Periodontal Probing Calibration in an Academic Setting

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Abstract: The purpose of this study was to locate the common discrepancy sites in a periodontal examination by new student dentists in a dental school setting and to evaluate student progress after one year of clinical training. Sixty-nine patients were enrolled in the initial phase of this study. Periodontal probing examinations were performed by both dental students and calibrated faculty members. A total of 9,171 sites were probed. Student-faculty agreement was then determined for each individual probing site. Frequency of agreement and average variance of agreement were calculated for each individual site probed. An identical procedure was conducted on thirteen patients by dental students after each had received one year of clinical training. A total of 1,991 sites were probed. Students new to the clinic had a significantly higher frequency of discrepancy in molars of all quadrants, with a trend of highest discrepancy shifting from mesial to distal sites when moving posteriorly in the posterior region. After one year of experience, there was a significant decline of discrepancy in all regions examined. More preclinical emphasis must be placed on proper probing technique to ensure accurate probing depths upon entry into the clinical setting.

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Keywords: dental education, dental students, clinical education, clinical evaluation, periodontics, periodontal probing

Submitted for publication 11/25/11; accepted 1/28/12

Periodontal probing is an essential evaluation of periodontal health. The main goal of probing is to measure the depth of the gingival sulcus. Probing depth is an efficient outcome measurement that is highly correlated with clinical attachment loss, alveolar bone loss, and tooth loss.[1] Periodontal probing is versatile in function: it helps assess bleeding response, calculus buildup, defective restorations, root resorption, and pocket dimensions and helps to locate the cementoenamel junction.[2] In order to properly diagnose patients and create effective treatment plans for them, it is imperative that practitioners perform accurate periodontal probing. Many of the following variables may impinge on the practitioner's ability to accurately measure pocket depth:[3,4] examiner probing force, errors in visual assessment, variation with severity of disease, angulation of probing, and root anatomy.[2] Measurement error plays a role in discrepancy in the duplication of pocket depth measurements.[5,6]

The standardization of periodontal probing may be hindered by the variety of probe designs available, each with slightly varying probe tip diameters.[7,8] Some probe tips taper, others remain at a constant diameter along the probe,[9] and others differ in their probe alignment.[10] Computerized periodontal probes have also been developed and utilized.[11,12] Blunted tips may penetrate the periodontal pocket depths to a lesser degree than rounded tips.[13] Assuming the standardization of periodontal probes, another underlying variable may hinder standardization: probing force may vary between examiners.[14] An increased probing force will likely yield a larger probing depth measurement.[14] Similarly, clinicians may fail to place the probe to the depth of the pocket in a periodontally healthy patient.[15] However, another study concluded that "probing forces have only a moderate influence on the depth of measurements and that the probing technique was the more critical factor in probing pocket depth measurement than the pressure applied to the probe."[16]

It is crucial to consider potential error and the consequences of inaccurate depth measurements.[17] In a dental school setting, a more significant interexaminer error is expected with novice student examiners. Although a seemingly minute component of an initial patient exam, obtaining accurate periodontal probing measurements is absolutely crucial to treatment

planning. Periodontal probing error, if undetected, may result in a misdiagnosis of periodontal and overall oral health. As a result, a patient's subsequent course of treatment may be inappropriate, potentially exposing the patient to iatrogenic harm. Our study attempted to isolate various probing sites in which students new to the clinic are deviating from the probing depth measurements established by the previously calibrated faculty members. With the second phase of the study, we were then able to determine in which regions the student population has shown improvement after one year of clinical training. Finally, we attempted to isolate sites in which students with one year of clinical experience were still deviating from the depth measurements determined by calibrated faculty members.

Materials and Methods

Phase one of the Institutional Review Board-approved study examined the performance of students new to the clinic during their first patient visit, while phase two of the study examined students with one year of clinical experience evaluating the periodontal pockets of a patient who had not been previously evaluated. Patients with any number of teeth were included in the study. Patients were not excluded based on the status of their periodontal health or on any other health or dental status. Sixty-nine patients were seen with a total of 9,171 sites probed using the Hu-Friedy UNC probe in phase one, and thirteen patients were seen with a total of 1,991 sites probed using the Hu-Friedy UNC probe in phase two. Both patient and student selections were random in both phases of the study.

Before initiating the study, the consistency of the three faculty examiners participating in the study was assessed and verified for intra- and interexaminer accuracy, a step crucial to the validity of the results. To evaluate that calibration had been achieved, each examiner probed all six sites of each tooth of quadrants 1 and 3 (of a randomly selected patient) two times (with fifteen minutes between each probing assessment). Each examiner probed the patient in isolation of the other two examiners. We found both intra- and interexaminer agreement of 1 (±1) to be 100 percent.

