Probing of Pockets Related to the Attachment Level*

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IT HAS NEVER been established to what extent a thin periodontal probe penetrates the epithelial attachment during clinical examination of pocket depth. Estimates on a conceptual basis vary from no penetration to partial or even complete penetration extending to the connective tissue attachment.[3, 8, 30]

The fact that the coronal border of the connective tissue attachment can be stained[12] as a definite demarcation on extracted teeth makes it possible to use this landmark for comparison of pre- and postextraction measurements related to the cemento-enamel junction.

The purpose of the present study was to relate post-extraction measurements of the stainable coronal border of the connective tissue attachment to pre-extraction measurements obtained by probing in periodontal pockets.

MATERIALS AND METHODS

The clinical attachment level as related to the cementoenamel junction of teeth with periodontitis and slated for extraction were measured by one investigator (F.G.B.). After extraction, the teeth were stained and remeasured by another investigator (J.F.S.). The pre-extraction and post-extraction measurements were compared for differences, and the differences were analyzed for statistical significance.

Selection of Patients

Immediate denture patients at The University of Michigan were screened for evidence of periodontal destruction. Twenty patients (10 women and 10 men) scheduled for immediate denture prosthesis and with evidence of periodontitis consented to participate in the study. The age of the patients ranged from 30 to 73 years. The average loss of attachment as measured from the cementoenamel junction was 4 mm with a range from 1 to 9 mm.

Selection of Teeth

Maxillary and mandibular incisors, cuspids, and bicuspids were selected for the investigation because these teeth are usually retained until delivery of the immediate denture, and they are easily accessible for clinical measurements. Measurements were made on 116 teeth.

Measurements

The measurements were obtained at the mesial and distal facial line angles of the teeth. Reference marks were cut in the crowns of the experimental teeth with a 556 crosscut fissure bur. The bur was held at the line angles parallel to the long axis of the tooth and was moved toward the tooth until a slight groove was cut in the clinical crown. The grooves were used as reference marks for all subsequent measurements.

All measurements were made in the direction of the long axis of the teeth using a Hiatt§ periodontal probe graduated in 3-mm segments. Four probes were used and each probe was numbered for identification. Measurements by one investigator (F.G.B.) were recorded from (1) the cementoenamel junction to the bottom of the pocket and (2) the cervical border of the coronal bur groove to the bottom of the pocket. All measurements were rounded to the nearest millimeter; except that anything close to 0.5 mm was always rounded to the lower whole millimeter. The patients were not anesthetized and the bottom of the pocket was determined by the probe meeting definite resistance but without provoking pain.

Preparation for Bench Measurements

After extraction in The University of Michigan Department of Oral Surgery, the experimental teeth were rinsed gently in tap water to remove blood and debris. They were then immersed in 4% methylene blue dissolved in 50% alcohol for 1 minute and again rinsed in tap water for 30 seconds.

Method of Bench Measurement

The identical numbered probe used for the clinical measurement for each patient was again used for the bench measurement by an investigator (J.F.S.) other than the one who made the clinical measurements (F.G.B.). The distances from (1) the cementoenamel junction to the most coronal extension of the stained connective tissue attachment and (2) the cervical border of the coronal bur groove to the most coronal extension of the connective tissue attachment were measured. The measurements were recorded only when these landmarks could be identified clearly. All measurements were made in the direction of the long axis of the tooth and were rounded to the nearest millimeter; except that anything close to 0.5 mm was always rounded to the lower whole millimeter. Subsequently, dividing calipers were used to repeat the above measurements. The distances defined by the calipers were converted to millimeters using a

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millimeter scale with a Vernier scale and were recorded to the tenth of a millimeter.

Calibration

The first 15 teeth were measured at least three separate times in a random order, both clinicallly and benchwise. These data were then analyzed to determine the reproducibility of the measurements.

The standard deviation, average deviation per score, and the percentage of measurements showing no change at all were determined.

The analysis of scorer error (Table I) showed that the clinical measurements (recorded by F.G.B.) had a standard deviation of ± 0.07 mm for measurements from the cementoenamel junction and ± 0.08 mm for measurements from the coronal groove. The average deviation, which is based on the algebraic sum of all deviations for all cementoenamel junction measurements was ± 0.11 mm, and for all groove measurement was ± 0.10 mm. Seventy-two percent of the measurements from the cementoenamel junction and 70% of the measurements from the coronal groove showed no change.

