Original Article

Quantitative analysis of Miller mobility index for the diagnosis of moderate to severe periodontitis - A cross-sectional study

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Abstract *Background/purpose:* We assessed the mobility of single-root teeth by using Miller's mobility index (MMI) and to analyze the validity of MMI for the diagnosis of periodontitis.

Materials and methods: A total of 30 patients were included and the Spearman correlation coefficient was used to assess the correlation between MMI, clinical attachment level (CAL), and probing depth (PD). The validity of MMI for the diagnosis of the severity of periodontitis was evaluated using the receiver operating characteristic (ROC) curve, area under curve (AUC) value, positive predictive value (PPV).

Results: Strong correlations were observed between MMI and CAL ($r = 0.92$) and between MMI and PD ($r = 0.76$). When the CAL $= 3-4$ mm and CAL ≥ 5 mm groups were pooled together, the AUC value was 0.81. The AUC was 0.86 for diagnosis with MMI in the CAL ≥ 5 mm group. A PPV of 100% was achieved for all grades when MMI >1. When the teeth with PD ≥ 5 to <7 mm and PD ≥ 7 mm groups were pooled together, the AUC value for MMI was 0.80. The PPV was 98.8%, 99%, and 100% for MMI Grade 1, Grade 2, and Grade 3, respectively. When PD ≥ 7 mm was defined as severe periodontitis, the AUC value for MMI was 0.72.

Conclusion: MMI may provide valuable information for the diagnosis of moderate and severe periodontitis when CAL is not obtainable during routine practice.

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Introduction

Periodontitis is an inflammatory reaction caused by bacteria. It can lead to the destruction of the gingiva and connective tissues, and, in particular, alveolar bone loss. If left untreated, it ultimately leads to tooth loss. Increased tooth mobility is a common symptom of severe periodontal disease and is one of the main reasons patients seek consultations at periodontal clinics. A study conducted by Eke on the prevalence of periodontitis in adults aged 30 years and older in the United States demonstrated that in 2009—2012, 46% of adults in the United States, or approximately 64.7 million adults, had periodontitis, with 8.9% of cases being severe.[1] Between 2003 and 2005, Lai conducted a study on residents of Keelung, Taiwan who were aged 35—44 years to assess the prevalence of periodontal disease. The community periodontal index and loss of clinical attachment were used as parameters, and the prevalence of periodontal disease was determined to be 94.8%.[2]

Despite increasing understanding of the reasons for and mechanisms of periodontal disease in recent years, the methods used by dentists to diagnose periodontal disease have not changed. Diagnoses are still largely based on dental X-rays and clinical periodontal parameters such as probing depth (PD), clinical attachment level (CAL), bleeding on probing (BOP), and tooth mobility. Miller's mobility index (MMI) is the most widely accepted method for routine clinical examinations of tooth mobility.[3] The tooth is held between the metallic handles of two instruments and moved in the buccolingual or buccopalatal direction, and the moved distance is visually estimated by the person conducting the examination. Mobility is then classified into Grades 0—3. Although special devices such as periodontometers can be used to obtain quantitative measurements of tooth mobility, the operation of such devices is complicated and time consuming.[4]

In recent years, receiver operating characteristic (ROC) curves have been widely used to diagnose diseases.[5] The true positive rate, which is indicated as sensitivity, is plotted on the y-axis of the ROC curve, and the false positive rate, which is indicated as 1-specificity, is plotted on the x-axis. A 45° diagonal line is used as a reference line for interpreting the ROC curve. The closer the ROC curve is to the upper left corner, the higher the sensitivity of the diagnostic tool toward the disease and the lower the false positive rate, indicating that this diagnostic tool exhibits more efficient discrimination than others.

The purpose of this study was to assess quantitative changes in the mobility of single-rooted anterior tooth by using MMI and to analyze the correlation between mobility and various clinical periodontal parameters. The ROC, area under curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of MMI for the clinical diagnosis of periodontal disease were assessed.

Materials and methods

Patients with no systemic diseases who were visiting the Periodontal Clinic of the Department of Dentistry at Taipei Medical University Hospital for the first time and who had not received previous treatment for periodontal disease at other hospitals or clinics were recruited. The patients were diagnosed as having full-mouth chronic periodontitis, with at least six anterior teeth with mean PD $\geq$ 5 mm in combination with BOP (+), and they received complete nonsurgical periodontal therapy. Patients with a history of AIDS, unstable cardiovascular disease, and uncontrolled diabetes mellitus (HbA1c > 8.0%) were excluded from the study. In addition, pregnant women and people with mental or intellectual disabilities, parafunction of chewing habit, severe malocclusion, and those who received clinical treatment and antibiotic therapy for periodontal disease in the past 6 months were excluded.