For both the brand-new student dentists and the student dentists with one year of clinical experience, periodontal probing examinations were performed by dental students and faculty members, and the student-faculty agreement (|student measurement-faculty measurement|) was then determined for each individual probing site. The six sites examined were the mesiofacial, midbuccal, distofacial, distolingual, midlingual, and mesiolingual. At each site, the frequency of agreement 1 was determined. This was achieved by dividing the number of measurements of frequency of agreement 1 by the total number of times the site was probed. A chi-square test was then used to assess if there were any statistically significant differences between frequencies of agreement 1 of selected regions. The average variance at each site was then calculated by adding the site-specific variances calculated for all students and dividing that by the number of times that site had been probed across all patients. A two-sample t-test was then used to assess if differences of variance in selected regions were statistically significant.

To assess student improvement after one year of treating patients, a chi-square test was used to determine if there were significant differences between frequencies of agreement before and after one year of clinical training in selected regions of interest. A two-sample t-test was used to determine if the differences of variance before and after one year of clinical training were significantly different in selected regions of interest.

Results

Prior to the study, the consistency of the three faculty examiners participating in the study was assessed and verified for intra- and interexaminer accuracy. We found both intra- and interexaminer agreement of 1 to be 100 percent, confirming the accuracy of examiners.

For the new student dentists (Table 1), the results were as follows:

- Posterior sites: 85.32 percent agreement of 1; average variance of 0.8160. Anterior sites: 92.64 percent agreement of 1; average variance of 0.5820. Chi-square $p<0.0001$; 2-sample t-test $p<0.0001$.
- Facial sites: 88.89 percent agreement of 1; average variance of 0.7204. Lingual sites: 88.78 percent agreement of 1; average variance of 0.6978. Chi-square $p=0.8671$; 2-sample t-test $p=0.1588$.
- Maxillary sites: 88.46 percent agreement of 1; average variance of 0.7255. Mandibular sites: 89.19 percent agreement of 1; average variance of 0.6953. Chi-square $p=0.8681$; 2-sample t-test $p=0.07$.

Table 1. Comparing new student dentists' data alone

	Anterior Sites	Posterior Sites	p-value	
% of Agreement 1	92.64	85.32	<0.0001	
Avg. variance (mm)	0.5820	0.8160	<0.0001	
	Maxillary Sites	Mandibular Sites	p-value	
% of Agreement 1	88.46	89.19	0.8681	
Avg. variance (mm)	0.7255	0.6953	0.0700	
	Buccal Sites	Lingual Sites	p-value	
% of Agreement 1	88.89	88.78	0.8671	
Avg. variance (mm)	0.7204	0.6978	0.1588	
	Mesial Sites	Distal Sites	Midbuccal/Lingual Sites	p-value
% of Agreement 1	86.80	85.63	94.04	0.1810, <0.0001, <0.0001†
Avg. variance (mm)	0.7744	0.7619	0.5852	0.0562, <0.0001, <0.0001†

Note: p-values for % of agreement 1 comparison listed first followed by average variance comparison.

†p-values for these three comparisons are listed in the following order: mesial vs. distal, mesial vs. midbuccal/lingual, distal vs. midbuccal/lingual.

- Midbuccal and midlingual sites: 94.04 percent agreement of 1; average variance of 0.5852.
- Mesial sites: 86.80 percent agreement of 1; average variance of 0.7744. Distal sites: 85.63 percent agreement of 1; average variance of 0.7619. Mesial vs. distal chi-square p=0.181; 2-sample t-test p=0.05616. Midbuccal/midlingual vs. mesial chi-square p<0.0001; 2-sample t-test p<0.0001. Midbuccal/midlingual vs. distal chi-square p<0.0001; 2-sample t-test p<0.0001.
- Sites with lowest agreement 1: mesiolingual #17 (57.14 percent); distobuccal #19 (63.89 percent); mesiobuccal #1 (64.29 percent); mesiolingual #14 (65.91 percent); distobuccal #30 (67.50 percent); distolingual #30 (68.29 percent); mesiobuccal #19 (70.27 percent); distobuccal #3 (71.43 percent); midlingual #31 (71.79 percent); mesiobuccal #16 (72.72 percent). Sites with highest average variance in mm: mesiolingual #17 (1.53); distobuccal #19 (1.44); mesiobuccal #1 (1.29); mesiolingual #14 (1.24); mesiolingual #19 (1.22); mesiobuccal #17 (1.20); mesiobuccal #19 (1.19); distobuccal #19 (1.19); distobuccal #31 (1.19); distolingual #30 (1.15).

