An Evidenced-Based Scoring Index to Determine the Periodontal Prognosis on Molars

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Background: This retrospective study evaluates and assigns scores to six prognostic factors and derives a quantitative scoring index used to determine the periodontal prognosis on molar teeth.

Methods: Data were gathered on 816 molars in 102 patients with moderate-to-severe periodontitis. The six factors evaluated (age, probing depth, mobility, furcation involvement, smoking, and molar type) were assigned a numeric score based on statistical analysis. The sum of the scores for all factors was used to determine the prognosis score for each molar. Only patients with all first and second molars at the initial examination qualified for the study. All patients were evaluated a minimum of 15 years after treatment.

Results: The post-treatment time ranged from 15 to 40 years and averaged 24 years. When the study was completed, 639 molars survived (78%), and, of those surviving molars, 588 survived and were periodontally healthy (92%). In molars with lower scores (scores 1-3), the 15-year survival rates ranged from 98% to 96%. In molars with middle scores (scores 4-6), the 15-year survival rates ranged from 95% to 90%, and, for molars with higher scores (scores 7-10), the survival rates ranged from 86% to 67%.

Conclusion: The present results indicate that the periodontal prognosis of molars diagnosed with moderate-to-severe periodontitis can be calculated using an evidence-based scoring index. *J Periodontol 2014;85:214-225.*

KEY WORDS

Long-term care; molar; periodontitis; prognosis; smoking; tooth mobility.

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Determining prognosis is one of the most important functions undertaken in clinical practice. In medicine, determining treatment and prognosis is often assisted by quantitative methods, including combinations of algorithms, decision trees, and/or clinical balance sheets.[1,2] Although there are many systems for determining prognosis in periodontal disease,[3-8] there is a need for an objective, evidenced-based scoring index that will provide a prognosis score for each individual tooth.[9,10] Such a scoring index would be beneficial because determining an accurate prognosis for periodontally involved teeth is crucial to the development of an appropriate treatment plan.[11] One clinician described assigning periodontal prognosis as an "art based on a science."[12] Another stated "that a coin toss would be an easier and more accurate way for a clinician to assign a prognosis under traditional guidelines."[13,14]

Periodontal disease is multifactorial and includes both risk factors (factors that cause disease) and prognostic factors (factors that focus on disease outcome once disease is present).[15-17] Abundant evidence exists in the periodontal literature regarding the association between prognostic factors and tooth loss in periodontally maintained patients.[6,13,18-28]

Although some prognostic factors can be altered by treatment, others

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cannot. Prognostic factors can be categorized as follows: 1) those that can be controlled by the patient (daily plaque removal, smoking cessation, compliance with wearing occlusal guards, compliance with the recommended preventive maintenance schedule); 2) those affected by periodontal treatment (probing depth [PD], mobility, furcation involvement, trauma from occlusion, bruxism, other parafunctional habits); 3) those associated with systemic disease (diabetes mellitus [DM], immunologic disorders, hypothyroidism); and 4) those that are uncontrollable (poor root form, poor crown/root ratio, tooth type, age, genetics).[29]

Traditionally, prognosis of periodontally involved teeth has been evaluated using the terms "good," "fair," "poor," "questionable," and "hopeless."[7,14] Additionally, "short-term" and "long-term" have been used to signify the future. These arbitrary terms do not offer clinicians a reliable method for assigning prognosis. McGuire and Nunn[13] concluded that the ability to predict tooth survival accurately is the ultimate test for any index devised to determine prognosis. The current concept of assigning periodontal prognosis is often based on clinical opinion. The clinician typically considers many factors, including disease severity. Although clinical experience, therapeutic skill, and patient compliance can influence prognosis, an objective way of determining prognosis is needed. The purpose of this study is to develop and test a practical, evidence-based scoring index to objectively determine the prognosis of periodontally involved molars. This study has four significant features: 1) the use of a long-term cohort study; 2) scoring all molars at the initial examination, even those planned for extraction; 3) scoring molars only, the most difficult teeth to treat and maintain; and 4) evaluation of the periodontal health of the surviving molars. The scoring index must be simple to score as well as easily understood by both the dentist and patient. It should be designed so a dental assistant can calculate the score from examination data. Ultimately, software could be developed that would calculate the score electronically.