This study was approved by the Taipei Medical University Joint Institutional Review Board, and a certificate of approval (No. N201512036) has been issued. All participants were informed of the significance and purpose of the study and signed a consent form.

A total of 30 patients (13 men and 17 women) who had received a diagnosis of moderate to severe periodontitis from April 20, 2016 onwards December 20, 2016 were selected. The clinical periodontal parameters included MMI, CAL, PD, BOP, and plaque index (PI). Six sites for each anterior tooth (tooth #13—23 and #33—43) without obvious fremitus in the position of centric occlusion were measured.

The Williams true pressure-sensitive probe (Pro-Dentec, Arkansas, USA) was used to measure PD and CAL. All examinations were performed by a highly trained dentist (Wu CP), and intraexaminer kappa values for PD and CAL measurements were evaluated before the investigation.

According to the American Academy of Periodontology (AAP) 2015 Task Force Report, BOP (+), PD, and CAL measurements are necessary for the classification of mild, moderate, and severe periodontitis. CAL = 3—4 mm or PD $\geq$ 5 to <7 mm were defined as moderate periodontitis and CAL $\geq$5 mm or PD $\geq$ 7 mm were defined as severe periodontitis.[6]

Griner et al. revealed that statistical validation of a potentially useful diagnostic test involved the use of a 2 × 2 decision matrix.[7] Accordingly, the use of ROC, AUC, sensitivity, specificity, PPV, and NPV of MMI as diagnostic tools for periodontal disease were assessed. Spearman correlation coefficient was used to assess the correlation between MMI, CAL and PD. Statistical analysis was performed using SPSS version 19.0 (SPSS Inc., Chicago, USA). The level of significance was set at p < 0.05.

Results

The intraexaminer kappa values for PD and CAL were 0.93 and 0.88, respectively. Table 1 presents the baseline characteristics of all participants. A total of 30 patients (13 men and 17 women) with a mean age of 60.45 years and 338 teeth (152 belonging to men, 186 belonging to women) were included in this study.

The correlations between MMI and various clinical periodontal parameters for different gender groups are presented in Table 2. A strong correlation was observed between MMI and CAL (r = 0.92) and between MMI and PD (r = 0.76).

Table 1 Basic data in gender.

	Total	Male	Female
Person number	30	13	17
Tooth number	338	152	186
Mean age (years)	60.45	59.68	61.03
Age range (years)	46—70	46—70	46—70

Table 2 Correlation between MMI and other parameters in gender.

	30 Subjects		13 Male		17 Female	
	correlation	r	correlation	r	correlation	r
MMI/CAL	high	0.92	high	0.94	high	0.91
MMI/PD	high	0.76	high	0.82	high	0.71
MMI/PI	medium	0.31	low	0.20	medium	0.36
MMI/BOP	medium	0.35	medium	0.39	medium	0.33

MMI = Miller's mobility index.
CAL = clinical attachment level.
PD = probing depth.
BOP = bleeding on probing.

Table 3 presents the numbers and percentages of teeth classified as having mild, moderate, and severe periodontitis among the gender groups, on the basis of various definitions of periodontitis. According to the definition of severe periodontitis as CAL $\geq$5 mm, of 338 teeth, 79.29% were classified as having severe periodontitis. According to the definition of severe periodontitis as PD $\geq$7 mm, only 12.42% of teeth were classified as having severe periodontitis.

When we pooled the teeth with CAL = 3—4 mm and CAL $\geq$5 mm as the moderate to severe group, the ROC curve for MMI grades was obtained as shown in Fig. 1a. The curve was situated in the upper left region of the diagonal line. The AUC value was 0.81. The true positive rate was higher than the false positive rate, which indicates that MMI has an excellent discriminating power in the diagnosis of moderate to severe periodontitis. The optimal cutoff point was

MMI Grade 1. The sensitivity was 62.2% and the specificity was 100%.

When CAL $\geq$5 mm was used to define severe periodontitis, the ROC curve for MMI grades was obtained as shown in Fig. 1b. The curve was situated in the upper left region of the diagonal line. The AUC value was 0.86, which indicates that MMI has an excellent discriminating power in the diagnosis of this disease. The optimal cutoff point was MMI Grade 2. The sensitivity was 72.15% and the specificity was 97.14%.

When we pooled the teeth with PD $\geq$ 5 to <7 mm and PD $\geq$ 7 mm as the moderate to severe group, the ROC curve for MMI grades was obtained as shown in Fig. 1c. The curve was situated in the upper left region of the diagonal line. The AUC value was 0.80, which indicates that MMI has excellent discriminating power in the diagnosis of this disease. The optimal cutoff point was MMI Grade 1, and the sensitivity and specificity were 73.5% and 79%, respectively. When PD $\geq$ 7 mm was used to define severe periodontitis, the ROC curve for MMI grades was obtained as shown in Fig. 1d. The curve was situated in the upper left region of the diagonal line. The AUC value was 0.72, which indicates that MMI has acceptable discriminating potential in the diagnosis of this disease. The optimal cutoff point was MMI Grade 2, and the sensitivity and specificity were 61.23% and 80.46%, respectively.

