An Evaluation of Clinical Tooth Mobility Measurements

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IN ORDER TO make a diagnosis, formulate a comprehensive treatment plan, and objectively evaluate the results of periodontal therapy over long periods of time, accurate and complete documentation is necessary. The more objective the methods we use to evaluate the periodontium the more meaningful our observations become, both to ourselves and to others who may need to rely on our documentation.

Tooth mobility is one parameter which we use to evaluate the status of the periodontium. There are extremely accurate methods available for assessing the horizontal mobility of teeth;¹ ² ³ however, these methods are either too time consuming, too cumbersome and/or too costly for routine clinical use. There are several methods which have been suggested for use by the clinician to assess tooth mobility;⁴ ⁵ ⁶ ⁷ ⁸ ⁹ however, these methods seem to be rather subjective in their approach. Perhaps the most widely used of these methods was suggested by Miller in 1938.⁶ He suggested the following scoring system:

1 = "the first distinguishable sign of movement greater than normal".
2 = "a movement of the tooth which allows the crown to move one millimeter from its normal position in any direction."
3 = "allows the tooth to move more than one millimeter in any direction. Teeth which may be rotated or depressed in their alveoli are classified as mobility #3."

It is the purpose of this study to evaluate the reliability of a clinical method of tooth mobility assessment with respect to its reproducibility and its usefulness in quantifying tooth mobility. The method to be evaluated is based on a modification of the Miller Index.

MATERIALS AND METHODS

Study Group

A total of five subjects ranging in age from 22 to 65 years participated in this study. Subject selection was designed to provide a group of teeth with a wide range of horizontal tooth mobilities. Each subject was required to have a minimum of five teeth in each quadrant. The five most anterior teeth were selected for measurement. Two diagonal quadrants (maxillary right and mandibular left or maxillary left and mandibular right) were selected for measurement on random basis. In all, 50 teeth were measured, i.e. 10 teeth in each of the five subjects.

Documentation

Horizontal tooth mobility was measured in this study by two methods. One method utilized O'Leary and Rudd's periodontometer³ as modified by Friedman and Cohen. The placement of the dial indicator recording point was determined by centering the point mesiodistally on the crown of the tooth and 4 mm from the incisal edge or buccal-occlusal cusp tip. A fixed distance marking device was used to transfer a dot to the tooth for accurate placement of the recording point. A 500-gm force was applied and released three times in quick succession in a buccal or facial direction and three times in a palatal or lingual direction. The maximum deflections of the teeth in each direction were recorded and totaled for the measurement of horizontal tooth mobility.

The second method of measuring tooth mobility was similar to the one described by Miller, with the modification that half scores could be used. Thus scores of 0, ½, 1, 1½, 2, 2½ and 3 were utilized.

Procedure

Each patient had the horizontal mobility of 10 teeth (five in each of two quadrants) measured five times. The first and last measurements (T0, T4) were made with the periodontometer. All measurements utilizing the periodontometer were done by NHS and KL who previously had been calibrated by Dr. O'Leary. The exams at T1, T2 and T3 were performed by three different Board Certified Periodontists using the Miller Index. Prior to examining the patients these periodontists were given the following instruction: "Please examine the following subjects and record your evaluation of the mobility of the designated teeth. The following method and classification as described by Miller must be used for this examination. Activate the tooth by grasping it between two instrument handles and moving it from side to side. First degree mobility is the first distinguishable sign of movement greater than normal. Second degree mobility allowed the crown to move as much as 1 mm in a buccolinguinal direction. Third degree mobility allows the crown to move more than 1 mm in a buccolinguinal direction or
to be depressed in its socket. You may use one half degree increments if applicable.17

The order in which these periodontists performed exams T1, T2 and T3 was decided on the basis of a random draw, (See Table 1). At least 10 minutes elapsed between examinations in order to allow the tooth to rebound.10

RESULTS

In order to examine the reliability of the periodontists in applying the Miller assessment the following mathematical model was devised.11

$$y_{ijk} = \mu + A_i + B_{ij} + \gamma_k + (A \gamma)_{ik} + (B \gamma)_{ijk} + e_{ijk}$$

This is a mixed model where:

$\mu$: is a general effect

$A_i$: subjects (considered random)

$B_{ij}$: teeth (considered random) nested in subject

$\gamma_k$: an examiner effect (considered fixed)

$e_{ijk}$: an error term

Model Description

Subjects are crossed with examiners with teeth nested in subject and crossed with examiners.