The bench measurements (By J.F.S.) showed a standard deviation of ± 0.12 mm for measurements from the cementoenamel junction with the probe and a standard deviation of ± 0.04 mm for measurements from the coronal groove with the probe. The measurements from the cementoenamel junction and coronal groove deviated an average of ± 0.11 mm per score, and 85% of both measurements showed no change. The bench measurements using the caliper showed a standard deviation of ± 0.04 mm for measurements from the cementoenamel junction and a standard deviation of 0.05 mm for measurements from the coronal groove. Each measurement from the cementoenamel junction and coronal groove deviated an average of ± 0.14 mm and ± 0.15 mm from the mean respectively.

The results represent a very low scorer error and a high degree of reproducibility.

The caliper measurements in units of 0.1 mm cannot be compared meaningfully in percentage of no change with probe measurements in units of 1.0 mm.

Results and Data Analysis

The measurements from all of the experimental teeth were recorded and analyzed by an analysis of variance and a pairwise test. The analysis of variance tested the significance of interplay between four variables: quadrant, patient, technique of measurement (bench and clinical), and surface measured. These were analyzed separately for each of the following comparisons:

1. Comparison of clinical probe measurements from the cementoenamel junction to the bottom of the pocket with bench probe measurements from the cementoenamel junction to the most coronal connective tissue attachment in maxillary teeth.
2. Comparison of clinical probe measurements from the cervical border of the coronal bur groove to the bottom of the pocket with bench probe measurements from the cervical border of the coronal bur groove to the most coronal connective tissue attachment in maxillary teeth.
3. Comparison of clinical probe measurements from the cementoenamel junction to the bottom of the pocket with bench probe measurements from the cementoenamel junction to the most coronal connective tissue attachment in mandibular teeth.
4. Comparison of clinical probe measurements from the cervical border of the coronal bur groove to the bottom of the pocket with bench probe measurements from the cervical border of the coronal bur groove to the most coronal connective tissue attachment in mandibular teeth.
5. Comparison of bench probe measurements from the cementoenamel junction to the most coronal connective tissue attachment with bench caliper measurements from the cementoenamel junction to the most coronal connective tissue attachment in maxillary teeth.
6. Comparison of bench probe measurements from the cervical border of the coronal bur groove to the most coronal connective tissue attachment with bench caliper measurements from the cervical border of the coronal bur groove to the most coronal connective tissue attachment in maxillary teeth.
7. Comparison of bench probe measurements from the cementoenamel junction to the most coronal connective tissue attachment with bench caliper measurements from the cementoenamel junction to the most coronal connective tissue attachment in mandibular teeth.
8. Comparison of bench probe measurements from the cervical border of the coronal bur groove to the most coronal connective tissue attachment with bench caliper measurements from the cervical border of the coronal bur groove to the most coronal connective tissue attachment in mandibular teeth.

The analysis of variance compared the means determined for each of the four variables. The significance for each comparison was determined from each F value. To equalize all cells in the analysis of variance only patients with identical teeth were used in each comparison.

The pairwise *t* test utilized the pooled measurements for all teeth. Means were determined for: clinical probe measurements from (1) the cementoenamel junction and (2) the coronal bur groove to the bottom of the pocket, and the bench probe and caliper measurements from (1) the cementoenamel junction and (2) coronal bur groove to the coronal extension of the connective tissue attachment. These means were then compared with mean difference, standard deviation, *t* statistic, and significance in the following pairings:

1. Clinical probe vs. bench probe measurements from the cementoenamel junction to the attachment level.
2. Clinical probe vs. bench caliper measurements from the cementoenamel junction to the attachment level.

3. Bench probe vs. bench caliper measurements from the cementoenamel junction to the attachment level.
4. Clinical probe vs. bench probe measurements from the coronal groove to the attachment level.
5. Clinical probe vs. bench caliper measurements from the coronal groove to the attachment level.
6. Bench probe vs. bench caliper measurements from the coronal groove to the attachment level.

An analysis of variance for all the teeth was also computed testing the interplay of patient and the technique of measurement (clinical and bench). The F value and significance were determined.

