Endoscopic vs. Tactile Evaluation of Subgingival Calculus

Joy B. Osborn, RDH, MA; Patricia A. Lenton, RDH, MA; Scott A. Lunos, MS; Christine M. Blue BSDH, MS

Introduction

The ability to detect subgingival calculus is paramount to the successful treatment of periodontal disease. Historically, dental professionals have used conventional (manual) explorers to feel the root surfaces for residual calculus when assessing scaling and root-planing procedures. Difficulties cited have included working in a subgingival environment without vision, clinical judgment in distinguishing between calculus and root morphology, and individual variations in acuity with tactile sensations.[1-6] Development of the Perioscope™ (Perioscopy Inc., Oakland, Cali) purports to provide some relief to these concerns because it offers sight into the subgingival environment.[1,2,6-8] The Perioscope™ uses endoscopic technology, where a fiber optic tip inserted into the periodontal pocket is used to relay images of the subgingival environment to a monitor adjacent to the patient chair.[8] The ability to visually inspect the root surfaces for calculus may improve detection, and thereby removal, of these deposits.[1,2,6,7]

Calculus has been an ongoing source of study and debate regarding its clinical importance in the periodontal disease process.[2,9-13] Historically, the role of residual calculus in disease progression has shifted precariously in the literature.[2,10,12,14] The need for absolute subgingival calculus removal came into question with reports of improved periodontal tissues in spite of remaining deposit.[9,10,12,14,15] While clinicians were not advocating the intentional leaving behind of calculus, doing so appeared to still have positive, although perhaps temporary, gingival outcomes. The idea of what was an "acceptable" level of smoothness appeared to chal-

Abstract

Purpose: Endoscopic technology has been developed to facilitate imagery for use during diagnostic and therapeutic phases of periodontal care. The purpose of this study was to compare the level of subgingival calculus detection using a periodontal endoscope with that of conventional tactile explorer in periodontitis subjects.

Methods: A convenience sample of 26 subjects with moderate periodontitis in at least 2 quadrants was recruited from the University of Minnesota School of Dentistry to undergo quadrant scaling and root planing. One quadrant from each subject was randomized for tactile calculus detection alone and the other quadrant for tactile detection plus the Perioscope ™ (Perioscopy Inc., Oakland, Cali). A calculus index on a 0 to 3 score was performed at baseline and at 2 post-scaling and root planing visits. Sites where calculus was detected at visit 1 were retreated. T-tests were used to determine within-subject differences between Perioscope™ and tactile measures, and changes in measures between visits.

Results: Significantly more calculus was detected using the Perioscope™ vs. tactile explorer for all 3 subject visits (p<0.005). Mean changes (reduction) in calculus detection from baseline to visit 1 were statistically significant for both the Perioscope™ and tactile quadrants (p<0.0001). However, further reductions in calculus detection from visit 1 to visit 2 was only significant for the Perioscope™ quadrant (p<0.025), indicating that this methodology was able to more precisely detect calculus at this visit.

Conclusion: It was concluded that the addition of a visual component to calculus detection via the Perioscope™ was most helpful in the re-evaluation phase of periodontal therapy.

Keywords: dental calculus/diagnosis, calculus detection, residual calculus, periodontal endoscope, perioscope™ technology

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lenge conventional wisdom. However, this theory had a relatively short life span as research better delineated the structure of calculus and the role of plaque biofilm covering its surface.[2,16,17] There is presently greater advocacy toward eliminating as much root roughness as necessary in order to achieve a smooth root surface and gingival health. Pattison warns that clinicians, educators and researchers may have shifted too far in the opposite

direction without justification, and that a greater focus on the root surface is again necessary for long-term periodontal management of disease.[2]

In spite of a philosophical desire for total calculus removal, studies have identified several aspects of clinical practice limiting the clinician's ability.[1,3-6,9,14] Periodontal pocket depth has often been a point of discussion as researchers have found that a greater level of residual calculus is present in deeper vs. shallower pocket depths.[5,18] Anatomy such as furcations, cementoenamel junctions and multi-rooted teeth can pose additional problems.[3-5] Some researchers have questioned the promise of total calculus removal in closed debridement,[5,10,19] or without surgical procedures.[4,20] Other factors to consider are location of the deposit (facial/lingual vs. proximal),[1] operator experience,[4,6] inability to visualize the subgingival root surface[1,2] and overall ability of practitioners to clinically detect residual calculus.[1]