For the student dentists with one year of experience (Table 2), the results were as follows:

- Posterior sites: 93.98 percent agreement of 1; average variance of 0.4480. Anterior sites: 96.47 percent agreement of 1; average variance of 0.3501. Chi-square p=0.0192; 2-sample t-test p=0.0006.
- Facial sites: 94.36 percent agreement of 1; average variance of 0.4171. Lingual sites: 95.47 percent agreement of 1; average variance of 0.3946. Chi-square p=0.4045; 2-sample t-test p=0.1627.
- Maxillary sites: 95.64 percent agreement of 1; average variance of 0.3736. Mandibular sites: 94.19 percent agreement of 1; average variance of 0.4369. Chi-square p=0.1418; 2-sample t-test p=0.0291.
- Midbuccal/midlingual sites: 97.30 percent agreement of 1; average variance of 0.2907. Mesial sites: 92.69 percent agreement of 1; average variance of 0.4706. Distal sites: 94.77 percent agreement of 1; average variance of 0.4563. Mesial vs. distal chi-square p=0.0756; 2-sample t-test p=0.7069. Midbuccal/midlingual vs. mesial chi-square p<0.0001; 2-sample t-test p<0.0001. Midbuccal/midlingual vs. distal chi-square p=0.0006; 2-sample t-test p<0.0001.

In the comparison of new student dentists to student dentists with one year of experience by region, the results were as follows:

- By % agreement (Table 3 and Figure 1), where N=new student dentists and E=student dentists with one year of experience: Anteriors: N=92.64, E=96.47; p<0.0001. Posteriors: N=85.32, E=96.47; p<0.0001. Facial: N=88.89, E=94.36; p<0.0001. Lingual: N=88.78, E=95.47; p<0.0001. Maxillary: N=88.46, E=95.64; p<0.0001. Mandibular: N=89.19, E=94.19; p<0.0001. Midbuccal/midlingual: N=94.04, E=97.30; p<0.0001. Mesial: N=86.80, E=92.69; p<0.0001. Distal: N=85.63, E=94.77; p<0.0001.
- By average variance (Table 4 and Figure 2), where N=new student dentists and E=student

Table 2. Comparing data alone of student dentists with one year of experience

	Anterior Sites	Posterior Sites	p-value	
% of Agreement 1	96.47	93.98	0.0193	
Avg. variance (mm)	0.3501	0.4480	0.0006	
	Maxillary Sites	Mandibular Sites	p-value	
% of Agreement 1	95.64	94.19	0.1418	
Avg. variance (mm)	0.3736	0.4369	0.0291	
	Buccal Sites	Lingual Sites	p-value	
% of Agreement 1	94.36	95.47	0.4045	
Avg. variance (mm)	0.4171	0.3946	0.1627	
	Mesial Sites	Distal Sites	Midbuccal/Lingual Sites	p-value
% of Agreement 1	92.69	94.77	97.30	0.0756, 0.0001, 0.0001†
Avg. variance (mm)	0.4706	0.4563	0.5852	0.7069, 0.0001, 0.0001†

Note: p-values for % of agreement 1 comparison listed first followed by average variance comparison.

†p-values for these three comparisons are listed in the following order: mesial vs. distal, mesial vs. midbuccal/lingual, distal vs. midbuccal/lingual.

dentists with one year of clinical experience: Anteriors: N=0.5820, E=0.3501; p<0.0001. Posteriors: N=0.8160, E=0.4480; p<0.0001. Facial: N=0.7204, E=0.4171; p<0.0001. Lingual: N=0.6978, E=0.3946; p<0.0001. Maxillary: N=0.7255, E=0.3736; p<0.0001. Mandibular: N=0.6953, E=0.4369; p<0.0001. Midbuccal/midlingual: N=0.5852, E=0.2907; p<0.0001. Mesial: N=0.7744, E=0.4706; p<0.0001. Distal: N=0.7619, E=0.4563; p<0.0001.

Discussion

The purpose of this study was to evaluate the frequency and location of student errors in periodontal examinations by new dental students in a clinical setting, as well as to evaluate the frequency of error of dental students with one year of clinical experience. We tracked relative progress over time by comparing frequency and location of errors made by dental students new to the clinic to errors made by the dental students with one year of clinical experience. Examiner accuracy is a crucial aspect of clinical periodontal evaluation.[18-22]

New student dentists in the clinic showed significant errors in probing posterior teeth. Higher sources of errors were seen in the distals of the most posterior teeth and the mesials of the more anterior of the posterior teeth. Not surprisingly, students with one year of clinical experience were significantly more accurate in every region of probing than their new student dentist counterparts. The student dentists new to the clinic were likely erring in the posterior region due to limited access and visibility as well as to the contour of posterior teeth. They were less adept at properly positioning themselves and the patient. Students in the program are required to complete ten quadrants of scaling and root planing by the end of their first year of clinical training.