The analysis of variance (Table II) was utilized to determine the influence of the interaction of the four variables and whether their influence was significant. The means were calculated per patient for all variables and comparisons were made according to the previously listed pairings and in Table II. To equalize the cells in each pairing of the analysis of variance, teeth were grouped from patients all having the same teeth. The interaction of the quadrant variable and surface variable with each other or the other two variables was not pertinent. The influence of the interaction of the patients variable and technique of measurement variable was of paramount importance. The differences between the means of the grouped teeth were not significant for any pairing at the 0.01 level. The F values for the patient-technique interaction were not significant for any of the pairings at the 0.01 level (Table II). Therefore, the variability between patients as to its influence upon the technique of measurement (clinical and bench) was negligible.

Since patient variability was not a factor, all of the teeth were pooled. Means were calculated for all teeth

TABLE I. *Analysis of Scorer Error*

Measurement	Standard Deviation	Average Deviation Per Score	% of No Change
Clinical Probe CEJ - Attachment Level	.07 mm	± .11 mm	72
Clinical Probe Groove - Attachment Level	.08 mm	± .10 mm	70
Bench Probe CEJ - CTA	.12 mm	± .11 mm	85
Bench Probe Groove - CTA	.04 mm	± .11 mm	85
Bench Caliper CEJ - CTA	.04 mm	± .14 mm	NA
Bench Caliper Groove - CTA	.05 mm	± .15 mm	NA

CEJ - Cementoenamel Junction
CTA - Connective Tissue Attachment
Groove - Coronal Bur Groove
NA - Not Applicable

TABLE II. *Analysis of Variance for Grouped Teeth*

Pairings	Cell Means		F Value For Patient Technique Interaction	Significance At .01
	Clinical	Bench		
Clinical Probe vs. Bench Probe Measurements from the CEJ to A.L. in Maxillary Arch	3.448	3.229	4.18	N.S.
Clinical Probe vs. Bench Probe Measurements from the Groove to A.L. in Maxillary Arch	5.823	5.833	1.34	N.S.
Clinical Probe vs. Bench Probe Measurements from the CEJ to A.L. in Mandibular Arch	5.489	5.854	2.10	N.S.
Clinical Probe vs. Bench Probe Measurements from the Groove to A.L. in Mandibular Arch	7.403	7.611	1.90	N.S.
Pairings	**Cell Means**		**F Value For Patient Techniques Interaction**	**Significance At .01**
	Probe	**Caliper**		
Bench Probe vs. Bench Caliper Measurements from the CEJ to CTA in Maxillary Arch	**3.229**	**3.159**	**.83**	**N.S.**
Bench Probe vs. Bench Caliper Measurements from the Groove to CTA in Maxillary Arch	**5.833**	**5.734**	**1.95**	**N.S.**
Bench Probe vs. Bench Caliper Measurements from the CEJ to CTA in Mandibular Arch	**5.864**	**5.760**	**3.47**	**N.S.**
Bench Probe vs. Bench Caliper Measurements from the Groove to CTA in Mandibular Arch	**7.611**	**7.514**	**2.80**	**N.S.**

A.L. - Attachment Level
CEJ - Cementoenamel Junction
CTA - Connective Tissue Attachment
Groove - Coronal Bur Groove
N.S. - Not Significant

from each patient, and a pairwise *t* statistic was determined (Table III). The means were paired to compare clinical and bench measurements from the cementoenamel junction and coronal bur groove using both the probe and caliper results. Also, the means were paired to compare bench measurements from the cementoenamel junction and coronal bur groove using both the probe and caliper. The mean difference between the pairings was determined and the standard deviation calculated. The *t* statistic was determined to test the null hypothesis that the difference between the means was not significant. The *t* statistic for all pairings was not significant at the 0.01 level. The null hypothesis that the difference between the means is zero was proven.

The final analysis of variance for all teeth (Table IV) showed the patient-technique of measurement (clinical and bench) to be not significant at the 0.01 level.