MATERIALS AND METHODS

The study received Institutional Review Board approval at the Medical University of South Carolina. More than 800 recall patients, treated in a private periodontal practice from 1969 to 1994, were evaluated. Patients provided oral consent to participate in the study. Criteria for inclusion were as follows: 1) all first and second molars present at the initial examination; 2) a diagnosis of moderate-to-severe chronic periodontal disease;[30] and 3) periodontal maintenance (PM) for at least 15 years. For patients meeting these criteria, a data collection sheet was completed.

Only 106 patients met the inclusion criteria because most patients referred for periodontal treatment were already missing at least one molar. The dates of molar extraction could not be found on four patients, and they were eliminated from the study. Thus, the present study consists of 102 patients (44 males and 58 females, aged 23 to 71 years; mean age: 42 ± 9.47 years) with 816 molars. The majority (99 patients) were non-Hispanic whites, one was non-Hispanic black, and two were of other ethnicities. Forty-two were aged <40 years, whereas 60 were ≥40 years; 34 (33.3%) were smokers. Dates of molar extraction(s) and final charting (including the health status of surviving teeth) were recorded at the exit examination (PDM). Active treatment began with the initial examination and ended at the first PM appointment, when oral hygiene instructions were reinforced and scaling and polishing were performed. PM lasted for as long as the patient continued to be seen and included periodontal health and oral hygiene assessment, retreatment when necessary, and surgery when periodontal health could not be maintained by non-surgical therapy.

Six prognostic factors that could be quantitatively evaluated were selected to be scored: 1) age; 2) PD; 3) furcation involvement; 4) mobility; 5) molar type; and 6) smoking. A statistically derived score was determined for each factor. The sum of these scores became the score for that tooth.

Originally, DM was to be a scored factor. However, at the initial examination, only two patients had a documented diagnosis of DM, and both reported their DM was well controlled. This low incidence of DM in the present patient pool prevents the authors from statistically evaluating DM as a factor. Plaque and bleeding scores were not included because they were not recorded in patient records. After the preliminary data analysis, scores were assigned for each factor as follows.

1) Age was based on the statistical analysis of the patient pool and was scored as follows: molars from patients aged <40 years = 0; and molars from patients aged ≥40 years = 1.
2) PD, not clinical attachment loss (AL), was scored because clinical attachment level (CAL) was not a commonly recorded examination finding when the study began in 1969. The deepest PD of six probing sites on a molar was used to determine the PD score: <5 mm = 0; 5 to 7 mm = 1; 8 to 10 mm = 2; and >10 mm = 3.
3) Mobility was scored as follows: No mobility = 0; Class I mobility = 1; Class II = 2; and Class III = 3.

Age (years)	No. of Furcations/Tooth	Smoking	Pockets (mm)	Mobility	Molar Type
0 to 39 = 0	0 furcations = 0	Non-smoking = 0	<5 = 0	0 = 0	Mandibular = 0
≥40 = 1	1 furcation = 1	Smoking = 4	5 to 7 = 1	1 = 1	Maxillary first = 1
	2 furcations = 2		8 to 10 = 2	2 = 2	Maxillary second = 2
	3 furcations = 3 Through-and-through (mandibular molars) = 3		>10 = 3	3 = 3	

Figure 1.
Determining the Miller–McEntire Score for each tooth. Miller–McEntire Score = Age + No. of Furcations/Tooth + Smoking + Pockets + Mobility + Molar Type.

A new and simplified mobility classification was used to determine mobility and was defined as follows: a) Class I: a tooth is mobile but, in the opinion of the clinician, the mobility is not affecting prognosis; b) Class II: a tooth is mobile and, in the opinion of the clinician, the level of the mobility is affecting prognosis; and c) Class III: a tooth is mobile and, although perhaps considered hopeless, may be treated under certain circumstances and maintained. If there was indecision between two classes of mobility, the higher class was used for scoring.

4) For furcation involvement, the severity of a furcation was not assessed; just the presence of a furcation involvement was used for scoring. In other words, if the concavity of a furcation was detected, it was scored as a furcation involvement as follows: no furcation involvement = 0; one furcation = 1; two furcations = 2; and three furcations or through-and-through furcations on mandibular molars = 3.
5) For molar type, molars were scored as follows: mandibular first and second molars = 0; maxillary first molars = 1; and maxillary second molars = 2.
6) Smoking was assessed only at the initial examination as follows: non-smokers = 0; smokers = 4.