Following the periodontists' assessment of the subject's teeth an analysis of variance table (Table 2) was produced which indicated large variation among subjects.

The average mouth score for the five subjects obtained by examiner 1 was 1.36; by examiner 2, 1.20, and by examiner 3, 1.33 (Table 3). The examiners were not found to differ statistically with respect to these overall mouth scores.

<table>
<thead>
<tr>
<th>Time</th>
<th>Measurement method</th>
<th>Examiners</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>periodontometer</td>
<td>NHS, KL</td>
</tr>
<tr>
<td>$T_1$</td>
<td>Miller Index</td>
<td>periodontist 1, 2, or 3*</td>
</tr>
<tr>
<td>$T_2$</td>
<td>Miller Index</td>
<td>periodontist 1, 2, or 3*</td>
</tr>
<tr>
<td>$T_3$</td>
<td>Miller Index</td>
<td>periodontist 1, 2, or 3*</td>
</tr>
<tr>
<td>$T_4$</td>
<td>periodontometer</td>
<td>NHS, KL</td>
</tr>
</tbody>
</table>

$T =$ time of measurement, with a minimum of 10 minutes between measurements.

* The sequence of measurement by periodontist no. 1, periodontist no. 2, and periodontist no. 3 was determined by a random assignment procedure.

The analysis demonstrated also that there was a statistically significant interaction between the periodontists and the subjects (Table 3). This interaction was not felt to be clinically significant.

The three examiners' individual tooth scores were pooled as a joint estimate of the Miller Index in order to examine the relationship between the periodontists' scoring system and that of O'Leary's periodontometer by a linear regression analysis.

In a situation where both regression variables are subject to inherent errors of measurement (not sampling) as well as joint serial correlation within the subjects' mouths, a grouped regression procedure (by mouth scores) is indicated.12,13 Forming the midpoint of the two periodontometer readings per tooth along with the pooled Miller Index results in the values in Table 4.

This relationship results in an estimated correlation of $\hat{\rho} = .91$ which with 3df is significant at $P < 0.05$. The linear relationship produced, taking mobilometer readings as dependent, was $\hat{y}_i = -28.93 + 111.78 x_i$. While the danger of extrapolation from five independent observations is fully recognized, this relationship indicates the correspondence between periodontometer readings and the modified Miller Index given in Table 5.

Individual intrapatient analyses indicated that the three periodontists (pooled) were able to rank teeth in order of their mobility with high accuracy relative to the periodontometer (0.78 $\leq$ $\hat{\rho}_i$ $\leq$ 0.94; $i = 1, 2, \ldots 5$).

The results may be summarized as follows:

1. There was a high positive correlation between the periodontists' (pooled) assessment of clinical tooth mobility and the mobility measurements of the periodontometer.

2. In any given patient, the three periodontists (pooled) were able to rank teeth in order of their mobility with high accuracy relative to the periodontometer values.

3. Comparison of the periodontist's (individually) clinical Miller Index assessments from patient to patient, however, showed a lesser degree of measurement consistency. These findings although statistically significant must be substantiated by further clinical trials.

