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Mark McCawley, D.M.D.

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By

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I certify that I am the sole author of this thesis, and that any assistance I received in its preparation has been fully acknowledged and disclosed in the thesis. I have cited any sources from which I used ideas, data, or words, and labeled as quotations any directly quoted phrases or passages, as well as providing proper documentation and citations. This thesis was prepared by me, specifically for the M.S. degree and for this assignment.

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Mark McCawley, D.M.D. August 24, 2015

Synopsis

My research investigated the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus. The gold standard for subgingival calculus detection has always been tactile probing. In this study I collected 27 teeth and investigated 108 surfaces, I had to exclude one tooth (group #13) where no calculus was observed on any surface, and three surfaces because of subgingival root caries to avoid confounding data, which left a total of 101 surfaces of 26 extracted teeth that meet the investigation criteria. The presence of subgingival calculus was observed on 75 tooth surfaces (74.25%). There was a correlation between tooth surface and the presence of calculus. Subgingival calculus was from most to least frequently observed on the Distal surface (92.0%), Lingual surface (76.9%), Mesial surface (70.8%) and Facial surface (57.7%). The amount of laser fluoresce increased according to the amount of subgingival calculus. There was a correlation between the amount of subgingival calculus and the amount of laser fluorescence. The tactile probing had a similar sensitivity compared to laser fluorescence for the detection of subgingival calculus. The laser fluorescence was more specific compared to tactile probing for the detection of subgingival calculus. The tactile probing had a similar accuracy compared to laser fluorescence for the detection of subgingival calculus. The laser fluorescence had more precision compared to tactile probing for the detection of subgingival calculus. My results show that by using both tactile probing and laser fluorescence the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus can be increased. An increase in the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus could help in the diagnosis and treatment of patients suffering from gingival recession and periodontal disease.

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Abbreviations

ANOVA	Analysis of Variance
CHX	Chlorhexidine gluconate
IRB	Institutional Review Board
mg	Milligram[10^{-3}]
ml	Microliter [10^{-6}]
ml	Milliliter [10^{-3}]
mm	Millimeter
USA	United States of America
wk	Week
LF	Laser Fluorescence

Statistical terms

P value	The probability of obtaining a result as extreme as the one that was actually observed from chance alone. The P value significance level used in my thesis was $P<0.05$.
ANOVA	Analysis of variance, a statistical test that provides the probability of whether or not there are any differences among two or more means of several groups.
Scheffe Test	This test is a multiple comparison post hoc ANOVA test to test the probability that there are differences among the means of several groups.
Chi Square	This test is nonparametric statistical test used to determine if a distribution of observed frequencies differs from the theoretical expected frequencies.

Products and materials in this research

Name	Supplier	City, State
11/12 ODU Explorer	Hu-Friedy	Chicago, IL
Diagnodent Classic	Kavo	Charlotte, NC
Diagnodent Perio Tip	Kavo	Charlotte, NC

1. Introduction

1.1. Periodontal Disease

Periodontal disease is a bacterially initiated, inflammatory mediated infection of the supporting structures of the teeth. While the bacteria are the cause of the disease, periodontitis can be initiated and exacerbated by a multitude of different host factors ranging from genetics, immune dysfunction, hormonal imbalance, systemic diseases, occlusal trauma to smoking (1). Periodontitis can affect all population groups and has a high prevalence with 47% of the adult population suffering from some form of the disease and 38% exhibiting moderate to severe periodontitis. The chronic form of the disease progresses with age with fewer younger people suffering from it. But as age advances past 75 the prevalence is almost 85% with many presenting with moderate to severe periodontitis (2).

A periodontal pocket has many different bacteria that colonize it. The pocket is colonized first by the more benign gram positive aerobes such as *Streptococcus* and *Actinomyces sp*. As time progresses if the bacteria are not removed periodontal disease can develop when the bacterial flora shifts to a higher prevalence of gram negative anaerobes. These gram negative anaerobes have been attributed to having a higher prevalence of disease. This microbial shift is aided by the complex interaction of the bacterial species such as with the filamentous rod *Fusobacterium nucleatum* that allow the late colonizers to attach and thrive in the more virulent biofilm (3,4).

The bacteria of the periodontal pocket have classically been divided up into complexes based on perceived virulence. The red complex is most attributed to exacerbation of disease and it is composed of the bacterial species *Tannerella forsythia, Treponema denticola*, and *Porphyromonas gingivalis* (5). These virulent pathogens

precipitate an immunologic inflammatory response that causes the creation of periodontal pockets by the loss of periodontal attachment and bone. Treatment is based on removal of the pathogens from the pocket mechanically and/or chemotherapeutically which is necessary to prevent further breakdown.

The periodontal bacteria have been correlated with a multitude of systemic diseases such as heart disease, stroke, diabetes, preterm births, and autoimmune diseases (6-9). This can be caused by the periodontal pathogens circulating in the blood stream or as a result of the chronic increased systemic inflammation from the immune reaction to periodontal disease (10).

1.2. Etiology of Calculus

The etiology of periodontal disease is a buildup and subsequent immunologic reaction to bacterial deposits of biofilm, calculus, and toxins adhered to diseased subgingival root surfaces. The subgingival calculus and plaque deposits act as a reservoir for periodontal pathogens and their byproducts (11). These biofilms are organized in such a way that they are frequently resistant to both the natural immune and mechanical defense mechanisms of the sulcus and to any adjunctive chemotherapeutics (12).