A summary of the scoring index can be found in Fig. 1.

At the exit examination, identical data as those taken at the initial examination were recorded. At the exit examination, the periodontal health of the surviving molars was assessed using criteria established by the American Academy of Periodontology that defines health as "the absence of inflammation which may appear clinically as redness, suppuration, and bleeding on probing."[31]

Data were imported into a statistical software program‡ for all statistical analyses. Scoring assignments for each prognostic factor were determined by exploratory visual examinations of plots for unadjusted Kaplan–Meier survival analysis. Molars extracted for any reason were treated as failures. They were counted at the time of extraction if performed in the practice of the authors. However, if the patient's general dentist extracted a tooth, the date used for statistical analysis was the last PM appointment in the periodontist's office. Molars never extracted were treated as successes, and they were counted at the exit exam. An iterative series of Kaplan–Meier procedures was used to determine applied clinically meaningful classifications for each factor until the survival distribution functions appeared proportional over the selected strata groups for all factors. Finally, the Harrell *C*-index was constructed to examine the predictive accuracy of the present survival analysis model, with a result of 67.1% (95% confidence interval [CI] = 49.7% to 82.6%). The Harrell *C*-index statistic can be interpreted as the probability that an individual from the molar-extraction group has a higher probability of having an extraction than an individual from the molar-survival group. Future studies are needed to test the periodontal prognostic reliability of the Miller–McEntire score while also considering differing subjective factors, including patient compliance and the clinician's philosophy.

The individual scores for each factor were statistically determined using only surviving molars; hence, the 32 molars extracted in active treatment were excluded from the analysis. Including healthy molars would necessarily skew the data and build in a bias because the scoring was based on diseased molars. An additional 40 healthy molars survived, each of which had a 0 score for smoking, PD, mobility, and furcation involvement and were not included in the statistical analysis because the analysis was based on diseased molars only. To ensure the stability of regression models, each score level had to include at least 10 molars. Therefore, seven surviving molars with a score of 12 and two surviving molars with a score of 13 were excluded. This left 735 molars to be analyzed statistically. After the scoring levels for each factor were established, all 816 molars were scored (Table 1).

Cox proportional hazards regression models that applied both the derived prognosis score and the simultaneous impact of each individual factor score

‡ SAS v.9.2, SAS Institute, Cary, NC.

Table 1.

Descriptive Statistics of the Periodontally Involved Molar Study Population

Variable	Analytical Molars* (n = 735)		All Molars (N = 816)	
	Extracted	Not Extracted	Extracted	Not Extracted
Age (years)				
≥40	352 (58.76)	82 (60.29)	110 (62.15)	370 (57.90)
<40	247 (41.24)	54 (39.71)	67 (37.85)	269 (42.10)
PD (mm)				
<5	1 (0.74)	20 (3.34)	5 (2.82)	56 (8.76)
5 to 7	71 (52.21)	428 (71.45)	75 (42.37)	428 (66.98)
8 to 10	54 (39.71)	146 (24.37)	68 (38.42)	150 (23.47)
>10	10 (7.35)	5 (0.83)	29 (16.38)	5 (0.78)
Mobility				
None or Class I	108 (79.41)	566 (94.49)	120 (67.80)	603 (94.37)
Class II	20 (14.71)	23 (3.84)	29 (16.38)	24 (3.76)
Class III	8 (5.88)	10 (1.67)	28 (15.82)	12 (1.88)
Smoking status				
Non-smoker	424 (70.78)	63 (46.32)	92 (51.98)	460 (71.99)
Smoker	175 (29.22)	73 (53.68)	85 (48.02)	179 (28.01)
Furcation				
None	44 (32.35)	311 (51.92)	50 (28.25)	347 (54.30)
One	51 (37.50)	185 (30.88)	54 (30.51)	185 (28.95)
Two	26 (19.12)	75 (12.52)	39 (22.03)	77 (12.05)
Three or through-and-through	15 (11.03)	28 (4.67)	34 (19.21)	30 (4.69)
Type of molar				
Mandibular	59 (43.38)	310 (51.75)	74 (41.81)	334 (52.27)
First maxillary	37 (27.21)	152 (25.38)	46 (25.99)	158 (24.73)
Second maxillary	40 (29.41)	137 (22.87)	57 (32.20)	147 (23.00)

Table 1. (continued)