Studies evaluating residual calculus post-scaling and root planing via tactile and visual means have often relied on extraction of hopeless teeth as an end point in their methodology.[1,3-5,8,9] Sherman et al compared visual and tactile calculus detection of 101 periodontally involved teeth.[1] In this study, tactile evaluation occurred before and after scaling and root planing in vivo, and at 2 re-evaluation appointments scheduled 1 week apart using a periodontal probe as well as an explorer. After extraction, visual evaluation used a scanning electron microscope at 10x magnification. Both evaluations used a presence or absence format for calculus determination. Results showed that the microscopic (visual) identification of calculus was always higher than the tactile detection. Additionally, of the total number of tooth surfaces scored microscopically as having calculus, 77.4% were scored as calculus free using the explorer.

Periodontal endoscopic technology has attempted to address many of the concerns related to conventional calculus detection by providing a visual alternative in the clinical setting.[8] The endoscope uses a fiber optic bundle covered by a sterile sheath mounted into an instrument referred to as an explorer.[7] The instrument tip gently pushes the free gingiva away during subgingival insertion.[7] The subgingival video image is then displayed on an adjacent monitor. Images are magnified 24 to 48x their original size, depending on the location of the lens in relation to the object viewed.[8] Potential advantages of using the endoscope have included real-time video viewing of the subgingival environment, high magnification of tooth structure, artifacts, caries, gingival attachment and sulcus wall,

and detection of calculus on the root surface.[8] Pilot research of this technology has indicated that clinicians could accurately detect subgingival calculus and caries on 95% of all root surfaces.[8] This was determined by comparing findings before (via subgingival endoscopic magnification) and after (via direct magnified vision) tooth extraction. By using an endoscope, clinicians were able to accurately locate calculus and caries over a wide spread tooth surface area.

Since calculus is conventionally detected with an explorer in a clinical setting, it was of interest to compare the use of the endoscope (visual) with an explorer (tactile) in degree of overall accuracy of detection. As a companion article to clinical effectiveness of using the periodontal endoscope, Geisinger et al examined root surface area of residual calculus with and without the aid of this technology during scaling and root planing.[6] Fifty tooth pairs of single-rooted teeth with a hopeless prognosis were used in this study. One of each pair was randomly assigned to either the test group, where calculus was visually detected with the endoscope, or a control group, where calculus was tactilely detected using an explorer. Following standard periodontal measurements, indices and scaling and root planing, these teeth were extracted and processed for stereomicroscope viewing and photography of individual surfaces. An image processing program was then used to obtain the total root surface area of each tooth surface, as well as the root surface area still containing calculus. Results demonstrated that a statistically significant decrease in surface area of residual calculus occurred when using the endoscope during scaling and root planing vs. scaling and root planing with the explorer alone. Additionally, the endoscope facilitated calculus removal in deeper pocket areas.

While Geisinger et al used single-rooted teeth to test their hypothesis,[6] Michaud et al used multi-rooted teeth.[3] In the latter study, teeth were again randomly assigned to test or control groups (endoscope or no endoscope, respectively), and extracted after debridement.[3] Calculus was assessed in terms of absence or presence after scaling and root planning. In this study, use of the endoscope resulted in significantly less calculus at interproximal sites, but not on buccal/lingual surfaces, or at sites with deep furcations or pocket depths. Authors speculated that viewing difficult areas subgingivally is one aspect of removal. The other is to have access at actual removal. Some subgingival sites are consistently difficult to access because of complex root anatomy.

Another approach to understanding the clinical

usefulness of an endoscope has been considered through investigation of subgingival inflammatory changes.[13,17] Wilson et al used an endoscope to determine whether or not a relationship existed between subgingival deposits and tissue inflammation.[17] An endoscope was used to measure plaque biofilm, calculus and subgingival pocket wall inflammation in 26 subjects with moderate to severe periodontitis. Findings of this study revealed that the presence of subgingival inflammation was significantly related to the presence of calculus and plaque together vs. calculus alone. In a companion study, Wilson et al used an endoscope during scaling and root planing of 6 teeth cited for extraction.[13] At the 6 month post-treatment extractions, chronic inflammation was not present upon histological biopsy.[13] While subgingival calculus was not the primary point of inquiry, these studies indicated that inflammation is more prevalent when calculus is present and that its removal in association to plaque attachment is an important step toward tissue health.[13,17]