New Student Dentists

Sites with the highest variance and lowest frequency of agreement 1 were all found to be on molars distributed across all four quadrants. Greater variance was seen in quadrant 3 and in the left side of the mouth in general. This result is unusual considering 97 percent of the students participating in the study were right-handed. A greater variance and lower percentage of agreement 1 were observed for posterior teeth when compared to anterior teeth. Mesial and distal sites also showed a greater variance and lower percentage of agreement 1 when compared to midbuccal/midlingual sites; when comparing mesial to distal sites, no significant difference was found. No significant difference was found when comparing facial to lingual sites and maxillary to mandibular sites.

Twenty-three sites (Figure 3) showed an average variance greater than 1 mm (clinically unacceptable), which this study deemed as "danger zones," i.e., sites where students frequently exhibited the most errors. Variance at these specific sites was likely

Table 3. Comparing average variance of new student dentists to student dentists with one year of experience

	New Student Dentists	Student Dentists with One Year of Experience	p-value
Posterior sites	0.8160	0.4479	<0.0001
Anterior sites	0.5820	0.3501	<0.0001
Maxillary sites	0.7255	0.3736	<0.0001
Mandibular sites	0.6953	0.4369	<0.0001
Buccal sites	0.7204	0.4171	<0.0001
Lingual sites	0.6978	0.3946	<0.0001
Mesial sites	0.7744	0.4706	<0.0001
Distal sites	0.7619	0.4563	<0.0001
Midbuccal/lingual sites	0.5852	0.2907	<0.0001

Note: p-values calculated using the 2 sample t-test.

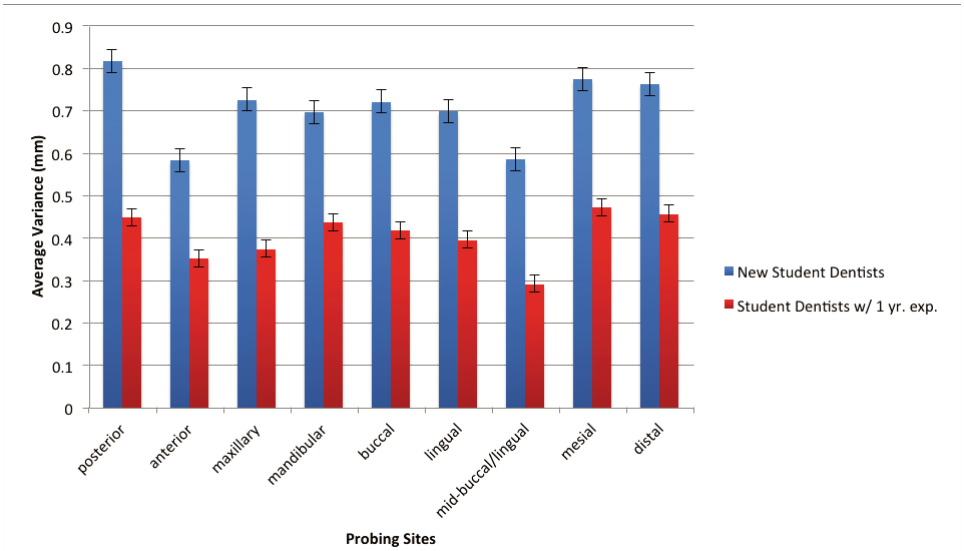

Figure 1. Comparing average variance of new student dentists to student dentists with one year of experience

due to limited access and visibility as well as to the contour of the posterior teeth.

A trend was noted while assessing distribution of danger zones. All danger zones were found in posterior teeth (all in the molars with the exception of three found in premolars). If third molars were excluded from the picture, danger zones seemed to appear at higher frequency at the distals of the most posterior teeth and appeared at a higher frequency to mesials of the more anterior of the posterior teeth (the first molars and premolars). This trend was likely the result of the clinicians maintaining a constant line of view and not shifting themselves or the patients as they moved through the quadrant. The distal sites of the more posterior teeth and the mesial sites of the more anterior teeth would logically be the most obstructed from view.