Descriptive Statistics of the Periodontally Involved Molar Study Population

Variable	Analytical Molars* (n = 735)		All Molars (N = 816)	
	Extracted	Not Extracted	Extracted	Not Extracted
Miller–McEntire score				
13	0	0	1 (0.56)	2 (0.31)
12	0	0	7 (3.95)	2 (0.31)
11	10 (7.35)	4 (0.67)	16 (9.04)	4 (0.63)
10	9 (6.62)	13 (2.17)	12 (6.78)	13 (2.03)
9	15 (11.03)	21 (3.51)	21 (11.86)	21 (3.29)
8	15 (11.03)	45 (7.51)	20 (11.30)	38 (5.95)
7	16 (11.76)	38 (6.34)	20 (11.30)	45 (7.04)
6	15 (11.03)	45 (7.51)	27 (15.25)	80 (12.52)
5	15 (11.03)	80 (13.36)	16 (9.04)	80 (12.52)
4	10 (7.35)	69 (11.52)	11 (6.21)	69 (10.80)
3	13 (9.56)	94 (15.69)	14 (7.91)	97 (15.18)
2	4 (2.94)	100 (16.69)	6 (3.39)	105 (16.43)
1	4 (2.94)	55 (9.18)	5 (2.82)	69 (10.80)
0	0	0	1 (0.56)	14 (2.19)
For all molars, mean ± SD (range)	6.93 ± 2.89 (0 to 13)	4.32 ± 2.56 (0 to 13)	6.54 ± 2.86 (0 to 12)	4.32 ± 2.56 (0 to 13)
For molars with PD <5 mm, mean ± SD (range)	1.20 ± 0.84 (0 to 2)	2.39 ± 2.22 (0 to 7)	1.20 ± 0.84 (0 to 2)	2.39 ± 2.22 (0 to 7)
For molars with PD ≥5 mm, mean ± SD (range)	7.10 ± 2.76 (1 to 13)	4.50 ± 2.52 (1 to 13)	6.74 ± 2.71 (1 to 12)	4.50 ± 2.52 (1 to 13)

All data are n (%) unless otherwise noted.
* Molars used for determining scoring levels.

Table 2.

Demographic Patient Characteristics (N = 102), Survival Scores of the Molars (N = 816), and Survival in Years

	Mean ± SD (range) or n (%)
Females	58 (56.86)
Non-Hispanic white	99 (97.06)
Age (years)	42 ± 9.47 (23 to 71)
Aged <40 years	42 (41.18)
Smokers	34 (33.33)
Total molars per patient	8 (100)
Molars extracted per patient	1.7 ± 2.01 (0 to 8)
PD among molars per patient (mm)	6.57 ± 1.55 (2.75 to 10.5)
Miller–McEntire score per patient	4.54 ± 2.21 (1.13 to 9.63)
Score of the 32 molars extracted during active treatment	8.68 ± 2.39 (9 to 13)
Score of the 145 molars extracted during PM	6.54 ± 2.86 (0 to 12)
Score of the 639 surviving molars	4.32 ± 2.56 (0 to 13)
Survival of the 32 molars extracted during active treatment (years)	0.54 ± 0.63 (0 to 2.33)
Survival of the 145 molars extracted during PM (years)	15.41 ± 8.46 (1.42 to 35.02)
Survival for the 639 surviving molars (years)	24.20 ± 6.46 (14.33 to 40.66)

were assessed to estimate associations with molar survival. Given the clustered nature of molars within the same patient, the robust sandwich variance estimate of Wei et al.[32] was applied for statistical inference of correlated survival data. The proportionality of hazards assumption was tested using score by time interaction and was satisfied for all of the present models.

RESULTS

At the initial examination of the 816 molars, 7.5% had PD <5 mm, 61.6% had PD = 5 to 7 mm, 26.7% had PD = 8 to 10 mm, and 4.2% had PD >10. A mobility score of 0 to 1 was noted in 88.6%, a score of 2 was noted in 6.5%, and a score of 3 was noted in 4.9%. No furcation involvement was found in 48.7%; 29.3% had one furcation involvement; 14.2% had two furcation involvements; and 7.8% had three or through-and-through involvements.

Overall, 177 total molars were extracted: 32 molars (3.9%) were extracted during the active phase of treatment, i.e., before patients entered the PM phase of treatment, whereas an additional 145 (17.7%) were extracted during the PM phase of the study. This left 639 molars (78.3%) that survived the duration of the study. Of the 639 molars that survived, 588 (92.0%) survived in periodontal health, and 512 (79.4%) of those had PD <5 mm.