Literature was not available that compared endoscopic and tactile calculus detection in patients without the use of tooth extraction as an aid in evaluation. Since this does not model the typical approach to current dental hygiene patient care, it was the intention of this study to use available calculus detection methodologies. Therefore, the purpose of this study was to compare the level of subgingival calculus detection using a periodontal endoscope with that of conventional tactile explorer in periodontitis subjects. This article addresses the calculus component of the study; a companion article addresses the periodontal outcome of using a periodontal endoscope.[21]

Methods and Materials

This study was one component of a clinical trial comparing the periodontal outcomes with and without the use of a Perioscope™ to treat subjects presenting with sites of periodontitis.[21] A randomized split mouth design was used to determine periodontal and calculus changes before and after scaling and root planing. The control group received scaling and root planing with the aid of the Perioscope™, while the experimental group received the same treatment without the aid of the Perioscope™.

Thirty adult subjects with chronic moderate periodontitis were recruited from the University of Minnesota School of Dentistry clinics for this study. Based on a 2-sided paired t-test with a 0.05 level of significance, a sample size of 30 subjects was determined to be sufficient to detect a pocket depth

effect size of 1.0 (mean difference=1.25 mm, standard deviation=1.25 mm) with greater than 90% power. For study participation, each subject was required to have a minimum of 4 individual periodontal sites of pocket depth measurement >5 mm in 2 separate quadrants. One quadrant of each subject was randomized to be evaluated using tactile calculus detection alone, and the other quadrant with tactile detection plus the Perioscope™. Tables of randomized pairings of possible quadrant combinations were used to assign quadrants. All subjects went through a consent process for participation. The study received IRB approval via the University of Minnesota Human Research Protection Program, Code Number 0902M60301.

Instrumentation used to conduct the calculus detection portion of this study involved the Perioscope™ and the 11-12 ODU Explorer (Hu Freidy, Chicago, Ill). The Perioscope™ incorporated visual magnification and fiber optic technology so that the subgingival environment could be viewed. The 11-12 ODU explorer was used as the standard tactile methodology for calculus detection and as a means of comparison to the visual perspective offered by the Perioscope™. Two dental hygiene faculty members at the University of Minnesota underwent training sessions to learn the Perioscope™ technique. A periodontist experienced in using the Perioscope™ led practice sessions in appropriate tip selections, monitor viewing vs. direct intraoral vision, viewing at high magnification, and practice with models as well as patients. A post-training calibration session of 6 periodontal subjects with subgingival calculus determined intra- and inter-examiner reliability using both the Perioscope™ and 11-12 explorer. A high percent of agreement within and between examiners was achieved for both methods of calculus detection. Percent inter-examiner agreement or repeated tactile measures ranged from 96.1 to 96.7%, and 93.2 to 92.2% for repeated Perioscope™ measures. These were not significantly different, indicating consistency between examiners using these detection methods.

Once subjects were recruited into the study, clinical measurements of pocket depth, attachment level, bleeding, gingival health and calculus were taken at study sites in both quadrants before treatment and at specific re-evaluation intervals. In the treatment group, the level of calculus was assessed using the Endoscopic Calculus Index developed by Checchi et al.[22] As an attempt to maintain similarities in calculus indices, a modified version of this index was used for tactile calculus detection with the ODU 11-12 explorer in both the treatment and control groups (Figure 1). Both calculus indices were based on a 0 to 3 range in scor-

Figure 1: Tactile Calculus Index*

> 0 = absence of calculus
> 1 = subgingival isolated flecks of calculus
> 2 = moderate explorable detectable subgingival calculus
> 3 = moderate to heavy ledge of subgingival calculus

*Modified from the Endoscopic Calculus Index

Table I: Subject Mean (SD) Periodontal Measures in Perioscope™ and Non-Perioscope™ Sites (n=26)

	Perioscope™ Sites x̄(SD)	Non-Perioscope™ Sites x̄(SD)	p-value*
Pocket Depth (mm)	5.29 (0.35)	5.39 (0.53)	0.3080
Clinical Attachment Loss (mm)	3.74 (1.07)	3.88 (0.93)	0.3725
Gingival Index	1.88 (0.41)	1.66 (0.40)	0.0047
Bleeding on Probing	0.88 (0.23)	0.87 (0.31)	0.8161

*t-test (paired)

ing. After baseline measurements were obtained, subjects underwent full mouth scaling and root planning with ultrasonic and hand instruments. The Perioscope™ facilitated calculus removal in the treatment quadrant but was not used in the control quadrant. Subjects returned for 2 subsequent 6 to 8 week re-evaluation appointments (visits 1 and 2) where re-measurement of all periodontal and calculus parameters occurred. Examiners measured the same subjects throughout the study where possible.