DISCUSSION

Most of the research pertaining to tooth mobility has utilized sensitive research tools. Results from most of
these studies are usually recorded in terms of linear measurements of the order of \(10^{-4}\) inches or \(10^{-2}\) mm. It would be useful for the clinician to be able to translate such results to the more precise clinical indices which he is forced to use. Such a translation is suggested by the results of this study. Table 4 compares the clinical measurements recorded by the three periodontists who participated in this study with the average measurement of the periodontometer for each of the clinical scores. The estimated periodontometer readings for any given clinical score are listed in Table 5. O'Leary\(^4\) has stated that values for "normal" horizontal tooth mobility are in the mean range of:

\[
26 - 42 \times 10^{-4}\text{ inches for incisors}
\]

\[
20 - 27 \times 10^{-4}\text{ inches for premolars and}
\]

\[
20 - 30 \times 10^{-4}\text{ inches for molars}
\]

Muhlemann\(^10\) has reported "normal" tooth mobility as being less than \(55 \times 10^{-4}\) inches for single rooted teeth, and less than \(40 \times 10^{-4}\) inches for multirooted teeth. It is interesting to note that some of these "normal" values fall well within the range of clinically perceptible tooth movement as perceived by the three periodontists who participated in this study. This finding is in conflict with clinical indices\(^4,\)\(^6\) which consider only teeth with no perceivable clinical mobility to be "normal".

In light of the findings of this study, an evaluation of currently available clinical indices is appropriate.

Wasserman, Geiger and Turgen\(^4\) describe a slight modification of the Miller Index which is used at the Columbia Dental School. This method utilizes a 1 to 5 scoring system where:

1 = normal tooth mobility.

2 = slight mobility—less than approximately \(3/4\) mm of movement bucco-lingually.

3 = moderate mobility—up to approximately 2 mm of movement bucco-lingually.

4 = severe mobility—more than 2 mm of movement.

A tooth which is intrudable is given a score for its measured mobility plus one. This index presents limitations in that out of five possible scores, three are reserved for highly mobile teeth. Mobility in the range of \(300 \times 10^{-4}\) inches (0.75 mm) to \(800 \times 10^{-4}\) inches (2.0 mm) would be scores above \(2^\circ\), thus placing very few teeth in the \(3^\circ - 5^\circ\) categories and most in the \(1^\circ\) or \(2^\circ\) category. Teeth with a mobility of \(300 \times 10^{-4}\) inches or greater with few exceptions have a hopeless prognosis which means that all teeth whose mobility might be amenable to periodontal therapy would be lumped in the \(2^\circ\) category, thereby greatly reducing the sensitivity of the index.

Glickman\(^7\) suggests that mobility be classified as either physiologic or pathologic. He further classified pathologic mobility as being either: Grade 1—slightly more than physiologic, Grade 2—moderately more than physiologic, and Grade 3—severe mobility buccolingually and/or mesiodistally combined with vertical displacement.

This index may not be clinically useful in that the physiologic or pathologic status of a tooth and its attachment apparatus may not be directly related to the tooth's mobility. It attempts to arrive at a diagnosis rather than to a parameter of the status of the periodontium.

Lovdal, et al.\(^5\) utilizes less objective criteria than either of the previously mentioned methods. These investigators estimated tooth mobility on the basis of the following criteria:

\[
0 = \text{normal mobility.}
\]

1 = teeth somewhat more mobile than normal.

2 = teeth showing conspicuous mobility in a transversal, but not in an axial direction.

3 = teeth mobile in an axial as well as a transversal direction.

Prichard\(^8\) states: "The system of grading depends on the individual examiner. It cannot be copied exactly but can be adequately adopted for clinical purposes. Grading from 1 to 3 is sufficient and plus and minus signs can be
used as an added refinement. Number 1 represents slight mobility, 2 moderate mobility and 3 extensive mobility in a lateral or mesiodistal direction combined with vertical displacement in the alveolus."

Grant, Stern, and Everett* state: "The degree of movement indicated on an arbitrary scale of 0 to 3. A reading of 0 indicates no perceptible movement; $\frac{1}{2}$ refers to the barely perceptible movement of a healthy lower incisor; $1\frac{1}{2}$ to 2½ are increasing degrees that end at 3, a degree of mobility indicating a hopeless prognosis. Teeth that can be depressed have a mobility of 3. The readings of trained observers correspond closely."