Each patient lost an average of 1.7 molars. The average number of extractions per patient during PM was 1.4. The 32 molars extracted during active treatment had an average initial prognosis score of 8.68. The 145 molars extracted during PM had an average initial score of 6.54 and survived an average of 15.4 years. The surviving 639 molars had an average initial score of 4.32 and survived an average of 24.2 years. Demographic patient characteristics, survival scores, and survival in years are provided in Table 2.

Risk of Molar Extraction by Clinical Factors and Miller–McEntire Prognosis Score

Multivariable Cox proportional hazards regression models for each individual score component among the analytical molars (n = 735) found that smoking had the largest effect (hazards ratio [HR] = 3.46, 95% CI = 2.04 to 5.88). Second was PD (HR = 2.20, 95% CI = 1.69 to 2.88), followed by mobility (HR = 2.08, 95% CI = 1.45 to 2.99) and furcation involvement (HR = 1.21, 95% CI = 1.01 to 1.45). Molar-type score showed marginally increased effects (HR = 1.20, 95% CI = 0.99 to 1.46), whereas

Table 3.

Multivariable Cox Proportional Hazards Model Results for Molar Extraction (n = 735)

Prognostic Factor	Parameter Estimate	Standard Error	*P* Value	HR	95% CIs of HR
Age	0.24	0.25	0.3271	1.27	0.79 to 2.06
Smoking	1.24	0.27	<0.0001	3.46	2.04 to 5.88
PD	0.79	0.14	<0.0001	2.20	1.69 to 2.88
Mobility	0.73	0.19	<0.0001	2.08	1.45 to 2.99
Furcation	0.19	0.09	0.0446	1.21	1.01 to 1.45
Molar-type	0.19	0.10	0.0574	1.20	0.99 to 1.46

the age score was: HR = 1.27, 95% CI = 0.79 to 2.06 (Table 3.)

Time-dependent covariates (interaction of each scored factor with $\log_e$* follow-up time) were added to the model to test and verify the proportionality of hazards for the regression method, and that assumption was satisfied. The constructed Kaplan–Meier curves and plots for the factor scoring values were proportional and approximately parallel.

Models for the Miller–McEntire score for all molars showed a 38% increase in risk for molar extraction with every unit increase in score (HR = 1.38, 95% CI = 1.34 to 1.61). A time-dependent covariate was added to test and verify the proportionality of hazards for the regression method, and results showed that this assumption was satisfied. Results from this Cox proportional hazards regression model were also used to produce estimated survival probability curves for each prognosis score level and then converted into percentages (Fig. 2).

DISCUSSION

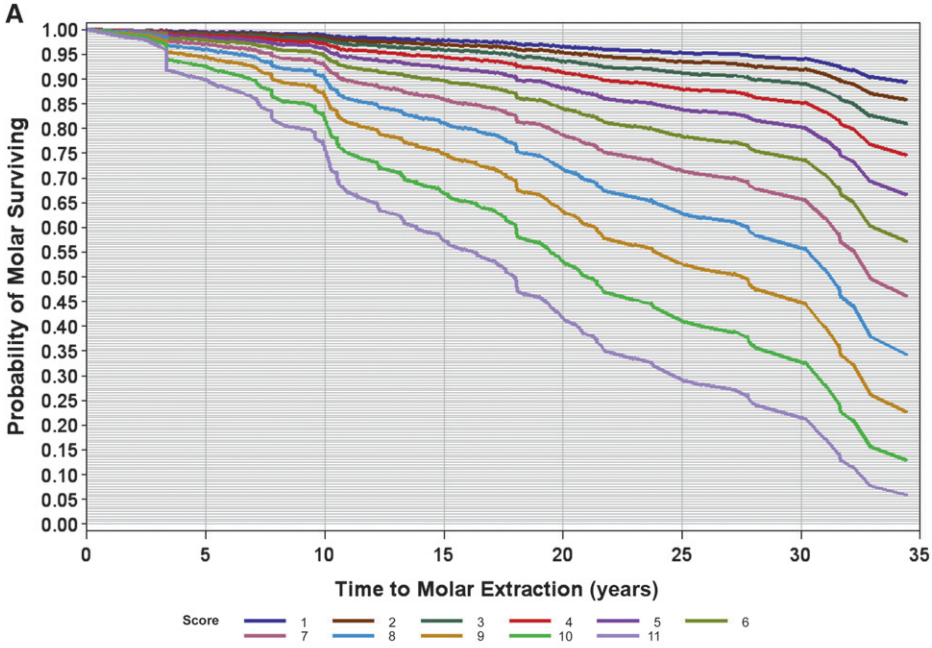
The authors elected to use a multivariable approach for statistical analysis rather than a univariable approach to assign scores and evaluate prognostic factors. Multivariable analyses is considered superior to univariable models of prognostic factors, so it was decided to use this method for the statistical analysis.[33,34] Using the Cox hazards regression model, McGuire and Nunn[13] found PD (regression ratio [RR] = 1.39), furcation involvement (RR = 1.29), mobility (RR = 2.05), percentage bone loss (RR = 1.04), parafunctional habit without a bite guard (RR = 2.17), and smoking (RR = 2.06) significantly associated with tooth loss in PM patients.

