Evaluation of periodontally diseased molars in diabetics with Miller–McEntire Periodontal Prognostic Index

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Abstract:
Aim and Objective: The aim of this study was to prospectively determine and establish the periodontal prognosis of diseased molars in diabetic patients using the Miller–McEntire Periodontal Prognostic Index (MMPPI) with an additional criterion for diabetes (changes in glycosylated hemoglobin levels), at 2-year postperiodontal therapy. Materials and Methods: A sample of 200 molars in 25 patients with diabetes mellitus (DM) and chronic periodontitis were evaluated. The prognostic parameters evaluated include age, probing depth (PD), mobility, furcation involvement, diabetes, and molar type. The total score calculated from all parameters was used considered prognosis score for each molar. All patients were evaluated at baseline and 2-year posttreatment. Results: The results of this study suggest that following prognostic factors, DM (hazard ratio [HR] = 5.2), age (HR = 0.4), and molar type (HR = 0.6) were clinically significant at the end of the 2-year posttherapy from baseline. A total of 4 (2%) teeth were extracted from the 200 teeth with a mean of 0.02 for the tooth lost during 2-year posttreatment. Significant improvements (P < 0.05) in the frequency PD, furcation, and mobility scores were noted at 2 years. Conclusions: These findings demonstrate that score for DM as prognostic criterion is a valid addition to MMPPI. The factors such as DM, age, and molar type can impact the prognosis of molar survival. Studies with a larger sample size and longer follow-up are required to affirm the findings of this preliminary study.

Key words: Diabetes, periodontitis, prognosis

INTRODUCTION

Optimal management of periodontally diseased molar requires precise and reliable means to assess their prognosis. The association between periodontal disease and diabetes mellitus (DM) is well documented.1 Studies suggest that there is a link between DM, tooth loss, and periodontal prognosis.2,3 DM can be controlled by lifestyle intervention, education, self-monitoring, and self-management by the patient under a physician’s care.4 Among various prognostic factors, local site-related factors such as probing depth (PD), mobility, and furcation involvement may be controlled by periodontal therapy, but patient-level factors such as plaque control, smoking, and DM cannot. Of course, age and molar type, which impact prognosis, cannot be changed. It follows that the reliable assignment of periodontal prognosis for periodontally diseased molars necessitates inclusion of a statistically validated score for diabetes.

A review of the existing literature found that the scoring index presented by Miller et al.5 Miller–McEntire Periodontal Prognostic Index (MMPPI) is the only quantitative and objective periodontal prognostic index for molar teeth. Not only is the scoring index reliable, valid, and accurate but the patient also can easily understand it. In the retrospective study conducted by Miller et al.,6 six prognostic factors were statistically evaluated (age, molar 38 type, smoking, probing depth, furcation involvement, and mobility) although DM was also planned to be scored. As the number of patients in the retrospective sample with DM was only 2, the statistical impact of DM as component of the prognostic index could not be determined.

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Therefore, the aim of this study was to prospectively determine and establish the periodontal prognosis of diseased molars in diabetic patients using the Miller–McEntire Periodontal Prognostic Index (MMPPI) with an additional criterion for diabetes (changes in glycosylated hemoglobin [HbA1c] levels), at 2-year postperiodontal therapy and determine the hazard ratios (HRs) for each studied prognostic criterion at 2-year postperiodontal therapy.

MATERIALS AND METHODS

A prospective cohort study was conducted with 25 patients (13 males and 12 females) with 200 teeth for 2 years. Ethics Committee approval for the study was obtained from the Dr. D.Y. Patil Vidyapeeth Ethics Committee. The participants were recruited from the Department of Periodontology, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth, Pune and scored. The total study duration ranged from June 2014 to August 2016 with a recruitment period of 2 months ranging from June 2014 to August 2014.

The sample size of 200 teeth with 95% confidence interval was calculated using the data from the previous literature and using the reported HR to calculate the sample size. Patients with DM and moderate-to-severe chronic periodontitis were screened for the study. The following inclusion criteria were considered: all first and second molars present at the initial examination, a diagnosis of moderate (clinical attachment loss = 3–4 mm) to severe (clinical attachment loss of ≥5 mm) chronic periodontitis in accordance with the currently accepted diagnostic criteria, and a concomitant diagnosis of DM and treated with metformin (250 mg a day) therapy for a period of at least 6 months. The exclusion criteria were as follows: molars with restorations, endodontically treated molars, and patients with dental prosthesis and prosthodontic abutments. Only first and second molars were considered for the study. Patients who fulfilled the study criteria were enrolled in the study. Sampling was continued until the desired sample size was reached. Verbal and written informed consent was obtained from all the selected patients.