Discussion

Whether a probe in routine probing of pocket depth will penetrate painlessly through the epithelial attachment to the connective tissue attachment or stop somewhere closer to the coronal border of the epithelial attachment always has been a controversial issue. Prior to 1921 it was felt that the epithelial attachment did not exist, and that clinical probing penetrated to the connective tissue attachment.[3, 27] This concept was based primarily on histological examination of decalcified speciments. In 1921 Gottlieb[8] introduced his theory of an organic epithelial attachment which could not be penetrated painlessly by routine probing. Gottlieb also based his theory on histological examination of decalcified specimens but with a visible primary enamel cuticle. According to his theory, the gingival sulcus ended where histologically the primary enamel cuticle met the crevicular epithelium. Periodontal pockets, according to his concept, would develop between the tooth surface and the epithelial attachment, and a probe could not penetrate this attachment without using undue force. Orban[19] concurred with Gottlieb's theory when he found it impossible to detach the epithelium from the enamel during probing without tearing the epithelium or connective tissue.

Gottlieb's theory of an organic epithelial attachment went almost unchallenged until Waerhaug[30] returned to the concept of a nonexistent epithelial attachment in 1952. Waerhaug was able to pass a steel blade, 0.05 mm × 1.0 mm, to the coronal level of the connective tissue attachment in dogs using only 7 gm of force. Using the same probe, 250 gm of force was required to penetrate the mucous membrane of the lip. Histological examination of the specimen did not demonstrate tearing of the epithelial cells from the tooth surface.

Orban[17] repeated Waerhaug's experiments but was unable to insert a probe to the connective tissue attachment. Histological evidence showed that the steel blades stopped within the epithelial tissue. The important distinction between Waerhaug's and Orban's experiments was that Waerhaug directed the tip of the blade along the tooth surface whereas Orban did not.

TABLE III. *Pairwise T-Statistics for All Teeth*

Measurement		Mean Difference	Standard Deviation	T-Statistic	Significance At .01 Level
CEJ-AL Clinical Probe	3.944	.081	.479	.758	N.S.
CEJ-CTA Bench Probe	3.863				
CEJ-AL Clinical Probe	3.944	.079	.462	.762	N.S.
CEJ-CTA Bench Caliper	3.865				
CEJ-CTA Bench Probe	3.863	.002	.135	.081	N.S.
CEJ-CTA Bench Caliper	3.865				
Groove-AL Clinical Probe	6.960	.138	.424	1.450	N.S.
Groove-CTA Bench Probe	6.822				
Groove-AL Clinical Probe	6.960	.195	.430	2.024	N.S.
Groove CTA Bench Caliper	6.765				
Groove-CTA Bench Probe	6.822	.057	.104	2.463	N.S.
Groove-CTA Bench Caliper	6.765				

AL - Attachment Level
CEJ - Cementoenamel Junction
CTA - Connective Tissue Attachment
Groove - Coronal Bur Groove
N.S. - Not Significant

TABLE IV. *Analysis of Variance for All Teeth*

Measurement	Cell Means Clinical Probe	Bench Probe	Bench Caliper	F Value for Patient-Technique Interaction	Significance at .01 Level
CEJ-AL or CTA	3.700	4.001	3.967	.241	N.S.
Groove-AL or CTA	6.635	6.736	7.176	.812	N.S.

AL - Attachment Level
CEJ - Cementoenamel Junction
CTA - Connective Tissue Attachment
Groove - Coronal Bur Groove
N.S. - Not Significant

Numerous other investigators attempted to determine the limits of the gingival sulcus by various methods. Zander[33] forced cellulose acetate strips into the gingival sulcus of a young dog. Histological examination showed that the strips had reached the connective tissue attachment. Weinreb[31] forcefully placed cavit and self-curing acrylic into the gingival sulcus of monkeys and was unable to separate the epithelium from the enamel. He also placed steel blades (0.05 mm × 1.0 mm) and plastic strips into the gingival sulcus. If light pressure was applied, the blades and strips did not penetrate the epithelial attachment. If force was used, the blades and strips stopped within the epithelium. No separation of the epithelium from the tooth occurred. Here again the tip of the blade or strip was not kept in contact with the tooth surface. Henning and Zander[10] used carbon insufflation in determining the limits of the gingival sulcus. At 25 psi they produced various planes of separations with some particles reaching the connective tissue attachment. The rationale for this technique was that gas would be able to follow the path of least resistance and be capable of following the curvature of the tooth.