Fig. 2a presents the PPV and NPV of the disease for each MMI grade when we pooled CAL = 3—4 mm and CAL $\geq$5 mm teeth as the moderate to severe periodontitis group. When the MMI was greater than Grade 1, a PPV of 100% was achieved for all grades.

Fig. 2b presents the PPV and NPV of the disease for each MMI grade when we pooled the teeth with PD $\geq$ 5 to <7 mm and PD $\geq$ 7 mm together. The PPV was 98.8%, 99%, and 100% for MMI Grades 1, 2, and 3, respectively.

Discussion

The correlation between MMI and other periodontal parameters has rarely been investigated. Our results indicate that MMI is strongly correlated with CAL and PD. Moreover, a moderate correlation was observed between MMI, BOP, and PI.

Table 3 Teeth numbers and percentage of various severities on different definition of AAP 2015 Task Force Report in gender.

	Total		Male		Female	
	numbers	%	Numbers	%	Numbers	%
Mild P.						
CAL 1—2 mm	10	2.95%	2	1.3%	8	4.3%
PD > 3 to <5 mm	36	10.65%	15	9.87%	21	11.29%
Moderate P.						
CAL 3—4 mm	60	17.75%	29	19%	31	16.67%
PD $\geq$5 to <7 mm	207	61.24%	83	54.6%	124	66.67%
Severe P.						
CAL $\geq$5 mm	268	79.29%	121	79.61%	39	79.03%
PD $\geq$7 mm	42	12.42%	30	19.74%	12	6.45%

Mild P. = mild periodontitis.
Moderate P. = moderate periodontitis.
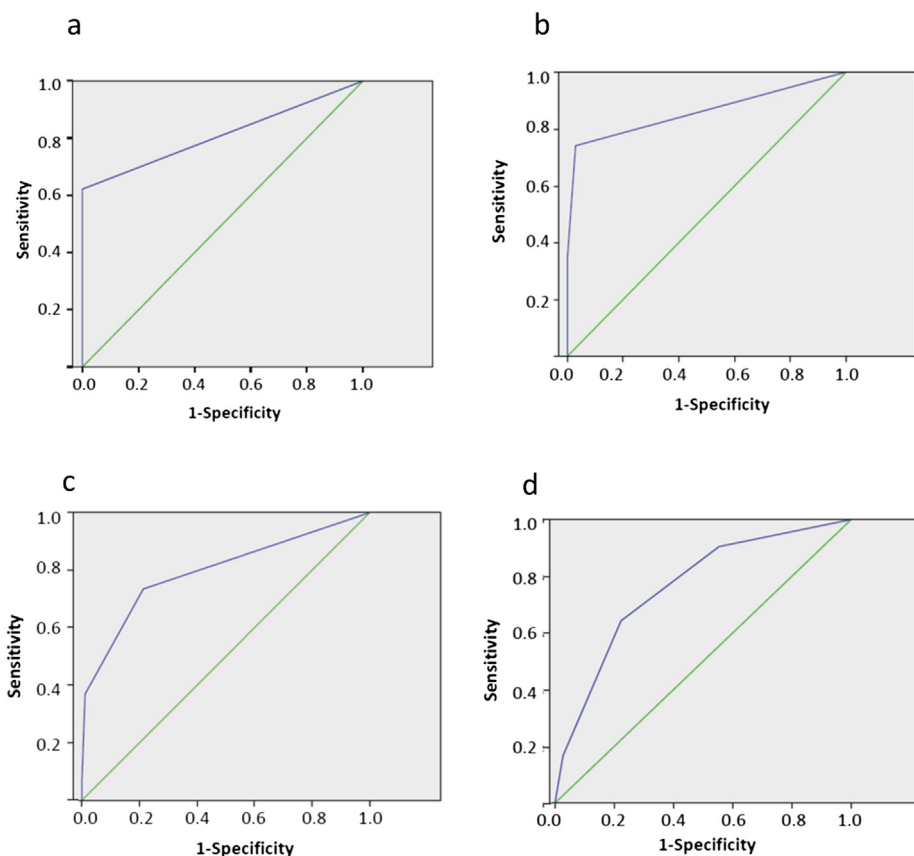Severe P. = severe periodontitis.