On inclusion, HbA1c level was determined for all patients using the Miller–McEntire Periodontal Prognostic Index (MMPPI) with an additional criterion for diabetes (changes in glycosylated hemoglobin [HbA1c] levels), at 2-year postperiodontal therapy and determine the hazard ratios (HRs) for each studied prognostic criterion at 2-year postperiodontal therapy.

On inclusion, HbA1c level was determined for all patients in a single laboratory, using a high-performance liquid chromatography laboratory test compliant with the National Glycohemoglobin Standardization Program (D-10 HbA1cTM, Bio-Rad Laboratories, Germany). The MMPPI was calculated by scoring for seven prognostic criteria, namely, age, smoking, diabetes, molar type, PD, furcation involvement, and mobility.

The scoring for each criterion was as follows:
1. Age of <40 years = score 0; age of 40 years and above = 1[4]
2. Smoking: Here, nonsmokers were scored as 0; occasional smokers were scored as 1; smoking of half-pack/day was scored as 2; smoking 1 pack/day was scored as 3; and smoking more than 1 pack/day was scored as 4[4]
3. DM was scored based on HbA1c level thresholds[5]
   1. >6.0 (0)
   2. 6.0–7.0 (1)
   3. 7.1–8.0 (2)
   4. 8.1–9.0 (3)
   5. 9.1+ (4)
4. Molar type: Mandibular first and second molars were scored as 0; maxillary first molars were scored as 1; and maxillary second molars were scored as 2[4]
5. PD: The average of six probing sites on a molar was determined. An average PD of <5 mm was scored as 0; PD of 5–7 mm was scored as 1; PD of 8–10 mm was scored as 2; and PD of >10 mm was scored as 3[4]
6. Furcation involvement: Only the presence of a furcation involvement was used for scoring and severity was not taken into account. No furcation involvement was scored as 0; a single furcation involved was scored as 1; two furcations involved were scored as 2; and three furcations involved or through-and-through furcation involvement on mandibular molars was scored as 3[4]
7. Mobility: The simplified mobility classification reported by Miller et al. was used, where Class I mobility indicated a clinically mobile tooth where the clinician’s judgment was that mobility did not impact prognosis, Class II indicated a tooth that was mobile and was clinically adjudged as affecting prognosis, and Class III mobile indicated which may be considered hopeless but has potential for treatment and maintenance. In case of an unclear decision between two classes of mobility, the higher classed was assigned for scoring. Thus, the scoring criteria were as follows: no mobility was scored as 0; Class I mobility was scored as 1; Class II mobility was scored as 2; and Class III mobility was scored as 3[4]

The sum of these scores was considered as the MMPPI score for each tooth. Scoring was conducted during the initial examination and again at 2-year posttreatment by a single examiner (D.G) to avoid interexaminer bias. For all patients, once the baseline assessment was complete, active periodontal therapy was initiated. Patients were treated with scaling and root planing along with local drug delivery (Metronidazole GelTM), and as this study concerned diabetic patients, primary treatment was restricted to nonsurgical periodontal therapy. In addition, all patients were provided with supportive periodontal therapy at 6 monthly intervals which comprised oral hygiene reinforcement, professional scaling and polishing, and subgingival debridement of sites with persisting periodontal pockets. However, if residual periodontal pockets persisted at the end of the 2-year study, surgical periodontal therapy was considered for those patients presenting with sufficient glycemic control for surgical intervention.

For statistical analysis, first, the normality of the data distribution was assessed. Descriptive statistics and frequency distribution were carried out for all variables. Pearson’s Chi-square test was used to test for significance of difference between baseline and 2-year scores for each MMPPI component and total MMPPI scores. Cox proportional hazard model was applied to calculate the HRs for individual MMPPI components and the total MMPPI score. For this HR analysis, the baseline scores for the documented prognostic factors were each considered as independent predictors, with molar survival at the end of 2 years as the outcome. All analyses were carried out using MS Excel 2013 and IBM SPSS software version 20, Armonk, NY, United States of America.

