Calculus Detection Calibration Among Dental Hygiene Faculty Members Utilizing Dental Endoscopy: A Pilot Study

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Abstract: Dental and dental hygiene faculty members often do not provide consistent instruction in the clinical environment, especially in tasks requiring clinical judgment. From previous efforts to calibrate faculty members in calculus detection using typodonts, researchers have suggested using human subjects and emerging technology to improve consistency in clinical instruction. The purpose of this pilot study was to determine if a dental endoscopy-assisted training program would improve intra- and interrater reliability of dental hygiene faculty members in calculus detection. Training included an ODU 11/12 explorer, typodonts, and dental endoscopy. A convenience sample of six participants was recruited from the dental hygiene faculty at a California community college, and a two-group randomized experimental design was utilized. Intra- and interrater reliability was measured before and after calibration training. Pretest and posttest Kappa averages of all participants were compared using repeated measures (split-plot) ANOVA to determine the effectiveness of the calibration training on intra- and interrater reliability. The results showed that both kinds of reliability significantly improved for all participants and the training group improved significantly in interrater reliability from pretest to posttest. Calibration training was beneficial to these dental hygiene faculty members, especially those beginning with less than full agreement. This study suggests that calculus detection calibration training utilizing dental endoscopy can effectively improve interrater reliability of dental and dental hygiene clinical educators. Future studies should include human subjects, involve more participants at multiple locations, and determine whether improved rater reliability can be sustained over time.

Keywords: dental hygiene education, dental hygiene faculty, calibration training, calculus detection, educational technology, dental endoscopy, faculty development

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Dental and dental hygiene faculty members often do not provide consistent instruction in the clinical environment. Previous research has revealed inconsistencies in agreement among faculty members due to variations in clinical judgment. North American dental students identified inconsistent clinical feedback as one of the major obstacles in achieving clinical competence. Although the impact of faculty variation on student performance is yet unknown, inconsistencies in clinical instruction may diminish students’ incentive to learn, reduce student satisfaction, and ultimately affect patient care. Calibration training can increase consistency in clinical instruction among faculty members. Training that involves realistic situations and contexts comparable to practice provides the most effective outcomes.

Calibrating clinical faculty members can promote standardized instruction in educational environments. Calibration training uses criteria-based standards to evaluate students and to reproduce those standards in different situations. A well-designed calibration program includes a faculty-developed clinical evaluation system for assessing student performance; subsequent evaluation of the faculty in regards to implementing the clinical evaluation system; and evaluation of the outcomes of the calibration program in regards to learner competence. Mackenzie et al. described one such program that provided opportunities in which faculty members identified critical or unacceptable errors, reproduced those errors on typodonts or extracted teeth, and shared those examples with colleagues. Another study found that faculty calibration resulted in
evaluating student performance within the program’s acceptable range of the gold standard (accuracy); repeated consistent evaluations of student performance (intrarater reliability); and similar evaluations of student performance within an acceptable range (interrater reliability). Other researchers have suggested that programs require the calibration of faculty to the gold standard using the mastery approach, which mandates instructors to score within an acceptable range of the gold standard prior to providing clinical instruction. The mastery approach in those studies was found to ensure a determined standard of rater reliability in order to promote competent instructors that provided consistent clinical instruction.

Many obstacles prevent effective outcomes of periodic calibration training, and personal tendencies arising from previous experiences have encumbered calibration efforts. Calibration training has been found to help minimize the influence of individual philosophies and values of clinical instructors with formative and summative evaluation. Overall, calibration training in those studies promoted the advantages of consistent clinical instruction and minimized the effects of instructional inconsistencies.

From the students’ perspective, clinical feedback has been perceived as more credible when the faculty were trained with exercises that fostered subject mastery. The credibility of instructors can be compromised when instructor evaluations vary with similar student performance. In two previous studies, dental faculty members demonstrated low levels of interrater agreement with other faculty members and with dental students in interpretation of radiographs, diagnosis, and treatment planning of periodontal disease. These types of inconsistencies can compromise the integrity of clinical instruction by varying the level of competence, which can deter students from learning.