The indices of Lovdal, Grant, and Prichard described above are similar to one another in that none of them utilizes specific linear measurements. Instead they offer the clinician three broad, rather subjective categories from which to choose.

The results of this study suggest that the Miller Index may not be used exactly as originally described in 1938. The periodontists scored as a 2° mobility a tooth that moved approximately 0.5 mm ($200 \times 10^{-4}$ in) not 1.0 mm ($393 \times 10^{-4}$ in) as described by Miller. The periodontists perception of a score of $3^\circ$ was approximately 0.8 mm ($327 \times 10^{-4}$ in) as opposed to greater than 1.0 mm in the Miller system. The original Miller Index was modified for the purpose of this investigation by adding the scores of $\frac{1}{2}$, 1½, and 2½ to the existing scores of 0, 1, 2 and 3 giving the clinician a total of seven increments for mobility classification. This modification in no way altered these inconsistencies. It appears that the three periodontists either ignored the references to 1 mm in the description of the Miller Index given to them during the study or that they were unable to estimate what constitutes 1 mm of movement in the mouth.

It appears that either a clinical mobility index containing no specific units of measurement should be used, or that the Miller Index should be further modified so that a score of $2^\circ$ is a movement of the tooth which allows the crown to move 0.5 mm from its normal position in any direction, and a score of $3^\circ$ allows the tooth to move more than 0.75 mm in any direction.

There is some controversy regarding the degree of accuracy and reproducibility which can be obtained from such clinical indices. O'Leary* feels that the Miller Index is, "useful for diagnosis and treatment planning for an individual practitioner, but its value for clinical research is limited by its inability to discriminate closely and by its subjectivity (in application and direction of force applied, visual estimation of tooth movement, and poor reproducibility)." Parfitt* on the other hand states that, "Sensitivity of the clinical methods is not to be underrated. Movement of 0.01 mm (4.0 $\times 10^{-4}$ inches) can be detected between two adjacent bodies on palpation and vibrations of smaller amplitude can be detected but not discerned as movement."

Perhaps the most significant finding in this investigation is that the modified Miller Index appears to be a highly accurate, clinically acceptable method of assessing horizontal tooth mobility on an averaged basis.* Considering the small sample size of the study, the subjectivity of the index, and the inherent human error, a correlation of 0.91 between the periodontists (pooled) averaged index scores and the periodontometer averaged scores is most significant. With this degree of accuracy it can be concluded that the modified Miller Index may be a valid tool for tooth mobility evaluation in epidemiological surveys.

The discussion to this point has dealt with mean tooth scores, mouth scores and periodontometer scores. This information tells us what has happened on the average—not on an individual tooth basis. Analysis of the data on a tooth by tooth basis reveals that periodontists contribute a statistically significant degree of error in their clinical evaluation of tooth mobility from patient to patient and tooth to tooth.

From a clinical standpoint it can be stated that given two teeth (or the same tooth at different times) with the same measurement of horizontal tooth mobility, a clinician may assign different modified Miller Index values at each examination, but on the average he will make a very consistent evaluation. This implies that scoring tooth mobility by the modified Miller Index is a valid technique that could be useful in epidemiological studies involving large populations. For individual teeth where the clinician is trying to evaluate the effects of therapy on the periodontium and relatively few evaluations are made, the clinician utilizing the modified Miller Index is more likely to err.

It is suggested that the modified Miller Index as described here provides a clinical mobility evaluation system that will give accurate, reproducible mobility scores in clinical studies requiring an estimation of this parameter. Presently several calibration systems are being developed and tested to reduce some of the error inherent in this system.

**Summary**

This study evaluated the reliability and reproducibility of the modified Miller Index of horizontal tooth mobility.

Each of three periodontists utilizing the modified Miller Index assessed the horizontal tooth mobility of 50 teeth in five subjects. The same teeth were also evaluated by the periodontometer. The results of these two methods were then compared.