Figure 1 (a) ROC curves of MMI based on the definitions of CAL = 3—4 mm (moderate group) and CAL $\geq$ 5 mm (severe group) pooled together, (b) CAL $\geq$ 5 mm (severe periodontitis), (c) PD $\geq$ 5 to <7 mm (moderate group) and PD $\geq$ 7 mm (severe group) pooled together, and (d) PD $\geq$ 7 mm (severe periodontitis).
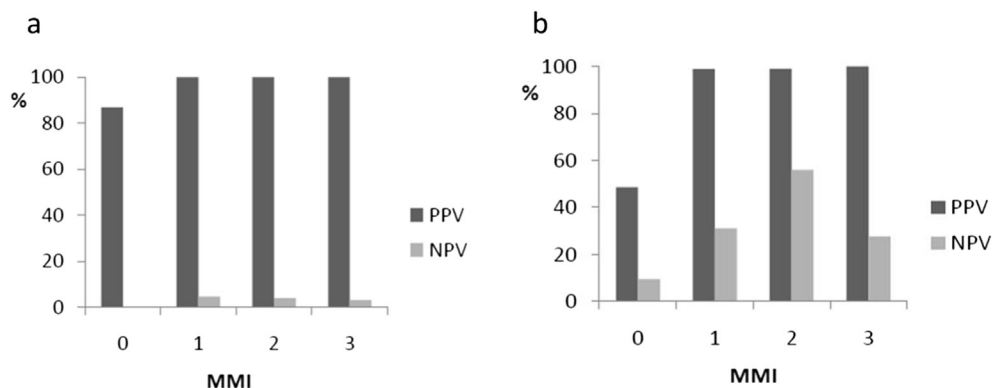

Figure 2 PPV and NPV of MMI based on the definitions of (a) pooled CAL = 3—4 mm and CAL $\geq$ 5 mm groups and (b) pooled PD $\geq$ 5 to <7 mm and PD $\geq$ 7 mm groups.

In 1959, Ramfjord stated that to record the progress and behavior of periodontal disease through longitudinal studies or to obtain a basis for the evaluation of various periodontal treatments, clinicians require an index that is defined as the distance from the cementum—enamel junction (CEJ) to the bottom of the periodontal pocket.[8] At the 1999 International Workshop for a Classification of Periodontal Disease and Conditions, CAL was used to define and categorize the severity of periodontitis.[9] However, according to the AAP 2015 Task Force Report, CAL measurement has proven

to be challenging during routine clinical practice.[6] The difficulty in identifying the CEJ can be attributed to the following reasons: the swelling of the gingival margin above the CEJ, covering of the prostheses margin, and disappearance of the CEJ because of toothbrush abrasion, all of which hinder CAL measurement. Therefore, most general practitioners measure only PD and may face difficulties in recording CAL. According to the results of our study (Table 3), the percentage of total teeth categorized as having severe periodontitis (CAL $\geq$ 5 mm) was 79.29%; however,

that of total anterior teeth categorized as having severe periodontitis on the basis of PD $\geq$ 7 mm was 12.42%. Similar results were obtained when categorizing teeth with moderate periodontitis (17.75% vs. 61.24%). Clearly, various definitions of periodontitis make it difficult to compare data with diverse clinical severities. The AAP 2015 Task Force Report summarized the recommended guidelines for determining the severity of periodontitis, and indicated that PD is prevailingly used for the cross-sectional diagnosis of periodontitis.[6] When we pooled the teeth with PD $\geq$ 5 to <7 mm and PD $\geq$ 7 mm as the moderate to severe group and analyzed the total ROC curve, the PPV was 100% for MMI Grades 1–3 (see Figure 2b). In addition, when we pooled CAL 3–4 mm and CAL $\geq$5 mm as the moderate to severe group (Figure 2a), the PPV for MMI Grade 1 was 99% and that for MMI Grades 2 and 3 was 100%. Clearly, MMI is an eligible tool for the diagnosis of moderate to severe periodontitis and can be easily used for clinical measurements when a large difference exists between PD and CAL, or when the CAL is not obtainable in routine practice. From the results of the present single-root teeth study, we suggest that MMI grade can be used as one of the guidelines for determining moderate to severe periodontitis.

Although the MMI classification method may be too simplistic and lack objectivity, a study conducted by Stoller in 1980 indicated that clinicians may be capable of using it to discriminate mobility in the 0.1-mm range.[10] However, the results of the cross-sectional study must be interpreted with caution. We calculated MMI, PD, and CAL at the tooth level because the rating measurement of MMI on each single tooth was necessary. Patient-level assessment requires a larger sample size and is more difficult for the interpretation of the relation between ordinal MMI and variable periodontal parameters. The design of the cross-sectional study intended to reflect the diagnostic value of MMI during diseased status. A longitudinal comparison, including the influence of periodontal treatment, between MMI and mechanical measurement devise will be executed in the next study. In conclusion, we suggest that MMI can be used as an analog for translating CAL and PD in patients with moderate to severe periodontitis. The ease of clinical operation and the ability to diagnose moderate and severe periodontitis renders MMI suitable for routine periodontal examinations.

Authorship and conflicts of interest statement

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