Calculus itself is formed by bacterial byproducts and is composed of a mixture of roughly half inorganic and half organic substances. The acellular portion is mostly made of a calcium phosphate material with crystals of calcium, phosphorous, and magnesium. A majority of the organic composition of calculus is a dense cellular matrix where the bacteria reside (13). Supragingival calculus can usually be differentiated from subgingival because at or above the gums it is usually white while the subgingival deposits absorb iron from the bleeding pockets and are frequently darker in color (14,15).

1.3. Clinical Attachment Loss

Clinical attachment loss along with probing depth and recession are measurements of loss of periodontal support. These measurements are recorded in millimeters using a periodontal probe. Probing depth is the distance from the free gingival margin to the furthest extent of probing down to the base of the pocket. Recession is the distance from the cementoenamel junction to the free gingival margin. Combining both measurements from the cementoenamel junction to the base of the probing pocket gives the clinical attachment loss. These measurements are typically made on 6 surfaces of the teeth but epidemiological studies have used as few as 2. The current study uses 4 surfaces with the facial, lingual, mesial and distal due to the inability to clinically and visually differentiate an exact delineation between the interproximal facial and lingual surfaces (16).

1.4. Periodontal Therapy

The primary goal of periodontal therapy is to maintain the natural dentition by controlling the microbial periodontal infection thus arresting the chronic inflammation that leads to the creation of periodontal pockets. This can be successfully accomplished by disrupting and removing the bacterial biofilm, calculus, and toxins from infected crown and root surfaces. The mechanical debridement accomplishes the removal of calculus and biofilm from the periodontally disease root surfaces and reliably reduces inflammation, probing pocket depths, and increasing the clinical attachment level (17). This debridement is the basis for the treatment of all inflammatory periodontal diseases and can be performed surgically or nonsurgically.

1.4.1 Nonsurgical Therapy

Nonsurgical subgingival debridement is a relatively noninvasive periodontal treatment consisting of ultrasonic and/or hand scaling the root surfaces. Subgingival scaling and root planing is the gold standard for nonsurgical therapy and has been shown to be an effective periodontal treatment (18) and is effective for reversing or controlling inflammatory periodontal disease by reducing bleeding on probing, probing depths and increasing attachment levels (19). Nonsurgical therapy is typically used as the first line treatment choice in all pocket depths and has been shown to reduce probing depths 1–2 mm in moderate to deep pockets and increase attachment levels about 0.5-2 mm in moderate to deep pockets but there are several drawbacks with this therapy (20-25).

This treatment does tend to cause some clinical attachment loss when shallow pockets are overinstrumented so care should be taken to limit the root planing to sites that require it. Visualization and identification of the calculus are limiting factors for treatment success, often times leading to incomplete removal of these deposits (26). These lead to questionable the long-term maintainability of deep periodontal pockets with having a high number of posttreatment residual pockets exhibiting bleeding on probing and > 5 mm deep being related to a higher risk of disease recurrence and lower clinical stability (11). The success of this technique is heavily dependent on the skill of the operator. At depths 3-5mm there can be residual calculus and this residual etiology is more commonly left behind in pockets (27) deeper than 5mm (28). This leads to an incomplete healing and continuation of disease. This limits the use of nonsurgical therapy as a definitive treatment to relatively shallow pockets where identification and removal of the calculus is not as difficult.

1.4.2 Surgical Therapy

Periodontal surgery is another treatment modality that eliminates the limiting factors of nonsurgical therapy by reflecting a mucogingival flap. This aids in the clear identification of subgingival calculus deposits and adequate access to the root surfaces followed by ultrasonic and/or hand scaling to remove these deposits. While nonsurgical therapy is most effective in shallow sites (29) the surgical approach is superior in pocket reduction and etiology removal in the deeper pockets but it is not without its own drawbacks. Periodontal surgery has a high morbidity for the patient with severe post-operative pain as well as recession and hypersensitivity commonly occurring as well as attachment loss in the shallower pockets (30,31,32). This painful and unaesthetic surgical treatment limits patient acceptance. Due to these drawbacks the less invasive nonsurgical therapy should be preferred to treat periodontal disease (33) if the etiology can be removed and comparable results are expected.

1.5. Calculus Detection

Calculus detection remains extremely important in surgical and nonsurgical scaling. For nonsurgical scaling the gold standard for calculus detection has been with an 11/12 ODU explorer. This method uses minute tactile touch to subgingivally probe around the roots (34) and when a large enough deposit of calculus is encountered the tip gets caught on it before jumping over it with a feeling that has been likened to a "click". This method has severe drawbacks as it is very technique sensitive (35) and somewhat time consuming to thoroughly probe each tooth for calculus. The technicians can be misled by root roughness or anatomy therefore leading to over or under treatment. A hygiene study showed that multiple examiners only agreed on their detection for 1/3 of the calculus

deposits (36). This indicates that there is a massive amount of calculus that would go undetected by some examiners as well as the possibility of false positives. This level of disagreement by trained professionals for a technique that is fundamental to the success of therapy indicates that there is a large amount of subjectivity involved in calculus detection.