Dental Students with One Year of Experience

Three sites (Figure 4) showed an average variance greater than 1 mm (clinically unacceptable), which this study deemed as "danger zones." All three sites were found on the mandibular molars. A greater variance and lower percentage of agreement

Table 4. Comparing percentage of agreement 1 of new student dentists to student dentists with one year of experience

	New Student Dentists	Student Dentists with One Year of Experience	p-value
Posterior sites	85.32	93.98	<0.0001
Anterior sites	92.64	96.47	<0.0001
Maxillary sites	88.46	95.64	<0.0001
Mandibular sites	89.19	94.19	<0.0001
Buccal sites	88.89	94.36	<0.0001
Lingual sites	88.78	95.47	<0.0001
Mesial sites	86.80	92.69	<0.0001
Distal sites	85.63	94.77	<0.0001
Midbuccal/lingual sites	94.04	97.30	<0.0001

Note: p-values calculated using chi-square test.

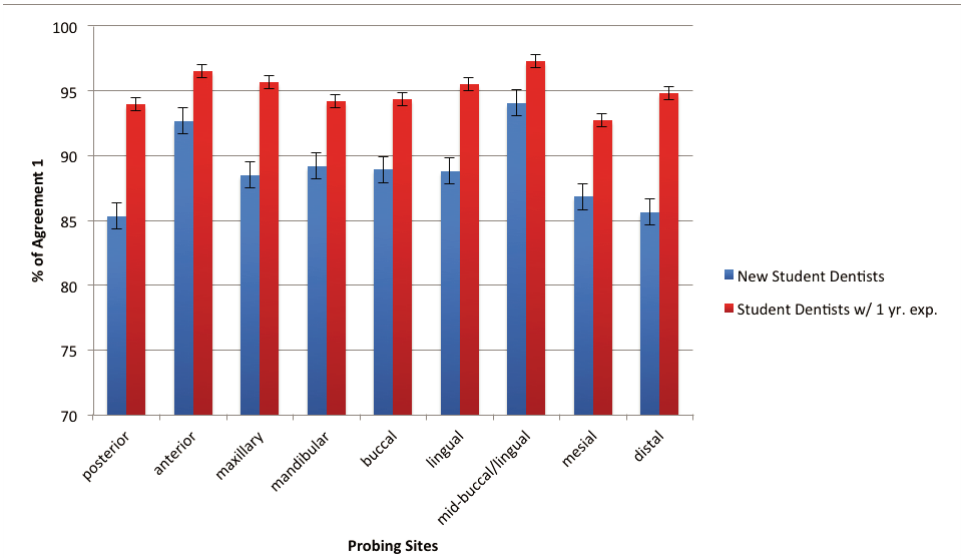

Figure 2. Comparing percentage of agreement 1 of new student dentists to student dentists with one year of experience

1 were observed for posterior teeth than anterior teeth. Mesial and distal sites each showed a greater variance and lower percentage of agreement 1 when compared to midbuccal/midlingual sites; when comparing mesial to distal sites, no significant difference was found. No significant difference was found when comparing facial to lingual sites and maxillary to mandibular sites. In mapping out the danger zones for the more experienced dental students, only three probing sites (Figure 2) had an average variance greater than 1 mm.

Comparison of Two Groups of Students

A statistically significant improvement was made in every region of the mouth after one year of clinical training. Percentage agreements and average variance were compared in each category (maxilla, mandible, facial, lingual, anterior, posterior, mesial, midbuccal/midlingual, and distal), and all comparisons were found to have $p<0.0001$, with significant improvement made in each of the categories after one year of clinical experience.

Figure 3. "Danger zones" depicted on both maxillary arch (left) and mandibular arch (right) for new student dentists

Note: Third molars of respective arches depicted by teeth below each arch.

Figure 4. "Danger zones" depicted on both maxillary arch (left) and mandibular arch (right) for student dentists with one year of experience

Note: Third molars of respective arches depicted by teeth below each arch.

Conclusion

Commonly, the preclinical curriculum does not involve exposure to real patients; instead, students practice periodontal probing on dental manikins and/or on their classmates, who likely have healthy pockets. Although two studies found that the use of manikin-based dental simulators can increase educational outcomes,[23,24] it is still important to shrink the time period in which students have a high propensity for erroneous probing readings in real patients. This can be accomplished by the exposure of students to patients during preclinical training. We propose that a requirement that students assess the periodontal status of patients during their initial visit examinations should be included and completed in preclinical training. Each one of these probing assessments is to be checked by a periodontal faculty member, and the probing of areas of variance greater than 1 mm should be demonstrated to the students new to the clinical setting. This practice will not only demonstrate proper clinician and patient positioning to the student new to the clinic but also the proper probe angulation.

Acknowledgments

The authors would like to acknowledge Bernice April and Marianne Contino for all of their help throughout the project. We would also like to thank Emil Pitkin for his statistical prowess.

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