RESULTS

A total of 200 teeth from 25 participants were assessed over a period of 2 years. Among these, there were 13 females and
12 males. All 25 patients reported at the 2-year follow-up and a total of four molar teeth were extracted. Thus, out of the 200 molars included, 196 molar teeth survived at 2 years. The baseline and 2-year characteristics of the participants are described in Table 1. Among the participants, 22 participants were above the age of 40 years (176 teeth) and the three were below 40 years of age (24 teeth). None of the included participants were smokers; therefore, this variable was excluded from further analysis. At the baseline, 100% (25 participants) of the study participants reported having DM score ≥1, and at the end of the 2 years, only 12% (three participants) reported with DM score ≥1. Thus, the majority

| Prognostic parameter | Baseline (25 participants/200 teeth) | 2 years - frequency (25 participants/196 teeth) | \( \chi^2 \) statistic, \( P \) |
|----------------------|--------------------------------------|-----------------------------------------------|-------------------|
| Age (year)           |                                      |                                               | 0, 1              |
| <40                  | 0: 3 participants (24 teeth)         | 0: 3 participants (24 teeth)                  |                  |
| >40                  | 1: 22 participants (176 teeth)       | 1: 18 participants (172 teeth)                |                  |
| PD (mm)              |                                      |                                               | 122.88, <0.001    |
| <5                   | 106 teeth                           | 196 teeth                                      |                  |
| 5-7                  | 78 teeth                            | 0 teeth                                       |                  |
| 8-10                 | 15 teeth                            | 0 teeth                                       |                  |
| >10                  | 1 tooth                             | 0 teeth                                       |                  |
| Mobility             |                                      |                                               | 61.47, <0.001     |
| Class I              | 145 teeth                           | 196 teeth                                      |                  |
| Class II             | 55 teeth                            | 0 teeth                                       |                  |
| Class III            | 0 teeth                             | 0 teeth                                       |                  |
| Smokers              |                                      |                                               |                  |
| Score 0              | 25 participants (200 teeth)         | 21 participants (196 teeth)                   | 0, 1              |
| Score 1              | 0 participants                      | 0 participants                                |                  |
| Score 2              | 0 participants                      | 0 participants                                |                  |
| Score 3              | 0 participants                      | 0 participants                                |                  |
| Score 4              | 0 participants                      | 0 participants                                |                  |
| Diabetes             |                                      |                                               |                  |
| Score 0              | 0 participants                      | 22 participants (24 teeth)                     | 378.66, <0.001    |
| Score 1              | 2 participants (16 teeth)            | 1 participant (8 teeth)                       |                  |
| Score 2              | 3 participants (24 teeth)            | 0 participants (0 teeth)                      |                  |
| Score 3              | 20 participants (160 teeth)          | 0 participants (0 teeth)                      |                  |
| Score 4              | 0 participants                      | 0 participants (0 teeth)                      |                  |
| Furcation            |                                      |                                               |                  |
| Score 0              | 181 teeth                           | 196 teeth                                      | 17.90, <0.001     |
| Score 1              | 19 teeth                            | 0 teeth                                       |                  |
| Score 2              | 0 teeth                             | 0 teeth                                       |                  |
| Score 3              | 0 teeth                             | 0 teeth                                       |                  |
| Molar type           |                                      |                                               |                  |
| Score 0              | 100 teeth                           | 98 teeth                                      | 0, 1              |
| Score 1              | 50 teeth                            | 48 teeth                                      |                  |
| Score 2              | 50 teeth                            | 50 teeth                                      |                  |

\( P \) value is significant at <0.05. PD – Probing depth; \( P \) – Probability Value

Table 1: Distribution of prognostic parameter and modified Miller-McEntire Periodontal Prognostic Index scores at baseline and 2 years

| Prognostic parameter | Baseline (25 participants/200 teeth) | 2 years - frequency (25 participants/196 teeth) | \( \chi^2 \) statistic, \( P \) |
|----------------------|--------------------------------------|-----------------------------------------------|-------------------|
| Total Miller-McEntire Score | 0                                     | 4                          | 11.53, 0.32 |
|                      | 1                                     | 95                          |                  |
|                      | 2                                     | 48                          |                  |
|                      | 3                                     | 49                          |                  |
|                      | 4                                     | 21                          |                  |
|                      | 5                                     | 46                          |                  |
|                      | 6                                     | 35                          |                  |
|                      | 7                                     | 72                          |                  |
|                      | 8                                     | 10                          |                  |
|                      | 9                                     | 06                          |                  |
|                      | 10                                    | 0                           |                  |
|                      | 11                                    | 0                           |                  |
|                      | 12                                    | 0                           |                  |
|                      | 13                                    | 0                           |                  |
|                      | 14                                    | 0                           |                  |
|                      | 15                                    | 0                           |                  |
|                      | 16                                    | 0                           |                  |
|                      | 17                                    | 0                           |                  |
|                      | 18                                    | 0                           |                  |
|                      | 19                                    | 0                           |                  |
|                      | 20                                    | 0                           |                  |