Recently there have been attempts to create more reliable and objective methods for calculus detection. These detection methods vary and include fiber optic endoscopy, autofluorescence, ultrasonic, as well as ER:YAG laser based identification (37). All of these devices have studies verifying their efficacy though many are costly, complicated and some of the combination detection/removal devices cannot be legally operated by a hygienist, who performs much of the scaling in a dental practice.

1.6. Laser Fluorescence Detection

Laser fluorescence for calculus detection works by emitting light with a diode laser and measuring the light that is reflected back by the native tooth structure and calculus. This is performed with an InGaAsP diode laser emitting a 655 wavelength light delivering the energy to the base of the pocket using a rigid sapphire tip. The same tip measures the light that is reflected back by the tooth and calculus. Healthy crown and root structure exhibits little fluorescence at this wavelength while plaque and calculus fluoresces back at a higher wavelength (720nm). This fluorescence is caused by bacterial metabolic activity (38) as well as porphyrins and other chromatophores present in subgingival calculus (39). The amount of fluorescence has a positive correlation to the presence of

calculus and is reproducible with the laser energy not being significantly influenced by the type of fluids (40).

Research has shown that laser fluorescence has a high level of sensitivity, specificity and reproducibility for caries detection (41,42). For calculus detection there have been only in vitro studies utilizing the laser fluorescence for calculus detection. These studies have shown that this method can reliably detect calculus deposits in the various mediums; air, saline, and blood (43). The laser fluorescence device can differentiate between calculus and cementum with great reproducibility and the values directly correlate to the presence of calculus deposits (40). Utilizing laser fluorescence for calculus detection when used in conjunction with curette instrumentation increased the removal of calculus deposits on multi rooted teeth leaving less residual etiology as compared to traditional explorer detection (44). The laser fluorescence readings have also been shown to correlate to volume and area of calculus (45).

While the laser fluorescence has already been proven to be effective in detecting calculus *in vitro*, this device has yet to be proven to detect calculus in vivo. If it accurately detects calculus in vivo then it could be used in conjunction with nonsurgical therapy as a replacement for the unreliable explorer based calculus detection. It's use during therapy could increase the identification and removal of the disease causing etiology leading to a more favorable post-operative healing and pocket reduction thus reducing the need for the more invasive periodontal surgery.

If laser fluorescence does prove to be more sensitive, specific, and accurate than the traditional explorer based calculus detection then it will be determined to be a superior calculus detection method. This comparison would determine if this is truly an improvement over the traditional detection method.

Laser fluorescence is a revolutionary innovation for calculus detection. It aims to replace the traditional explorer based calculus detection method with a more objective method that would also be more accurate and reproducible.

1.7. Research Objectives

The objectives of this research were to compare the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus. The gold standard for subgingival calculus detection has always been tactile probing. In this study I used tactile probing and laser fluorescence to estimate the amount of subgingival calculus, and then after the teeth were extracted I measured the presence of subgingival calculus on the surfaces of teeth.

2. MATERIALS AND METHODS

2.1. Regulatory Approvals

The study was given IRB approval. The study did not require an IACUC review and approval, because it did not involve animals.

2.2. Prescreening Visit

Potential subjects were identified by the residents and faculty in the NSU Department of Postgraduate Periodontology as being possible recruitment candidates for this study during routine periodontal evaluations and treatment.

2.3. Subject Screening

At the extraction appointment the potential subjects were evaluated according to the subject selection criteria and they were asked to consent to participate in the study as well as to allow the extracted tooth to be used in this research study.

2.4. Subject Selection

Volunteer healthy adults aged at least 18 years were recruited by postgraduate periodontal residents at Nova Southeastern University College of Dental Medicine. The purpose and design of the study was explained and the patients signed an informed consent form. The study design and consent form was also approved by the Nova Southeastern Institutional Review Board in accordance with the Helsinki Declaration of 1975, as revised in 2000. The subjects were incentivized to participate in this study by having their fee for the tooth extraction reduced by $50 with the reduction being paid from the HPD grant.

A total of twenty seven teeth in need of extraction were selected for this study (108 surfaces) among the participating subjects.

All subjects met the following criteria:

1) Must be at least 18 years old irrespective of gender or ethnicity.

2) Must not have uncontrolled diabetes or any history of radiation or bisphosphonate therapy.

3) Must not have been diagnosed, or believe themselves to be pregnant.

4) Must have at least one periodontally involved hopeless tooth (deemed in need of extraction).

5) Teeth must have had attachment loss, no root caries, with pockets between 4-9mm on all four surfaces to be evaluated: distal, facial, mesial, and lingual. The surfaces were delineated by the line angles of the tooth.

After checking all the extracted teeth, I had to exclude one tooth (group #13) where no calculus was observed on any surface. I also had to exclude three surfaces of other teeth because I found subgingival root caries on them. These teeth and surfaces were excluded to avoid including confounding data in my results. After the excluded tooth and surfaces were removed from my data, I had a total remaining of 101 surfaces of 26 extracted teeth that meet the investigation criteria.

2.5. Data Collection

I collected the data from the preoperative periodontal readings, tactile explorer detection of calculus, and stereomicroscopic analysis. Periodontal resident Dr. Kyle Deluca analyzed each surface of the teeth with laser fluorescence. Two blinded examiners were used for the detection stage so that neither examiner would know if the other found calculus to avoid bias.

2.6. Informed Consents.

Each of the subjects provided a written informed consent approved by NSU IRB prior to their participation in this research study.