Limited research exists that attempts to improve intra- and interrater reliability among clinical faculty members in regards to calculus detection. Previous studies, which utilized typodonts with simulated calculus in calibration training, did not find improvement in reliability levels. Those researchers acknowledged the unrealistic nature of simulated calculus as compared to authentic calculus and recommended that future studies involve human subjects and/or emerging technology in calculus detection. However, with human subjects, clinical faculty members have been found to experience difficulty teaching proficiency in calculus detection due to the subjective nature of sensory and motor nerve control with the explorer. In addition, a retrospective evaluation of interrater reliability among clinical instructors revealed low levels of agreement when faculty members were evaluated for residual calculus on human subjects after student scaling. Establishing a calibration training program that utilizes realistic conditions and objective methods of accurately detecting calculus remains a challenge.

In the clinical educational environment, instructors have relied on calibrating calculus detection with a gold standard or that of most senior faculty members when they used an explorer. However, emerging technologies have shown promise in the detection of calculus. Most of this technology, such as the LED-based optical probe, objectively detected root surface calculus within in vitro mediums of blood and sodium chloride solution, but lacked proven results in vivo periodontal conditions. However, dental endoscopy allows the clinician to see within the actual periodontal pockets and assists in the assessment, diagnosis, and treatment of periodontal disease.

One study explored the effectiveness of endoscopy-enhanced scaling and root planing (SRP) versus the gold standard in periodontal treatment of traditional SRP. Researchers have found that the dental endoscope maximized the removal of plaque, calculus, and root surface endotoxin and minimized the excessive removal of cementum, especially in pockets >5 mm on single- and multi-rooted teeth. However, other studies have found no significant differences with the dental endoscope that involved 5-8 mm pockets, multirrooted teeth, and inexperienced operators. In the assessment and diagnosis of periodontal conditions, researchers found a direct relationship between bleeding on probing and the presence and amount of subgingival calculus. The use of closed subgingival SRP aided by the dental endoscope resulted in the elimination of histological signs of inflammation. Despite this, no research has been published that explores if dental endoscopy enhances faculty calibration in the evaluation of calculus detection.

The aim of this pilot study was to determine if a training program utilizing dental endoscopy would improve intra- and interrater reliability levels of dental hygiene faculty members in calculus detection. Training included an ODU 11/12 explorer, typodonts, and dental endoscopy. The study was designed to address the following two research questions: Will a calibration training program utilizing dental endoscopy improve intrarater reliability among dental
Materials and Methods

This study received Institutional Review Board approval from the University of Texas Health Science Center at San Antonio (protocol number HSC20140057E). The aim was to evaluate the effect of calibration training utilizing typodonts and dental endoscopy on intra- and interrater reliability, utilizing a two-group randomized experimental design.

A convenience sample of six dental hygiene faculty members at Sacramento City College were assigned to control and training groups using adaptive randomization, based on faculty employment status. The participants were three full-time and three part-time faculty members. These individuals possessed many years of clinical dental hygiene experience and had teaching experience ranging from less than a year to over 20 years. Only one participant was a new faculty member, having started clinical teaching during the academic year of this study. At the informed consent meeting, the principal investigator discussed the study’s protocol and instructed participants to refrain from discussing the study with other participants to minimize any threats to group assignment and participant bias. Participants could voluntarily participate or withdraw from the study at any time. Upon agreement to adhere to the protocols, the participants signed the informed consent statement.