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of the study participants were able to control DM at the end of 2 years. In addition, at the end of 2 years, 100% of participants showed PD scores of 0, furcation scores of 0, and mobility scores of 0 [Table 1]. The average Miller–McEntire Scores at the end of 2 years for the individual score is $1.72 \pm 0.85$. Although the overall distribution of scores did not show significant difference at 2 years [Table 1], the comparison of baseline and 2-year data showed significant improvement in PD, mobility, diabetes, and furcation score components. However, age and molar type did not show any significant difference as expected. A total of four teeth (2%) were extracted out of 200 teeth included in the study during posttherapy maintenance phase before scoring at the end of 2 years. The mean number of teeth lost for 2 years was 0.02. A Cox proportional hazard model was applied to assess the HR at the end of 2 years [Table 2].

The HR for prognostic factors in the MMPPI assessed was age (0.4), molar type (0.6), diabetes (5.2), PD (1.51), furcation involvement (3.30), and mobility (1.30).

DISCUSSION

DM is both a risk and prognostic factor for periodontal disease.\(^1\)\(^2\) Considering the substantial burden of this condition in the population and the well-established dose-response relationship between the level of diabetic control and the periodontal disease process, it is imperative that a comprehensive periodontal prognostic index must incorporate diabetes as a criterion.

The Cox proportional hazards model was used to evaluate the impact of the prognostic factors analyzed in the present study.\(^1\)\(^4\) It was found that DM had a HR of 5.2, which implies a 5 times higher risk of molar loss in DM. Despite being statistically insignificant, this finding may be of clinical significance. It may be interpreted as a nonsignificant rise in hazard after accounting for other prognostic factors in the current data. A plausible reason for this finding could be the achievement of good overall diabetic control in the cohort at the end of the 2-year study period.

Among the 25 patients who were enrolled in the study, only 3 patients (12%) had DM at the end of 2-year posttherapy. Thus, a majority of the patients (88%) obtained good DM control. All the patients were treated with scaling and root planing with local drug delivery (Metrogyl™ DG Gel). One reason attributed to the change in DM control could be the impact of adequate periodontal therapy that eliminated periodontal infection and reduced inflammation. Such improvement in periodontal inflammatory burden is documented as positively influencing diabetic control.\(^7\)\(^1\)\(^1\)\(^1\) In addition, the other possible reasons that may be attributed to control of DM include lifestyle intervention, self-monitoring, and self-management by the patient.\(^1\)\(^8\)

The current study given that 22 out of the 25 patients were above 40 years of age and only three patients were below the age 40. The HR of 0.4 though statistically insignificant showed an opposing trend to that noted in the study by Miller et al.,\(^1\)\(^1\)\(^1\) where the HR for age was 1.27. This finding may be interpreted that the hazard rate was 2.5 times lower in the age group of above 40 years as compared to those below 40 years. In general, among patients with similar disease severity, periodontal prognosis tends to be worse for younger patients. Thus, these data suggest that younger aged patients with periodontal disease may be at greater risk for loss of molars if these are not treated appropriately. This finding was also in contrast to the findings of the study by Fardal et al. (odds ratio = 4.02).\(^1\)\(^2\)\(^2\) Although similar to the present study, age did not emerge as a significant factor noted by Miller et al.\(^1\)\(^1\)\(^1\) and several other studies,\(^1\)\(^1\)\(^3\)\(^-\)\(^1\)\(^6\) the noted trend suggests that age impacts the periodontal prognosis of molars and needs to be validated in larger samples.

In the current study, the HR for the molar type was 0.6. This finding seems to imply that mandibular molars had higher risk for loss than maxillary, which is in contrast to that noted Miller et al.,\(^1\)\(^4\) who found this value to be 1.20 indicating slightly higher risk for maxillary molar loss. However, this finding possibly reflects that although molar type as a factor plays a role in determining the prognosis of molar survival, such an impact may be subject to several other factors such as adequate therapy, maintenance care, and disease severity. A total of 4 (2%) teeth were extracted out of 200 teeth included in the study during posttherapy maintenance phase before scoring at the end of 2 years. The mean number of teeth lost for 2 years is 0.02. This finding is comparable with that noted by Miller et al.\(^1\)\(^4\) who found a mean annual tooth loss of 1.7 molars.