2.7. Probing Depth and Gingival Recession.

Topical anesthetic (20% Benzocaine) was applied to the injection site then 2% Lidocaine 1:100,000 epinephrine was injected. The teeth were supragingivally scaled to remove any calculus and plaque supragingivally to avoid confounding the calculus detection. Intraoral photos were taken of the teeth that were extracted. The tooth probing depths were measured using an UNC15 explorer to the nearest 1mm. The amount of gingival recession was measured from cementoenamel junction to the free gingival margin and recorded to the nearest 1mm.

The root surfaces were then checked with the laser fluorescence device followed by the 11/12 extended explorer on 4 surfaces from line angle to line angle and the readings were recorded for each surface.

2.8. Laser Fluorescence Detection of Subgingival Calculus.

A Diagnodent classic laser fluorescence device was fitted with a perio probe sapphire tip. Resident Dr. Kyle Deluca inserted the probe into the sulcus apically to the bottom of the sulcus, to a maximum of 9mm (limited by the probe length). The probe was walked around each surface on the tooth. The highest quantitative reading (0-99) was recorded for each surface.

2.9. Tactile Explorer Detection of Subgingival Calculus.

I used an 11/12 ODU explorer to tactilely feel around each tooth surface for the roughness or “click” of calculus. Each surface was graded on a scale of 0-2 as follows: 0)

no calculus, 1) light calculus or roughness, and 2) moderate to heavy calculus present (44).

After the laser and explorer assessment the teeth were atraumatically extracted by the attending resident to carefully to avoid removing the subgingival calculus with the extraction instruments. I cleaned the teeth by gentle tooth brushing with sterile saline and stored the teeth in sterile saline until stereomicroscopic analysis was performed.

2.10. Post-operative Treatment

The subjects were given chlorhexidine-gluconate 0.12% mouth rinse and instructed to use it twice daily for two weeks by the attending resident. The subjects were advised to take ibuprofen as needed for pain. The subjects were instructed to call the attending resident if any complications such as pain arose. The subjects were followed up with a post-operative visit 1-2 weeks later following tooth extraction to verify that the socket was healing within normal limits.

2.11. Stereomicroscopic Analysis

I examined the extracted teeth for the presence of calculus on their root surfaces at a 12x magnification. Photographs were taken at magnification on all surfaces of the specimens.

2.12. Assessment of Subgingival Calculus

I examined the presence of subgingival calculus on each tooth surface by stereomicroscopic and magnified visual analysis and graded the amount according to the

following criteria: 0) None, 1) Small amount of calculus, and 2) Substantial amounts of calculus (44). The presence of subgingival calculus was compared to the laser fluorescence detection as well as the tactile explorer detection for those surfaces (44). I used a fluorescence reading of 40 or higher to represent a positive detection of calculus (44).

2.13. Primary Outcome Assessments of Subgingival Calculus

The sensitivity, specificity, and accuracy were calculated for the laser fluorescence detection of subgingival calculus and were then compared to tactile explorer detection as determined by stereomicroscopic-magnified direct visual examination of the tooth root surfaces.

2.14. Biohazard Procedures and Waste Disposal

The extracted teeth were disposed of according to NSU standard OSHA protocols for handling potentially bio-hazardous waste, and they were collected after use for disposal by NSU waste services.

2.15. Statistical Analysis and Data Interpretation

All the data was collected in a de-identified manner to help avoid any experimenter bias. Then, I entered the data into excel spreadsheets which was imported into STATview (Cary, NY) a statistical analysis software program. The numerical data was then analyzed to determine the means, sample numbers, power, and Analysis of Variance (ANOVA) P value at the $P<0.05$ significance level. If a significant P value was found the data was analyzed further using a Scheffe post-hoc ANOVA test (46) at the $P<0.05$ significance

level. These statistical tests were used because they have been claimed to be versatile and the most conservative multiple comparison test (47).

If two sets of numerical data were to be analyzed a regression analysis was performed using an ANOVA test at the $P<0.05$ significance level. If qualitative data was analyzed a Chi-square statistical test was used at the $P<0.05$ significance level. Each individual data comparison was drawn as a chart and the statistical analysis for each chart is shown in the appendix.