In other studies not specifically designed to determine the limits of the gingival sulcus pertinent findings have been reported. In an experiment studying scaling, Ramfjord and Kiester[22] reported that routine scaling will tear and split the epithelial attachment and extend to the connective tissue attachment in humans. In a study of healing of mucoperiosteal flaps Kohler and Ramfjord[15] reported a high correlation between clinical and microscopic measurements of sulcus depth in humans. Measurements were made with a blunted No. 2 silver point from a coronal notch to the bottom of the gingival sulcus or pocket clinically and again from the coronal notch to the connective tissue attachment microscopically after extraction. Using the same method Costich and Ramfjord[7, 21] also showed a high correlation between clinical and microscopic sulcus in two studies investigating healing after denudation. The good correlation between the clinical and microscopic measurements suggest that the probe penetrated to the connective tissue attachment.

A good deal of the variation in results of conflicting studies can be explained by the false equation of histological and clinical sulcus depth. Histologically, sulcus depth is limited by the coronal border of the junctional epithelium.[24] However, measurement of clinical sulcus depth does not appear to be limited by the epithelial attachment. Histological sulcus depth cannot be directly related to clinical sulcus depth.[24] Pocket depth measured clinically may approach the connective tissue attachment.[24]

In the present study the results show that a thin periodontal probe reaches the connective tissue attachment in routine probing of pockets in patients with untreated periodontal disease. The differences between the clinical measurements and bench measurements were not significant at the 0.01 level. The differences that were recorded were due to numerous possible causes. Although the exact location at which the measurements were taken was marked by the coronal groove, slight differences in the angulation away from the long axis by either investigator could produce a different reading.[22] This is especially true on teeth with angular periodontal defects. Clinical probing on extremely convex teeth is hampered by the tonus of the gingival margin which might prevent the probe from following the curvature of the tooth.[2] The extremely convex teeth also could cause a difference between reading from the bench probe and the bench caliper. As the number of measurements increased these slight inaccuracies were negated.

Pocket depth measured from the cementoenamel junction proved as accurate as a pocket depth measured from the coronal groove. Although the cementoenamel junction may be difficult to locate in some instances, it is a reliable landmark. The numerous irregularities of the cementoenamel junction appear to balance out as the number of measurements increase. The coronal groove produced as much variation as did the cementoenamel junction.

The use of the calipers converting the measurements to tenths of millimeters showed measurements by the periodontal probe to be very accurate. The differences between measurements taken with the bench probe and bench caliper were very small and not significant at the 0.01 level. Therefore, the use of a periodontal probe graduated in 3-mm segments as used by the investigators in this study is very accurate in determining attachment levels.

This study does not relate histological sulcus depth with clinical sulcus depth. The histological sulcus is the shallow groove between the tooth and normal gingiva, extending from the free surface of the junctional epithelium to the gingival margin.[24] The clinical sulcus depth as determined in this study cannot be related to the histological sulcus depth since the probe easily penetrated the junctional epithelium.

Summary

Twenty immediate denture patients with periodontitis participated in a controlled study to determine the relationship between clinical probing of pocket depth and the connective tissue attachment. Maxillary and mandibular anterior teeth were probed clinically by one investigator to determine attachment levels. The mesial and distal facial line angles were probed from the cementoenamel junction and from a coronal bur groove, to the clinically determined attachment level. One hundred and sixteen teeth were measured.

The teeth were extracted, rinsed, and stained with 4% methylene blue in 50% alcohol to demonstrate the remaining connective tissue attachment. A second investigator using the same probe as the first measured the distance from the coronal bur groove and cemento-

enamel junction to the most coronal extension of the connective tissue attachment. These measurements were repeated by the second investigator using a dividing caliper and a millimeter scale with a Vernier.

The data were analyzed by an analysis of variance for grouped teeth, pairwise *t* statistic for all teeth, and an analysis of variance for all teeth. The results showed: the influence of the interaction between the patients and technique of measurement, bench and clinical, was negligible for the grouped teeth and for all teeth. The difference between the clinical and bench measurements was not significant for all the teeth as well. The null hypothesis that the difference between the clinical measurement and bench measurement is zero was satisfied.

Conclusion

1. In routine clinical probing of untreated periodontal pockets a thin periodontal probe will penetrate to the coronal level of the connective tissue attachment which must be assumed to represent the base of the epithelial attachment.

2. A probe with markings for 3-mm segments, used by a well-trained investigator, will provide highly accurate and reproducible measurements of connective tissue attachment levels for untreated teeth with periodontal disease.

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