Statistical Analysis

Baseline measures calculated were descriptive in nature (mean and standard deviation). For the 2 successive re-evaluation visits, the average within-site differences were calculated for each patient. T-tests were used to determine whether there were within-subject differences between Perioscope™ and tactile measures, and changes in Perioscope™ and tactile measures between visits. A p-value<0.05 was declared to be statistically significant. P-values were not adjusted for multiple comparisons. SAS V9.1.3 (SAS Institute Inc) was used for the analysis.

Results

The 26 subjects completing the study presented with 202 Perioscope™ study sites and 162 non-Perioscope™ study sites. The median number of study sites per subject was 7 (range 4 to 27 sites) and 5 (range 2 to 20 sites) for the Perioscope™ and non-Perioscope™ quadrants, respectively. Table I indicates subjects' baseline periodontal measures in study sites for quadrants in each group. In general, subjects had a mean quadrant pocket depth between 5 and 6 mm, approximately 4 mm of clinical attachment loss, and generalized inflammation noted via the gingival index and bleeding on probing. For most of the clinical parameters, there were no significant differences between Perioscope™ and non-Perioscope™ sites, indicating that similar periodontal conditions were present when using both types of calculus detection methodologies. However, the Perioscope™ sites tended to have higher gingival index scores (p=0.005).

For the 3 subject visits where measurements were taken, reductions in calculus were detected at each successive appointment using both the Perioscope™ and tactile methods of calculus detection. The greatest reduction occurred from baseline to visit 1, where the first re-evaluation took place after scaling and root planing (Table II). This was expected since subjects generally presented at baseline with moderate or heavy levels of calculus, based on the mean calculus index scores. Significant differences in calculus detection occurred between the Perioscope™ and explorer at all visits (p<0.005). Overall, a higher level of calculus was consistently detected using the Perioscope™.

Table III shows the mean change in Perioscope™ calculus index scores between each visit. Again, the largest change occurred between baseline and the first re-evaluation appointment (visit 1; p<0.0001). While a 0.19 change on the Perioscope™ calculus index scale is quite small, a statistically significant level of calculus reduction was observed from visit 1 to visit 2 (p=0.025).

Changes in tactile calculus index scores are demonstrated in Table IV for sites in both the Perioscope™ and non-Perioscope™ quadrants. Similar results occurred in these quadrants with the explorer for calculus detection. There were statistically significant differences in calculus detection from baseline to visit 1 (p<0.0001), but not from visit 1 to visit 2. In comparison to the Perioscope™ results (Table III), the explorer did not facilitate calculus detection between the 2 re-evaluation appointments.

Additional analyses were completed to allow comparison of the Perioscope™ and explorer cal-

Table II: Comparison of Perioscope™ and Tactile Calculus Index Scores in Perioscope™ Sites

	Perioscope™ Calculus Index x̄(SD)	Tactile Calculus Index x̄(SD)	p-value*
Baseline	2.21 (0.52)	1.81 (0.75)	0.0046
Visit 1	0.68 (0.35)	0.25 (0.23)	<0.0001
Visit 2	0.48 (0.45)	0.18 (0.22)	0.0020

*t-test

Table III: Changes in Perioscope™ Calculus Index Scores Over Time For Perioscope™ Sites

	Perioscope™ Calculus Index Change x̄(SD)	p-value*
Baseline to Visit 1	-1.53 (0.64)	<0.0001
Visit 1 to Visit 2	-0.19 (0.41)	0.0248

*t-test

culus detection in relation to pocket depth, tooth rootedness and tooth surface (Table V). In most situations, the Perioscope™ detected significantly more calculus than the explorer (p-values range from 0.0001 to 0.0465). In comparing these calculus detection methods in shallow and deep pockets (≤5 mm vs. ≥6 mm), the Perioscope™ allowed detection of a higher level of calculus than the explorer except in deeper pockets at visit 2. Additionally, the Perioscope™ facilitated calculus detection on multi-rooted teeth more so than single-rooted teeth, and proximal surfaces vs. buccal/lingual surfaces in comparison to the explorer.