Using a multivariable logistic regression analysis, Fardal et al.[19] in a group of 100 PM patients, identified sex (odds ratio [OR] = 2.84), age (OR = 4.02), and smoking (OR = 4.18) as significant predictors of tooth loss. Like the present study, Dannewitz et al.[20] used a multilevel proportional hazards model for analyzing only molars. They identified that Class III furcation involvements (HR = 3.25), baseline bone loss (HR = 2.55), smoking (pack-years, i.e., number of cigarettes per day divided by 20 and multiplied by number of years smoking) (HR = 1.40), and number of molars left (HR = 0.77) significantly related to the retention time. Using a logistic regression model, Faggion et al.[9] identified DM (OR = 4.17), alveolar bone level (OR = 1.04), tooth mobility (OR = 5.52), root type (OR = 1.82), and a non-vital pulp (OR = 2.24) as significant factors. The present study finds that smoking (HR = 3.38), PD (HR = 1.33), and mobility (HR = 1.45) were the most significant prognostic factors. A comparison between the present study and these other prognosis studies can be found in Table 4.

Multivariable models showed that the patient's age was not a significant factor for tooth loss. These results are consistent with those of Dannewitz et al.[20] and Muzzi et al.[33] regarding age as a non-significant prognostic factor of molar tooth loss. Others have reported age as a significant factor, yet these studies found that the age group >60 years was significant.[25,26] However, using Kaplan–Meier survival curves for age, appropriate generally proportional survival curves for <40 versus ≥40 years were found, whereas curves for <60 versus ≥60 years were not.

Although age is the least statistically significant factor in the present study, it is included as a prognostic factor. Whether age should be included as a prognostic factor is debatable because the literature is ambivalent.[14,27] Additionally, scoring uncontrollable factors, such as age and molar type, does not necessarily depict the impact that periodontal treatment can have on lowering the overall score. Some clinicians are reluctant to provide in-depth surgical treatment to younger patients (aged 20 to 30 years) with severe periodontal disease

A



B

Score	10 years	15 years	20 years	30 years
1	100	98	96	94
2	99	97	95	93
3	98	96	94	89
4	97	95	92	85
5	96	93	88	80
6	95	90	84	74
7	93	86	79	66
8	90	81	72	56
9	87	75	63	45
10	82	67	53	33
11	76	53	42	22

Figure 2.
A) *Results from Cox proportional hazards model for molar extraction (HR = 1.35; 95% CI = 1.25 to 1.47). Miller–McEntire score range is from 1 (top curve) to 11 (bottom curve). Increasing scores reflect poorer prognosis.* ***B)*** *Probability (%) of molar survival by the Miller–McEntire score at 10, 15, 20, and 30 years obtained from the data in A.*

because the long-term prognosis is considered poor. However, the present findings suggest that these patients can have a favorable prognosis when they receive comprehensive periodontal therapy.

In the present study, the presence of furcation involvements was less significant when compared with other studies.[14,18,22,25,35,36] McGuire and Nunn,[13] Dannewitz et al.,[20] and König et al.[35] concluded that increased furcation involvement significantly reduces molar survivorship.

The difference in the present findings could be accounted for by the way furcations were scored. Only the presence of furcation involvements was scored, not the severity. Therefore, the impact of their severity could not be analyzed in the statistical models.