3. RESULTS

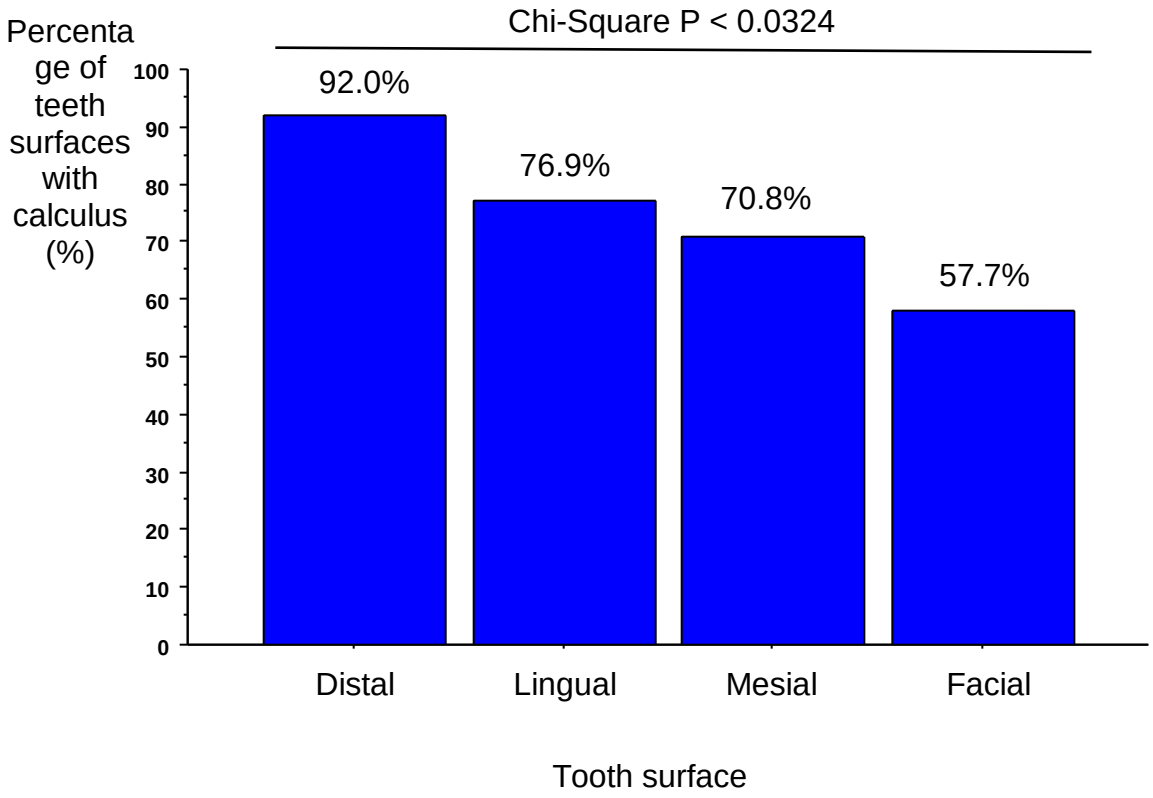
3.1. Subgingival calculus attached to the surfaces of extracted teeth.

I collected 27 teeth and investigated 108 surfaces, I had to exclude one tooth (group #13) where no calculus was observed on any surface, and three surfaces because of subgingival root caries to avoid confounding data, which left a total of 101 surfaces of 26 extracted teeth that meet the investigation criteria. The presence of subgingival calculus was observed on 75 tooth surfaces (74.25%). There was a correlation between tooth surface and the presence of calculus (Chi-Square G-squared value $P < 0.0324$). Subgingival calculus was from most to least frequently observed on the Distal surface (92.0%), Lingual surface (76.9%), Mesial surface (70.8%) and Facial surface (57.7%) (Figure 1.).

3.2. Amount of subgingival calculus on the surfaces of extracted teeth.

Subgingival calculus was graded according to the following criteria: 0 = None (Figure 2), 1 = Small amount of calculus (Figure 3), 2 = Moderate to heavy amounts of calculus (Figure 4) and 3 = Cement retention. There was a correlation between the presence of calculus and the amount of calculus (Chi-Square G-squared value $P < 0.0001$). There were 20 teeth surfaces with no calculus (n=0), 37 teeth surfaces had small amounts of calculus, 42 teeth surfaces had moderate to heavy amounts of calculus, and only 2 tooth surfaces had retained cement.

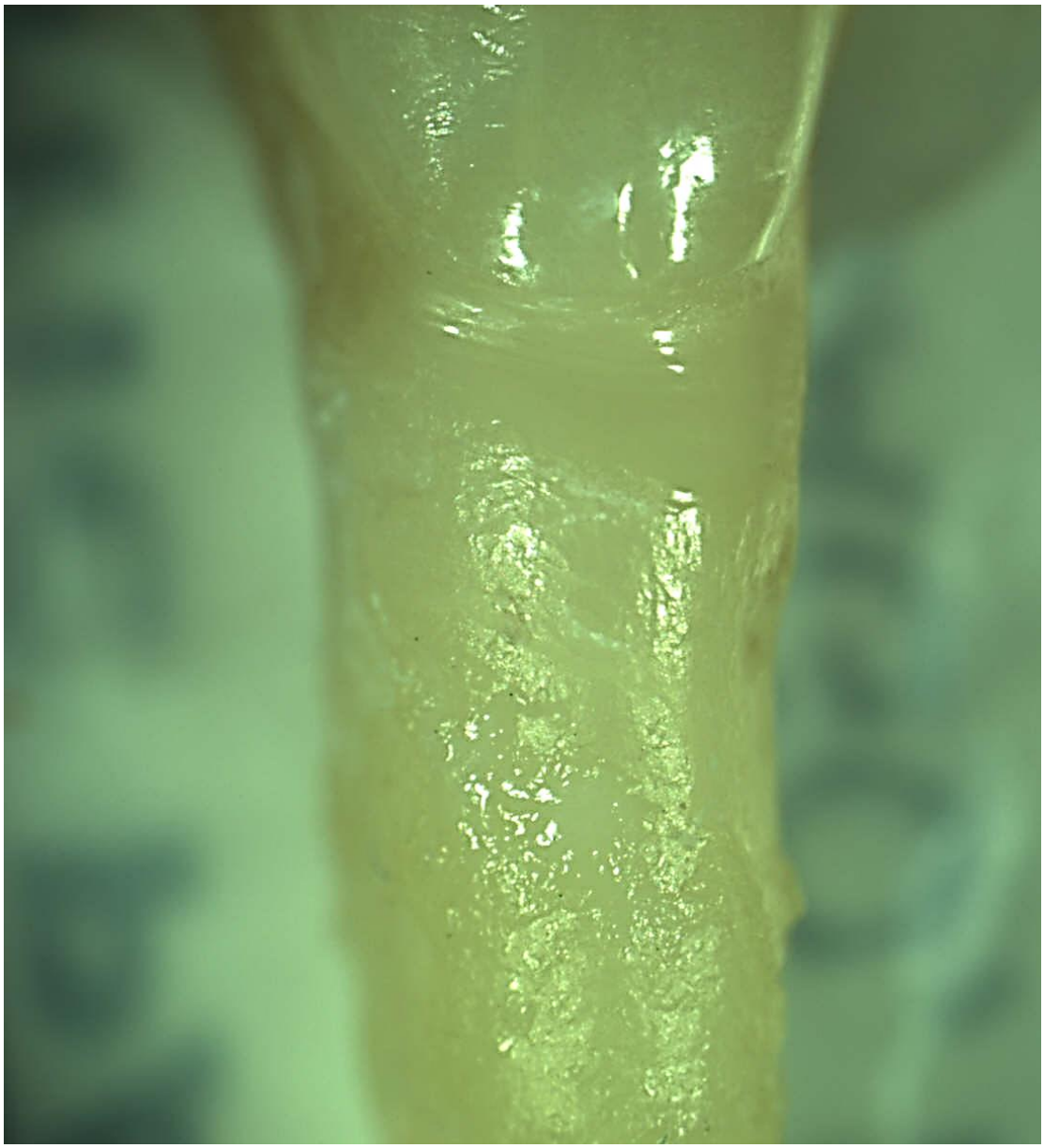
Figure 1. Bar chart of subgingival calculus attached to the surfaces of teeth.