Discussion

This study compared subgingival calculus detection with 2 methodologies: the conventional explorer and Perioscope™ subgingival visual technology. The Perioscope™ was found to have benefit over the explorer, particularly at the re-evaluation appointment when study examiners using the explorer did not completely locate the residual calculus. The difficulty of tactile location of minute deposits has been previously discussed in the literature.[1,2,19] Authors point out the practical impossibility of exploring the entire subgingival root surface area, and findings of this study support that contention.[1,19] Visual support of locating subgingival deposits facilitates their removal more so than explorer detection alone.

In a similar study examining the effectiveness of calculus detection and removal with and without a periodontal endoscope, Geisinger et al performed scaling and root planning with subsequent extraction for visual evaluation of remaining calculus.[6] Taking that aspect into consideration, the results of this study were similar to the Geisinger study in that a periodontal endoscope generally provided a statistically significant benefit over the explorer in calculus detection. In deeper pocket depths, both studies indicated that using an endoscope resulted in significantly less residual calculus than the explorer after periodontal therapy (i.e. the point of

extraction in the Geisinger study or visit 1 in the current study). However, the Geisinger study found significant differences between the 2 detection methodologies for interproximal as well as buccal/lingual sites. Significant differences for the current study were primarily found for interproximal sites. Regarding tooth rootedness, findings reported by Michaud et al indicated that the endoscope provided no additional benefit to the scaling and root planning process and calculus removal on multi-rooted teeth specifically.[3] In contrast, the Perioscope™ provided significant benefit on multirooted teeth in the current study. Overall, it appears that the periodontal endoscope offers a visual component to calculus detection to minimize these various challenges in periodontal instrumentation.

In comparison to these endoscopic clinical studies,[3,6] residual calculus data was collected in vivo. There were no extractions of hopeless teeth to obtain information about total percentages of root surface areas containing residual calculus. While the advantage could be better viewing of the entire tooth, the benefit of the current study protocol is that it more closely follows that of periodontal treatment in clinical practice. However, it was interesting to note the number of sites where calculus was detected with the Perioscope™ but not with the explorer. This particular analysis offers insight into visual vs. tactile senses when exploring. For instance, at baseline there were 188 calculus sites as determined with the Perioscope™, but 13 (6.9%) of those were calculus free with the explorer. At visit 1, this comparison was 127 calculus sites with the Perioscope™ vs. 93 (73%) explorer free, and then at visit 2, 85 calculus sites with the Perioscope™ vs. 63 (74%) explorer free. These numbers speak to the difficulty of clinically determining residual calculus with the explorer alone. Visual and tactile methodologies together can potentially reduce residual calculus that may perpetuate periodontal disease.

In spite of the visual support, areas of residual calculus remained in study sites at the 2 re-eval-

Table IV: Changes in Tactile Calculus Index Scores Over Time For Perioscope™ and Non-Perioscope™ Sites

	Perioscope™ Sites		Non-Perioscope™ Sites	
	Tactile Calculus Index Change x̄(SD)	p-value*	Tactile Calculus Index Change x̄(SD)	p-value*
Baseline to Visit 1	-1.55 (0.74)	<0.0001	-1.43 (0.88)	<0.0001
Visit 1 to Visit 2	-0.07 (0.25)	0.1687	-0.07 (0.34)	0.3252

*t-test

uation visits for the Perioscope™ group. This was also the case in the other endoscopic clinical studies.[3,6] There were continued reductions at each visit, but the calculus level still did not reach total absence for the experimental group. Geisinger discussed possible factors related to this issue.[6] There are varying degrees of calculus coloration when using an endoscope, and tissue inflammation, plaque and bleeding can impact subgingival visibility.[6] For instance, in the present study, calculus was detected with the explorer but not with the Perioscope™ during approximately 5% of the total number of Perioscope™ measurements taken at all visits. Bleeding was noted about half the time in these situations. Additionally, examiners felt that the level of subgingival plaque often present in this population of subjects could account for some difficulty in perception of calculus. Lastly, there is a learning curve for the operator in mastering the technique for best results.[6] While anecdotal evidence appears favorable toward the use of periodontal endoscopy, clinical practice changes are best made on evidence.[2,5,23] Continued clinical research and validation of the Perioscope™ with multiple patient types and clinical situations would be beneficial.