It was found that: (1) there was a high positive correlation between the periodontists' (pooled) assessment of clinical tooth mobility and the measurements of the periodontometer, (2) in any given patient the three periodontists (pooled) were highly accurate in their ability to rank teeth in order of their mobility as determined by the periodontometer, and (3) the perio-

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* i.e.: mouth scores.
dentists (individually) were not as consistent when comparing teeth with the Miller Index across different subjects.

The periodontists did not accurately utilize the Miller Index as it was originally described. It appears that the periodontists either ignored the reference to 1 mm in the description of the Miller Index, or they were unable to estimate what constitutes 1 mm of movement in the mouth. The periodontists all consistently scored as a 2° mobility a tooth that moved approximately 0.5 mm not 1.0 mm as described by Miller.

It is suggested that the modified Miller Index as described here provides an efficacious system for evaluating horizontal tooth mobility. It provides accurate, reproducible mobility scores in clinical studies requiring an estimation of this parameter. However, for individual teeth, when the clinician or researcher is trying to evaluate the effects of therapy on the periodontium and relatively few evaluations are made, the modified Miller Index may not provide the required degree of sensitivity.

References


Announcements

ASSOCIATION OF AMERICAN WOMEN DENTISTS

The Association of American Women Dentists will hold its 54th Annual Meeting in Chicago, Illinois on October 27 and 28, 1975. A Reception Honoring Visiting Women Dentists, a wine and cheese party, will be held on October 28th. All women dentists are invited to attend. Admittance is by invitation which may be secured at the registration desk for A.A.W.D. or in the Hospitality Suite which is located in the Continental Plaza Hotel.

DUTCH SOCIETY OF PERIODONTOLOGY

The Society will celebrate its 40th anniversary by an international congress in Amsterdam on April 22 and 23, 1976. The congress (in English) will have as its main theme “The Present Knowledge and the Future of Periodontology”. Further information may be obtained from Congress Bureau Free University, de Boelelaan 1105, Amsterdam 1011, The Netherlands.

POSTGRADUATE COURSE IN HEAD AND NECK ANATOMY

A four-day course entitled “The Alton D. Brashear Postgraduate Course in Head and Neck Anatomy” will be held at the Medical College of Virginia, Department of Anatomy, January 19–22, 1976.

Fresh specimens (unpreserved) whenever possible are used in the dissections and individual surgical approaches are welcomed. Lectures and demonstrations will augment the laboratory work. The course is approved for 40 elective hours by the American Academy for General Practice and Academy of General Dentistry.

Further information may be obtained from Dr. Hugo R. Seibel, Department of Anatomy, Medical College of Virginia, P.O. Box 906, Richmond, Va. 23298.

POSTGRADUATE DENTAL PROGRAM, ALBERT EINSTEIN COLLEGE OF MEDICINE

The following courses are available, during the academic year, 1975–1976

Periodontics DPD 62 (Minor Tooth Movement in Periodontics and General Dentistry), Gerald S. Wank, D.D.S., Wednesdays, November 5 & 12, 1975; $120.


Periodontics DPD 63 (Ultrasonics Today - A Twenty Year Review), Sol J. Ewen, D.D.S., Friday, February 13, 1976; $60.


Periodontics DPD 64, Sixteenth Anniversary Alumni Lecture (Philosophy of Periodontal Care), Timothy J. O’Leary, D.M.D., Wednesday, April 7, 1976; $60.

Postgraduate Extension Program (Off campus courses): Faculty members of the Postgraduate Dental Program, who are specialists in their fields, are available for short, intensive courses that can be given in various cities, if a sufficient number of practitioners evince interest. If clinical facilities are available, these courses can be a combination of lectures and demonstrations.

For further information and application, write to: Dr. Irving Yudkoff, Director, Postgraduate Dental Program, Albert Einstein College of Medicine, 1165 Morris Park Avenue, Bronx, New York 10461.