The bar char represents the percentages of teeth surfaces with subgingival calculus.

The subgingival calculus was from most to least frequently observed on the Distal surface (92.0%), Lingual surface (76.9%), Mesial surface (70.8%) and Facial surface (57.7%). There was a correlation between tooth surface and the presence of calculus (Chi-Square G-squared value P < 0.0324).

Figure 2. An extracted tooth with no subgingival calculus.

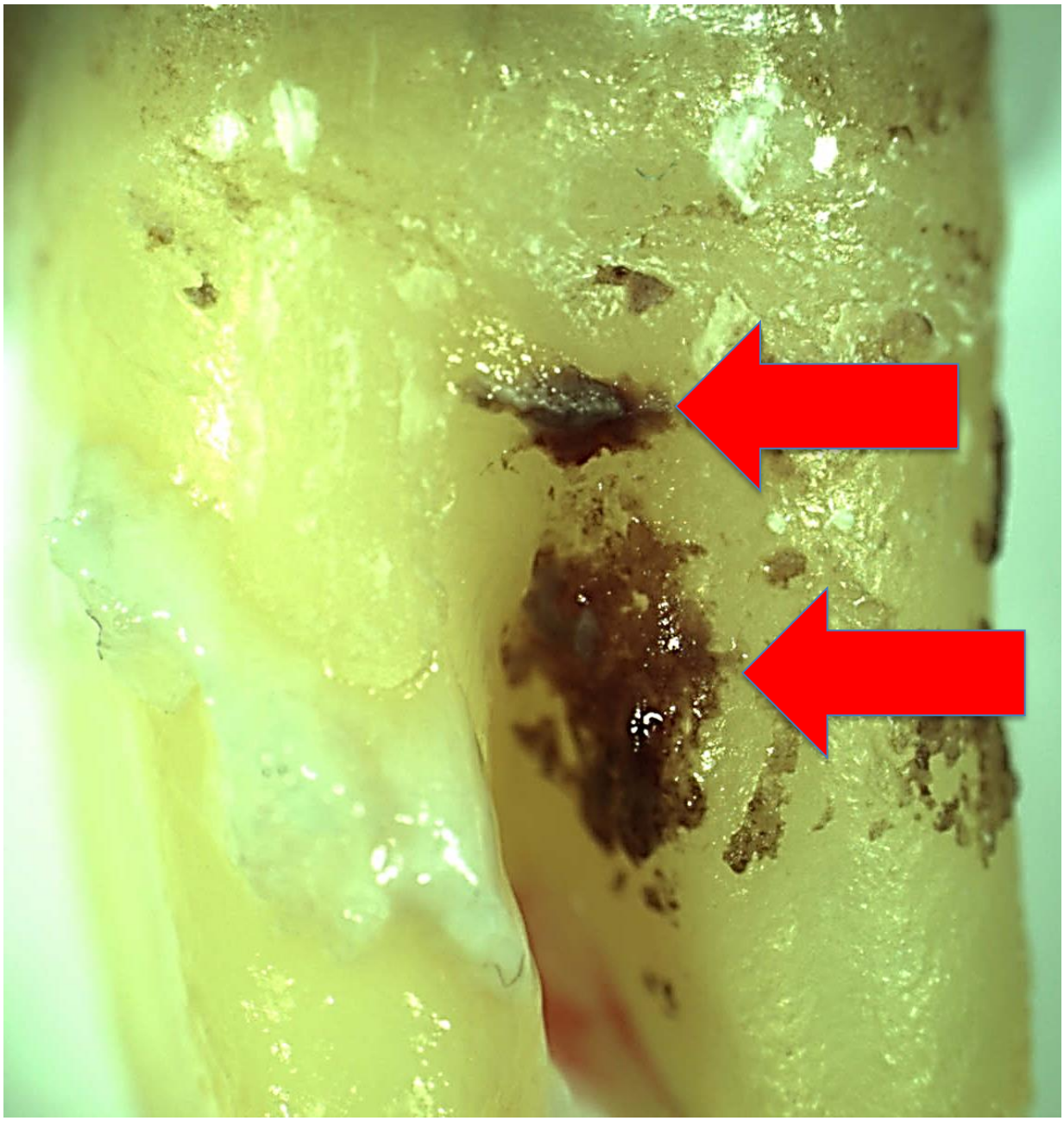


The 12X magnification photograph shows the root of an extracted human tooth where no subgingival calculus could be observed.

Figure 3. An extracted tooth with a small amount of subgingival calculus.

The 12X magnification photograph with an arrow showing a small amount of subgingival calculus.

Figure 4. An extracted tooth with a moderate to heavy amount of subgingival calculus.



