeth with initial good prognoses, but they are no more effective than a coin toss when used in the assignment of an accurate prognosis to teeth with an initial prognosis of less than good. In general, it was also found that this system for the assignment of prognosis is more likely to be accurate for anterior than posterior teeth. Although the system evaluated in these papers represents the typical method that dentists use to assign prognosis, only limited inference can be drawn from those analyses since prognosis is only a surrogate marker for the actual endpoint—tooth loss. This paper utilized survival analysis based on tooth loss to determine the actual effect that the clinical parameters and ultimately prognoses had on tooth survival. Most of the same clinical parameters (increased probing depth, increased furcation involvement, increased mobility, parafunctional habits, and smoking) that were found to be significantly associated with prognosis in the first two papers were found to be significantly associated with tooth loss, indicating that these clinical factors may be reasonable surrogate markers for tooth survival. Another significant finding was that patients double their risk of tooth loss when one adjusts for everything else, if they smoke or have a parafunctional habit and do not wear a biteguard. One might extrapolate from the data that these particular clinical parameters should be weighed more heavily when assigning prognosis than the other commonly used clinical parameters listed in Table 1. The results of this study reveal a distinct relationship between prognosis and tooth loss: teeth with a worse prognosis have a worse survival rate. The clinical parameters commonly used in the assignment of prognosis, however, inadequately explain that relationship or predict tooth survival. That a relationship exists between tooth loss and prognosis is clear, but the exact nature and description of that relationship remains yet to be determined.

These results demonstrate the need to develop better guidelines for the assignment of prognosis. In particular, the present system should be revised to account for those clinical parameters that are clearly associated with tooth loss, but are not presently reflected in the current method for assignment of prognosis. In addition, more work is required to determine which other risk factors should be taken into account during the assignment of prognosis.

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Send reprint requests to: Dr. Michael K. McGuire, Suite 102, 3400 South Gessner, Houston, TX 77063.

Accepted for publication December 27, 1995.