Others have reported the negative influence of smoking on periodontal prognosis.[37,38] This finding is supported by the dramatic impact that smoking has in this study. Based on the hazards model, smokers with periodontal disease have a 246% greater chance of losing their teeth compared to a non-smoker. Future studies should include more detailed data on smoking, including amount of smoking, as well as changes in smoking habits. In an effort to provide more clinically meaningful smoking scores, the clinician may consider the following proposed scores for smoking per day: 1 = occasional smoker; 2 = no more than half a pack; 3 = half a pack to one pack; and 4 = more than one pack.

Adherence to preventive maintenance therapy (supportive periodontal therapy [SPT]) is a key factor in maintaining periodontal health as well as determining prognosis.[23,24,39] Compliance with the recommended PM interval is variable and can be as low as 16%.[27,40] Lang and Tonetti[4] stated that, under optimal circumstances, SPT will be able to maintain stable CALs for years. In the present study, compliance in keeping PM appointments improved over time, confirming an observation made by Miyamoto et al.[24] that older patients were more compliant. Additionally, Costa and colleagues[41-43] found that personality type played a role in compliance and that neurotic patients were more compliant. Although the present study did not evaluate re-treatment, Fardal et al.[44] observed the following: 1) 50% of patients required re-treatment; 2) the need for re-treatment occurred every 6.7 years; and 3) 40% of PM patients required additional surgery.

Early in the present study, PM was done by alternating appointments with the general dentist. Over time, as general practitioners retired, many of these patients had all PM done by the hygienist in the periodontist's office.

The mean annual tooth loss rate of 0.07 in the present study is comparable to findings in previous retrospective studies. Hirschfeld and Wasserman,[18] König et al.,[35] and Fardal et al.[19] reported mean

Table 4.
Comparative Studies

Variable	Hirschfield and Wasserman (1978)[18]	McFall (1982)[22]	Wood et al. (1989)[27]	Tonetti et al. (2000)[28]	König et al. (2002)[35]	Fardal et al. (2004)[19]	Dannewitz et al. (2006)[20]	Faggion et al. (2007)[9]	Miyamoto et al. (2010)[24]	Present Study
Number of patients	600	100	63	273	142	100	71	195	295	102
Mean age (years)	42	44	45	52	46	46	46	48	42	42
Mean observation period (years)	22	19	13.6	5.6	10.5	9.8	5	11.8	20	24.2
Teeth evaluated	All teeth	All teeth	All teeth	All teeth	All teeth	All teeth	Molars only	All teeth	All teeth	Molars only
Percentage of teeth extracted during active therapy	N/A	N/A	N/A	4.8	N/A	4.98	6.5	3.6	5	3.9
Percentage of teeth extracted during PM	8.4	11.4	7.1	4.2	3.0	N/A	7.5	5.5	8.6	17.7
Mean annual tooth-loss rate	0.08	0.14	0.10	0.40	0.07	0.04	N/A	0.11	N/A	0.07

N/A = data not available.
Table adapted from Faggion et al.[9] with permission from John Wiley and Sons.

annual tooth loss rates of 0.08, 0.07, and 0.04, respectively. However, these studies included both multirooted and single-rooted teeth, as well as teeth with minimal or no periodontal involvement. Multiple studies have shown that molar teeth are at greatest risk for disease and tooth loss in periodontally involved patients.[18,22,24,33,35] Dannewitz et al.[20] evaluated molars and reported a mean tooth loss rate of 0.06, over a minimum of 5 years of PM, providing evidence that molar teeth can be well maintained in the periodontally compromised patients. The findings confirm their results but over a much longer period of time.

As in any retrospective study, this study has limitations. It is well recognized that DM negatively affects the progression of periodontal disease, yet this factor could not be scored statistically because only two of the 102 patients had a diagnosis of DM at the initial examination.

Over the duration of the study, only two additional patients were diagnosed with DM. This is a puzzling finding given the recent rise in patients diagnosed with DM. This raises an interesting question: "Does controlling periodontal disease, by reducing the overall inflammatory load, play a significant role in preventing the onset of DM?" Although the data did not enable the present authors to score DM, future studies could assign scores based on hemoglobin A1c levels. An example of how hemoglobin A1c levels might be incorporated in a future scoring index could be as follows: 1 = 6.5 to 7.0; 2 = 7.1 to 8.0; 3 = 8.1 to 9.0; and 4 = ≥9.1.