The 12X magnification photograph with an arrow showing a moderate amount of subgingival calculus.

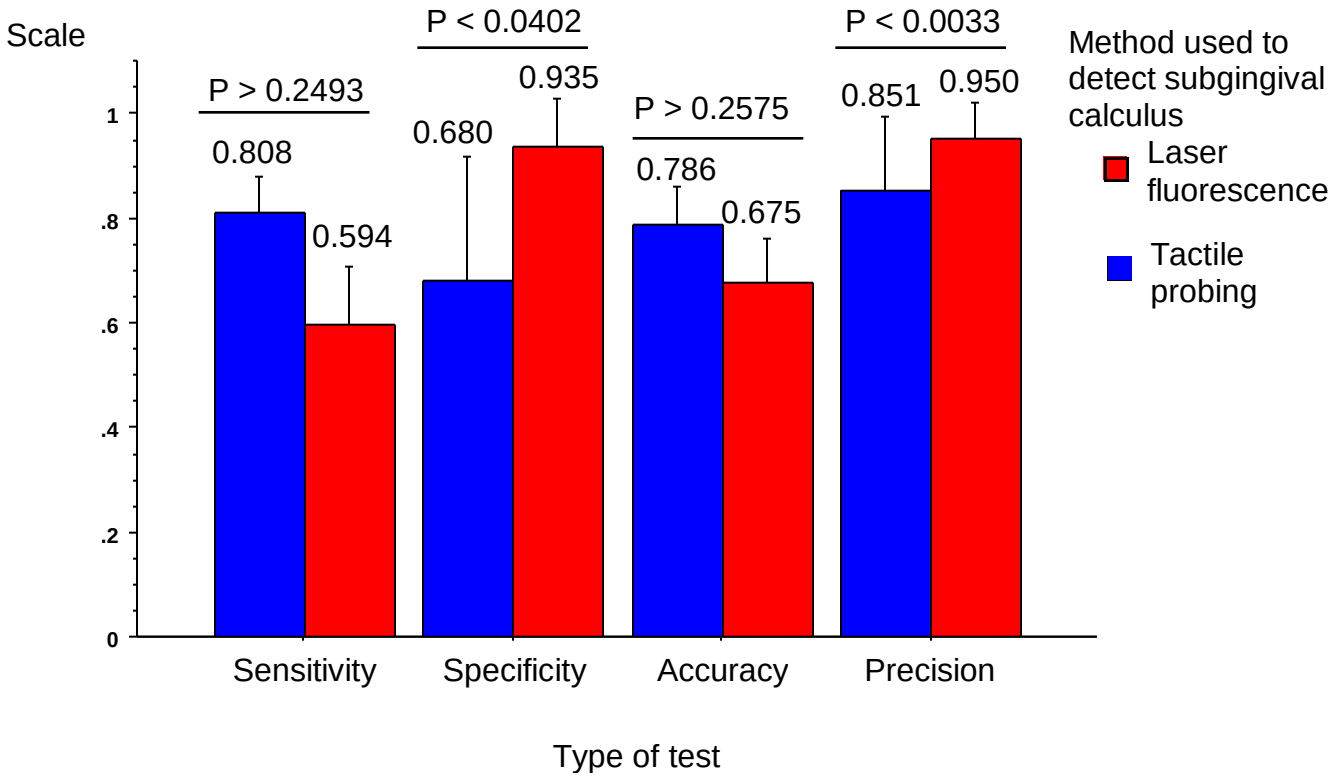
3.3. Comparison of the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus.

The tactile probing had a similar sensitivity (0.594) compared to laser fluorescence (0.808) for the detection of subgingival calculus, (ANOVA $P > 0.293$, Power 0.172). The laser fluorescence was more specific (0.935) compared to tactile probing (0.680) for the detection of subgingival calculus (ANOVA $P < 0.0402$, Power 0.648). The tactile probing had a similar accuracy (0.786) compared to laser fluorescence (0.675) for the detection of subgingival calculus (ANOVA $P > 0.2575$, Power 0.167). The laser fluorescence had more precision (0.950) compared to tactile probing (0.851) for the detection of subgingival calculus (ANOVA $P < 0.0033$, Power 1.000) (Figure 5).