Testing and training were performed using four typodonts with the manufacturer’s key that listed the locations of factory-manufactured subgingival calculus (Kilgore model P15DP-TR56C, Kilgore International, Inc., Coldwater, MI, USA). Three typodonts were used exclusively for pre- and posttesting, and one was reserved for training with the dental endoscope. The amount of calculus on specific teeth was modified to achieve a range of surfaces containing subgingival calculus: typodont 1 contained 10-16 surfaces, typodont 2 contained 17-24 surfaces, and typodont 3 contained 25-30 surfaces. The participants’ exploring during pretest evaluations altered the quality of simulated calculus due to variations in lateral pressure, stroke strength, fulcrum position, and deposit location on the tooth surface. Therefore, after the pretest evaluations, individual teeth containing factory-manufactured subgingival calculus replaced existing teeth, which restored conditions for the posttest evaluations.

During the calibration training of the training group, the principal investigator utilized the dental endoscope to allow 24X-48X magnified visualization of subgingival root surfaces. The endoscope explorer retracted artificial tissues with the sheath and stabilized the 0.99 mm optic fibers to capture images and project a video representation of an approximately 3 mm area. A variety of endoscope-specific explorers with different angulations provided optimal access to all tooth surfaces. To promote visualization, the water irrigation feature was not utilized.

In the pretest (week 1), all participants utilized the ODU 11/12 explorer for calculus detection on each of the three typodonts two times as a baseline for intra- and interrater reliability levels (Table 1). Each of the 27 teeth was divided into four surfaces, totaling 117 surfaces per typodont. The participants evaluated surfaces for the presence or absence of subgingival calculus and marked either yes (calculus detected) or no (calculus not detected) on the answer sheet designed by the principal investigator.

Training for the training group consisted of two one-hour calibration sessions. The first session involved didactic instruction and discussion (week 2) about various concepts in calibration, exploring technique, exploring sequence, and dental endoscopy. The second session involved individualized instruction (week 3). Each participant first evaluated for subgingival calculus with the ODU 11/12 explorer on a training typodont; immediately scored his or her answers; and then reconciled errors with visualization of the surfaces with the dental endoscope and physical re-detection with the explorer. Participants achieved mastery when they scored a
minimum of 80% accuracy (mean score=87%, mean Kappa=0.732) against the answer key. This score paralleled calibration training requirements for regional clinical board examiners. In the posttest (week 4), all participants (members of both the control and training groups) evaluated for calculus using the ODU 11/12 explorer on each of the three testing typodonts two times to test for changes in intra- and interrater reliability levels.

When analyzing the data, the principal investigator assessed accuracy with the comparison of participants’ responses against an endoscopy-enhanced answer key. Intra- and interrater reliability levels were calculated using Cohen’s Kappa coefficient because it analyzed data in nominal scale and considered rater agreement due to chance. Intrarater reliability compared attempt one against attempt two, whereas interrater reliability compared each attempt against the answer key. Kappa values ranged from zero (no agreement) to 1 (perfect agreement). Values from 0.41 to 0.60 were in moderate agreement, values from 0.61 to 0.80 were considered in full agreement, and values greater than 0.81 were in perfect agreement.

Pre-training and post-training Kappa averages of all participants were compared to determine the effectiveness of the calibration training on intra- and interrater reliability. Variances between sample groups were evaluated using repeated measures (split-plot) ANOVA of the Kappa averages between the following groups: control against training groups, typodont one against typodont two against typodont three, and all pretest against all posttest Kappa values (Figure 1).

**Results**

Table 2 shows mean Kappa averages, F-statistic, and p-values for the measured intrarater reliability levels. The data suggested that participation in the study improved intrarater reliability levels for all six faculty members, but significantly more for those who received training than those in the control group (test 3). A significant difference was found between pretest and posttest mean Kappa averages (test 3, f=25.728, p<0.01). Post hoc paired-samples t-tests determined the mean differences of the control group’s pretest to posttest levels and the training group’s pretest to posttest levels (test 3, control 0.228, t=3.810, p<0.01; test 3, training 0.269, t=4.116, p<0.01). Additional post hoc one-sample t-tests compared the mean differences and found that the mean Kappa averages of the training group increased.
t-tests determined the mean differences of the control group’s pretest to posttest and the training group’s pretest to posttest (test 3, control -0.112, t=2.789, p<0.01; test 3, training -0.256, t=5.874, p<0.01). Additional post hoc one-sample t-tests comparing mean differences revealed mean Kappa averages of the training group increased significantly more than mean Kappa averages of the control group (t=11.333, p<0.01). In addition, significant improvement was found between mean Kappa scores of the training group against the control group from pretest to posttest (test 4).