One feature of this cohort is that none of the selected participants were smokers despite there being no attempt to exclude smokers. A plausible reason may be the nature of the particular demographic included in the current study. The overall prevalence of ever-smokers in India was shown to be low at 15.6% in a large-scale epidemiologic study and even lower in females (2.1%).\(^1\)\(^7\) Considering the fact that out of 25 participants enrolled in this study and 52% (13 out 25) being females, it is plausible that no smokers were encountered for inclusion in this current cohort of diabetic participants. Therefore, the effect of smoking could not be addressed as a prognostic factor in the current cohort. Moreover, the primary line of treatment was scaling and root planing with adjunctive local drug delivery. The choice to restrict to nonsurgical therapy for the period of prospective observation was made owing to the fact that it was anticipated that uncontrolled diabetes could have precluded surgical therapy in a subset of the patients. Therefore, to standardize the treatment approach for the cohort, nonsurgical therapy with rigorous supportive therapy was applied and surgical approach was deferred until after the 2-year follow-up period.

| Prognostic factor         | Parameter estimate | SE   | P  | HR  | 95% CIs of HR       |
|---------------------------|--------------------|------|----|-----|---------------------|
| Diabetes                  | 1.66               | 1.00 | 0.01 | 5.25 | 0.74-37.27          |
| Age                       | -0.89              | 1.16 | 0.44 | 0.41 | 0.04-3.93           |
| Molar type                | -0.41              | 0.68 | 0.55 | 0.67 | 0.18-2.54           |
| Probing depth             | 0.41               | 0.69 | 0.66 | 1.51 | 0.39-5.79           |
| Mobility                  | -0.19              | 0.14 | 0.99 | 3.30 | 0.399-30.3          |
| Furcation involvement     | -1.82              | 1.35 | 0.99 | 1.30 | 0.13-77.08          |

*P* value is significant at<0.05. SE – Standard error; CIs – Confidence intervals; HR – Hazard ratio; *P* – Probability Value
Similar to diabetes, the factors such as PD, furcation, and mobility are time dependent and showed significant and continued improvement on therapy over the course of the study. Miller et al. [16] had large sampled retrospective design that enabled the analysis of these factors as fixed covariates. Therapeutic success led the scores from the above factors to decline at the end of 2-year posttreatment when compared to that at baseline. This finding is also likely to reflect the influence of supportive periodontal therapy, a key factor in maintaining periodontal health. [10–20] For these site-level factors, PD, mobility, and furcation involvement are time dependent and values changed on successful therapy. To understand how these impact prognosis, the HRs of baseline values were analyzed. Among the site-level factors, the baseline values predicted higher HRs for tooth mobility (3.30). Lower but positive (>1) HRs were noted for PD (1.51) and furcation involvement (1.30). This pattern was similar to that noted by Miller et al. [16] in the retrospective study. Thus, based on the current findings, it may be suggested that baseline mobility is likely to worsen the prognosis of periodontally diseased molars in spite of treatment. The current cohort included patients with Class I and Class II mobility and none with mobile teeth graded as hopeless (Class III). It is likely prognostic value of mobility may be even higher when Class III mobile molars are included.

The findings of this study need to be viewed in light of several inherent limitations. The cohort under study was small and did not include any smokers, which is a significant limitation. In addition, there were no participants with the highest levels of the factors such as mobility score, furcation score, and diabetes score. As high scores for these factors would represent the most severe end of the spectrum of periodontal disease, the lack of individuals may restrict the generalizability of the results as the absence of such teeth could limit the extrapolation of the noted HRs noted in the current study to such situations. Another limitation is that earlier application of surgical therapy in well-controlled diabetics potentially may have led to further improvement of the MMPPI scores. However, such an approach was not used as differential treatment would have been a possible confounding factor in a small sample size. Future studies with large sample size are essential to validate the MMPPI index while considering different therapeutic modalities as covariates. The short follow-up duration is another limitation in understanding the prognostic value of the MMPPI with added criterion for diabetes over longer periods. The restriction of patients with standardized drug regimen for the management of diabetes in this small cohort can preclude an understanding of the exact HRs posed on unmedicated and poorly managed levels of diabetes (HbA1c levels of >9.1). Further studies must be designed with more representative, robust samples and longer durations.

**CONCLUSIONS**

Our findings provide preliminary evidence that the addition of a score for DM in the MMPPI is valid for the assessment of prognosis of periodontally diseased molars when taking into account other prognostic factors (age, molar type, PD, furcation involvement, and mobility) with the exception of smoking which could not be addressed. For validation of these findings, additional research utilizing larger sample sizes, more representative populations inclusive of smokers, and longer evaluation periods is necessary.

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**Conflicts of interest**
There are no conflicts of interest.

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