Additionally, this study did not score the severity of furcation involvement, and future research should evaluate this as well as provide more comprehensive data on smoking history (e.g., amount, duration, and impact of cessation). Finally, for completeness, all teeth need to be scored, not just molars.

Because of the present impressive long-term results, clinicians might ask the following: "What type of periodontal treatment was rendered?" As a treatment philosophy, any non-mobile molar, regardless of PD or multiple furcation involvement, was treated. This could account for the low percentage (3.9%) of molars extracted during active treatment. Because the mean PD (6.7 mm) exceeded the depth of effective scaling and root planing (SRP) (5 mm), surgery was done on most molars[45,46] with emphasis on

thorough SRP. Conservative osseous surgery was done to remove thickened bone and to enhance flap adaptation. Before suturing, the roots were briefly scrubbed with a cotton pledget soaked in saturated citric acid to further decontaminate the root surface. Flaps were sutured (4-0 chromic gut) and positioned to cover the bone at the osseous crest or positioned slightly coronally. A periodontal dressing was placed with emphasis on obliterating the interproximal space to help prevent tissue proliferation during primary healing. No attempt was made to obtain a highly scalloped osseous architecture.

Later, when freeze-dried bone allograft became available, osseous graft material was placed in craters; even later, strips of polyglactin 910 tight-weave woven mesh[§] were placed under the flap and over the bone graft material in the interproximal space to stabilize the clot and prevent loss of the graft material. This procedure could be considered an early attempt at excluding epithelium and enhancing regeneration, i.e., a precursor to guided bone regeneration.[47]

Greenstein et al.[48] concluded that an individual can have periodontal stability around compromised molars despite less than ideal PDs. They referred to this as "clinical periodontal health." In this scenario, PDs remain stable over time, with no additional bone loss or AL. Based on a meta-analysis of the literature, they found that bleeding on probing (BOP) was a poor forecaster of disease activity and was not a reliable indicator of the demise of teeth. Nevertheless, the absence of BOP is an excellent predictor of no future AL.

In this study, 79.4% of surviving molars had a PD ≤5 mm, and 92% of those survived in periodontal health.[31] Currently, the treatment of teeth with continued AL is easier and more predictable than treating peri-implantitis on a failing implant, which is a reason for maintaining periodontally healthy but compromised teeth. In this study, when increasing PDs are noted, these areas are generally treated with SRP or by localized gingivectomy using radiosurgery,[‖] especially on the palatal interproximal aspects of maxillary molars.

Within the parameters of this study, it is proposed that a more accurate periodontal prognosis can be determined provided the following criteria are met by the patient: 1) complete the recommended periodontal therapy; 2) follow the recommended maintenance regimen; 3) practice adequate daily plaque removal; and 4) refrain from smoking. Although smoking cessation is desired, even a marked reduction in smoking should improve the prognosis. Although DM was not a scored factor, control of blood sugar in patients with DM must be a considered criterion.

Finally, active treatment for all patients in this study was completed by the end of 1994 before newer regenerative products and materials were available. As periodontal regenerative techniques evolve, the prognosis for all teeth, not only molars, will improve.[49] This alone places a greater emphasis on conveying a more accurate prognosis to the patient.

CONCLUSIONS

In the present study, 78.3% of the molars treated were never extracted and survived for an average of 24.2 years. They had an initial prognosis score of 4.32. Molars extracted during active treatment (3.9%) had a score of 8.34, whereas molars extracted during preventive maintenance (17.7%) had an initial score of 6.54 and were maintained on average for 15.4 years before they were extracted. Periodontal health, not simply retention of teeth, should be the goal of periodontal therapy. Although 78.3% of molars survived, it is important to note that 92% of those survived in periodontal health.

The authors' statistically derived prognosis scoring index allows clinicians and their patients to make more informed prognostic assessments of periodontally compromised molars. This should substantially improve treatment planning decisions and increase the number of patients accepting periodontal treatment. Of all the prognostic factors evaluated, smoking had the most negative impact (246% greater chance of losing their teeth), far exceeding the impact of PD, mobility, or furcation involvement. Molar type had a lesser impact, and age had the least impact. Finally, treating moderate-to-severe periodontal disease can result in an excellent long-term prognosis regardless of the patient's age.

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‖ Dento-Surg 90, Ellman International, Oceanside, NY.

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