Table 3 shows the mean Kappa averages, F-statistic, and p-values for the measured intrarater reliability levels. The data suggested that the training program significantly improved intrarater reliability levels for participants who received training in comparison to those who did not receive training (test 5). No significant differences were found between control and training groups when intrarater reliability calculus detection scores were compared (test 1=control/training groups and test 2=three typodonts). No significant improvement was found between mean Kappa scores of the training group against the control group from pretest to posttest (test 4).

Table 2. Intrarater reliability (self-agreement) tests of calculus detection

<table>
<thead>
<tr>
<th>Test</th>
<th>C/T Group</th>
<th>Pretest/ Posttest</th>
<th>Typodont</th>
<th>Mean Kappa Average</th>
<th>Standard Error</th>
<th>F-statistic</th>
<th>p-value</th>
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<tr>
<td></td>
<td>T</td>
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<td>0.045</td>
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<td>2</td>
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<td>All</td>
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C=control group, T=training group
†Follow-up paired-samples t-tests between control group pretest to posttest and training group pretest to posttest revealed significant results.
‡Additional follow-up one-sample t-tests comparing mean differences revealed mean Kappa averages of the training group increased significantly more than mean Kappa averages of the control group.

Results
This pilot study sought to determine if a training program utilizing dental endoscopy would improve intrarater reliability (self-agreement) and intrarater reliability (between-rater agreement) of dental hygiene faculty members in calculus detection. The small convenience sample functioned well for this pilot study. Overall self-agreement and between-rater agreement showed significant improvement between pretest and posttest mean Kappa averages. The training group showed significantly better self-agreement and between-rater agreement compared to the control group.

Discussion
This pilot study sought to determine if a training program utilizing dental endoscopy would improve intrarater reliability (self-agreement) and interrater reliability (between-rater agreement) of dental hygiene faculty members in calculus detection. The small convenience sample functioned well for this pilot study. Overall self-agreement and between-rater agreement showed significant improvement between pretest and posttest mean Kappa averages. The training group showed significantly better self-agreement and between-rater agreement compared to the control group.
However, in our study, the participants started in the moderate agreement range (all=0.524, control group=0.580, training group=0.468), which allowed for greater improvements. The data thus supported the benefit of calibration training for faculty members with less than full agreement levels. In addition, the data supported the value of calibration training to improve rater agreement between newly hired and experienced clinical faculty members.

Between-rater agreement levels significantly improved after the calibration training with dental endoscopy (Table 3, test 5). This result was not consistent with the Garland and Newell study. As with self-agreement levels, between-rater agreement levels improved significantly overall from pretest to posttest for participants in the control and training groups (Table 3, test 3). Again, this result was not consistent with the previous study, in which the

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**Table 3. Interrater (between-rater) reliability tests of calculus detection**

<table>
<thead>
<tr>
<th>Test</th>
<th>C/T Group</th>
<th>Pretest/Posttest</th>
<th>Typodont</th>
<th>Attempt</th>
<th>Mean Kappa Average</th>
<th>Standard Error</th>
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</table>

C=control group, T=training group

1Follow-up paired-samples t-tests between control group's pretest to posttest and training group's pretest to posttest revealed significant results.

2Additional follow-up one-sample t-tests comparing mean differences revealed mean Kappa averages of training group increased significantly more than mean Kappa averages of control group.