Practical aspects for clinicians to consider with endoscopic use are the time and cost of such technology. Geisinger et al considered the time involved in scaling and root planing each study tooth with and without the use of the an endoscope, finding significant differences between the 2 groups.[6] These authors noted that this difference decreased as study clinicians became more comfortable and efficient with the endoscope.[6] The present study did not incorporate time keeping into the clinical treatment of subjects. However, examiners would concur that initial work with the Perioscope™ was more time-consuming and, as the study progressed, became more equivalent to scaling and root planing without it. Financing this type of technology may be an initial concern for some clinicians. The original cost of the DV2 Perioscope™ system was approximately $15,000, which included a day of training. Used systems can range between $2,000 and $4,000.[24] A new prototype is currently under development and can be viewed at the company's website.

Table V: Comparison of the Perioscope™ and Explorer Calculus Indices Based On Pocket Depth, Tooth Rootedness and Tooth Surface

	Perioscope™ Calculus Index	Tactile Calculus Index	p-value*
Pocket depth (1 to 5 mm) (n=26)			
Baseline	2.21 (0.54)	1.85 (0.74)	0.0188
Visit 1	0.63 (0.37)	0.22 (0.23)	<0.0001
Visit 2	0.47 (0.43)	0.16 (0.21)	0.0025
Pocket depth (6+ mm) (n=20)			
Baseline	2.15 (0.74)	1.70 (0.93)	0.0245
Visit 1	0.90 (0.48)	0.25 (0.37)	0.0003
Visit 2	0.51 (0.64)	0.25 (0.40)	0.0966
Rootedness – single (n=20)			
Baseline	2.03 (0.75)	1.85 (0.81)	0.2814
Visit 1	0.75 (0.38)	0.26 (0.37)	0.0001
Visit 2	0.37 (0.44)	0.09 (0.18)	0.0046
Rootedness – multiple (n=25)			
Baseline	2.27 (0.53)	1.94 (0.80)	0.0229
Visit 1	0.70 (0.49)	0.27 (0.34)	0.0005
Visit 2	0.57 (0.51)	0.24 (0.31)	0.0056
Surface – buccal/lingual (n=7)			
Baseline	1.98 (0.85)	1.26 (0.38)	0.0465
Visit 1	0.55 (0.81)	0.26 (0.38)	0.1723
Visit 2	0.33 (0.47)	0 (0)	0.1106
Surface – proximal (n=26)			
Baseline	2.22 (0.51)	1.83 (0.77)	0.0070
Visit 1	0.70 (0.35)	0.25 (0.24)	<0.0001
Visit 2	0.49 (0.45)	0.19 (0.22)	0.0026

*t-test

Limitations of the study include:

1. Subject selection: while subjects met the inclusion criteria set forth in the study, varying levels of periodontal disease would have been of clinical interest.
2. Although the 2 calculus indices were a means of comparing the calculus outcomes between the Perioscope™ and the explorer, by virtue of their criteria, the indices are measuring differing concepts (visual vs. tactile). For example,

a score of 2 on the tactile index is virtually not the same as a score of 2 on the Perioscope™ index. An attempt was made to correlate the wording so that examiners could be as consistent as possible between the 2 indices.

3. Examiner experience: training and calibration using the Perioscope™ occurred prior to the study. However, some of the manipulation takes ongoing experience for a higher degree of mastery, which could have affected results.

In this study, the Perioscope™ offered a visual advantage to facilitate calculus reduction especially at the re-evaluation visits. Removal of initial moderate to heavy deposits did not require visual assistance, although it was still of benefit. From a clinical practice viewpoint, using this technology with patients who are not responding to periodontal therapy may be a primary point of intervention. More research is needed to know if the calculus reductions translate to improved periodontal outcomes using the Perioscope™.

Conclusion

The Perioscope™ improved calculus detection over the explorer at each subject visit, indicating that a visual component is a positive adjunct to tactile evaluation of subgingival calculus. Significantly more calculus was detected using the Perioscope™ than the explorer at each visit. Additionally, the Perioscope™ facilitated calculus detection between the reevaluation appointments, where the explorer did not. Overall, the Perioscope™ outperformed the explorer in residual calculus detection.

Joy B. Osborn RDH, MA, Associate Professor, Division of Dental Hygiene, School of Dentistry, University of Minnesota. Patricia A. Lenton, RDH, MA, Director, Oral Health Clinical Research Clinic, School of Dentistry, University of Minnesota. Scott A. Lunos, MS, Research Fellow, Biostatistical Design and Analysis Center, Clinical and Translational Science Institute, University of Minnesota. Christine M. Blue BSDH, MS, Associate Professor and Director, Division of Dental Hygiene, School of Dentistry, University of Minnesota.

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