Note: Repeated measures (split-plot) ANOVA of mean Kappa averages was used to determine whether training improved between-rater agreement (test 5) and to exclude confounding variables (test 1=all control group against all training group, test 2=typodont 1 against typodont 2 against typodont 3, test 3=all pretest against all posttest, and test 4=attempt 1 against attempt 2).
pretest between-rater agreement levels started in the full agreement range and limited the potential for improvement. In our study, the participants started in the moderate to full agreement range (all=0.601, control group=0.665, training group=0.536), which allowed for greater potential for improvement. Previous studies reported between-rater agreement levels of 0.340 and 0.780. The data in our study supported the value of calibration training for faculty members with less than full between-rater agreement and reemphasized the value of the quality of calibration training over the quantity. In our study, the training consisted of two one-hour sessions, one of which included individualized instruction with the endoscope. Anecdotally, the faculty members in the training group reported appreciating the opportunity to confirm their discrepancies in calculus detection and to self-assess personal detection errors.

A remarkable result was the finding that all participants significantly improved in self-agreement and between-rater agreement from pretest to posttest (Table 2, test 3 and Table 3, test 3). Faculty employment status may have affected the pretest agreement levels, which started in the moderate agreement range. Part-time faculty members provided better evaluations of periodontal procedures than full-time faculty members in a previous study; however, no previous study has measured differences in calculus detection rater agreement due to faculty status. The learning effect (i.e., gradual improvement with the repetition of a task) may help explain overall improvement with all participants in our study. The combination of the learning effect and training effect may also explain why the training group improved significantly more than the control group, which was observed in previous calibration studies. Another influencing factor for improvement from pretest to posttest was the pretest timing. The pretest, administered one week prior to the start of the term, was preceded by a one-month break between terms. Levels of agreement may vary depending on the amount of clinical dental hygiene performed external to the academic environment. No previous studies have measured levels of agreement at different times during an academic term.

The limitations of this pilot study included the simulated calculus, typodonts, and the production of the endoscopy-enhanced answer key solely by the principal investigator. In addition, the study was performed in only one academic dental institution, thus limiting its generalizability to other institutions. Despite these limitations, this calibration study resulted in significant improvements from pretest to posttest in both self-agreement and between-rater agreement levels (Table 2, test 3 and Table 3, test 3). In addition, the calibration training with the dental endoscope significantly improved between-rater agreement levels from pretest to posttest (Table 3, test 5).

Future studies to further the knowledge base should include human subjects combined with the emerging technology of endoscopy. The endoscopy-enhanced subgingival calculus answer key would reduce the subjective element of calculus detection and provide a realistic nature of calculus detection that is lacking when using typodonts. Since calculus detection could have varied depending on faculty employment status, whether part-time or full-time, additional research should investigate the effect of faculty employment status on calculus detection. Future studies should also conduct testing and training in the middle of academic terms to minimize the effects of pretest timing outside of academic terms. Although the mid-day timing of testing and training improved convenience for the participants, anecdotally they mentioned they would have preferred early morning sessions on non-academic days to improve alertness, concentration, and tactile sensitivity. The use of more participants from multiple sites would help identify the potential benefits for a variety of populations. Furthermore, the testing of rater agreement levels at different times during academic terms could help identify the need for more regularly scheduled calibration training. Since improved between-rater agreement occurred, future studies should determine if the effects of calibration training can be sustained over time.

**Conclusion**

This pilot study investigated the effect of calibration training on dental hygiene faculty members using the emerging technology of dental endoscopy to enhance calculus detection. Changes in self-agreement and between-rater agreement measured the levels of improvement. Our findings suggest that calibration training can be beneficial to dental hygiene faculty members and possibly dental faculty members as well, especially for those beginning with less than full agreement. Calibration training can also be valuable in improving rater agreement between newly hired and experienced
clinical faculty members. In addition, calculus detection calibration training utilizing dental endoscopy can effectively improve between-rater agreement of clinical educators.

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Disclosure

The authors do not have any financial, economic, or professional conflicts of interests to disclose.

REFERENCES