3.4. Comparison of the amount of subgingival calculus attached to the surfaces of teeth.

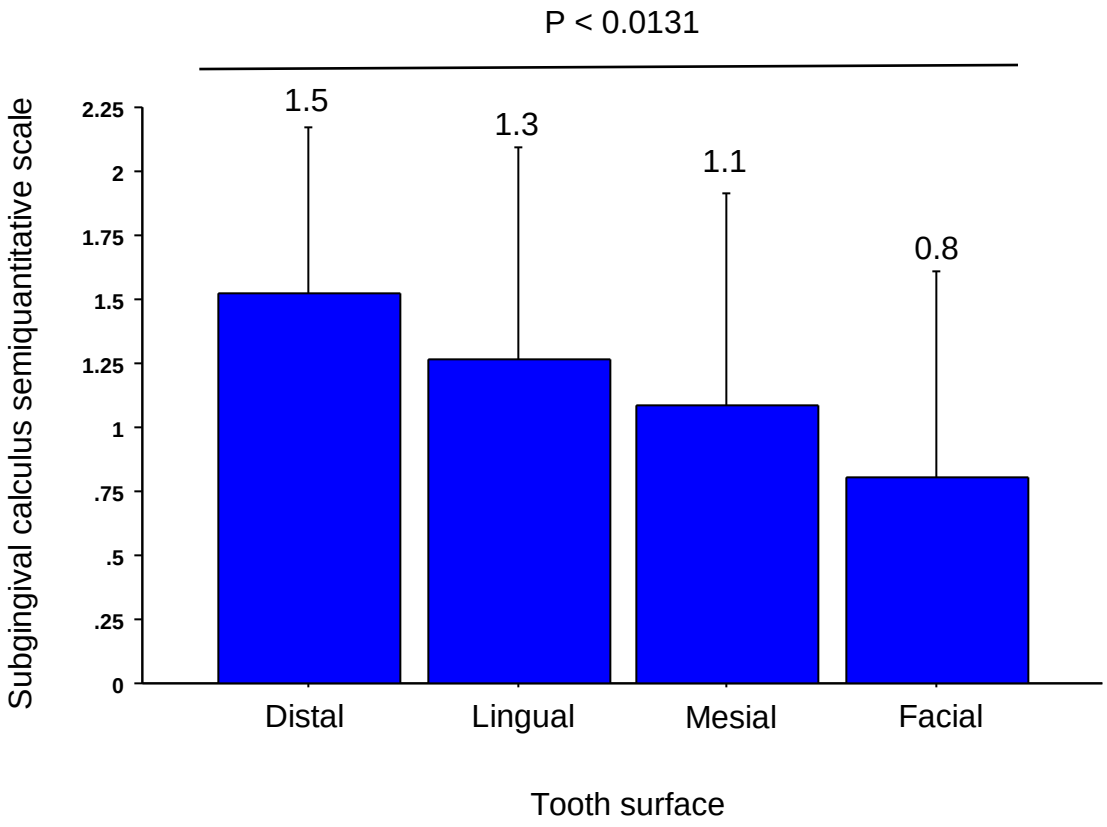
The semiquantative scale of subgingival calculus was highest (1.5) on the distal surfaces of teeth, less on the lingual (1.3) and mesial (1.1) and lowest on the facial surface of teeth (0.8). There was a difference between the amounts of subgingival calculus attached to the different surfaces of teeth (ANOVA $P < 0.0131$, Power 0.804) (Figure 6). The reduction in the subgingival calculus between the distal (1.5) and ligual (1.3) tooth surfaces was 13.3%. The reduction in the subgingival calculus between the lingual (1.3) and mesial (1.1) tooth surfaces was 15.4%. The reduction in the subgingival calculus between the mesial (1.1) and facial (0.8) tooth surfaces was 27.3% (Figure 6).

Figure 5. Bar chart of the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus.



The sensitivity of tactile probing (0.808) and laser fluorescence (0.594) was similar (ANOVA, P > 0.2493) for the detection of subgingival calculus. The specificity of laser fluorescence (0.935) was better (ANOVA, P > 0.0402) than tactile probing (0.680) for the detection of subgingival calculus. The accuracy of the tactile probing (0.786) and laser fluorescence (0.675) was similar (ANOVA, P > 0.2575) for the detection of subgingival calculus. The precision of laser fluorescence (0.950) was better (ANOVA, P < 0.0033) than tactile probing (0.851) for the detection of subgingival calculus.

Figure 6. Bar chart of the amount of subgingival calculus attached to the surfaces of teeth.



The semiquantative scale of subgingival calculus was highest (1.5) on the distal surfaces of teeth, less on the lingual (1.3) and mesial (1.1) and lowest on the facial surface of teeth (0.8). There was a difference between the amounts of subgingival calculus attached to the different surfaces of teeth (ANOVA P < 0.0131, Power 0.804). The reduction in the subgingival calculus between the distal (1.5) and ligual (1.3) tooth surfaces was 13.3%. The reduction in the subgingival calculus between the lingual (1.3) and mesial (1.1) tooth surfaces was 15.4%. The reduction in the subgingival calculus between the mesial (1.1) and facial (0.8) tooth surfaces was 27.3%.

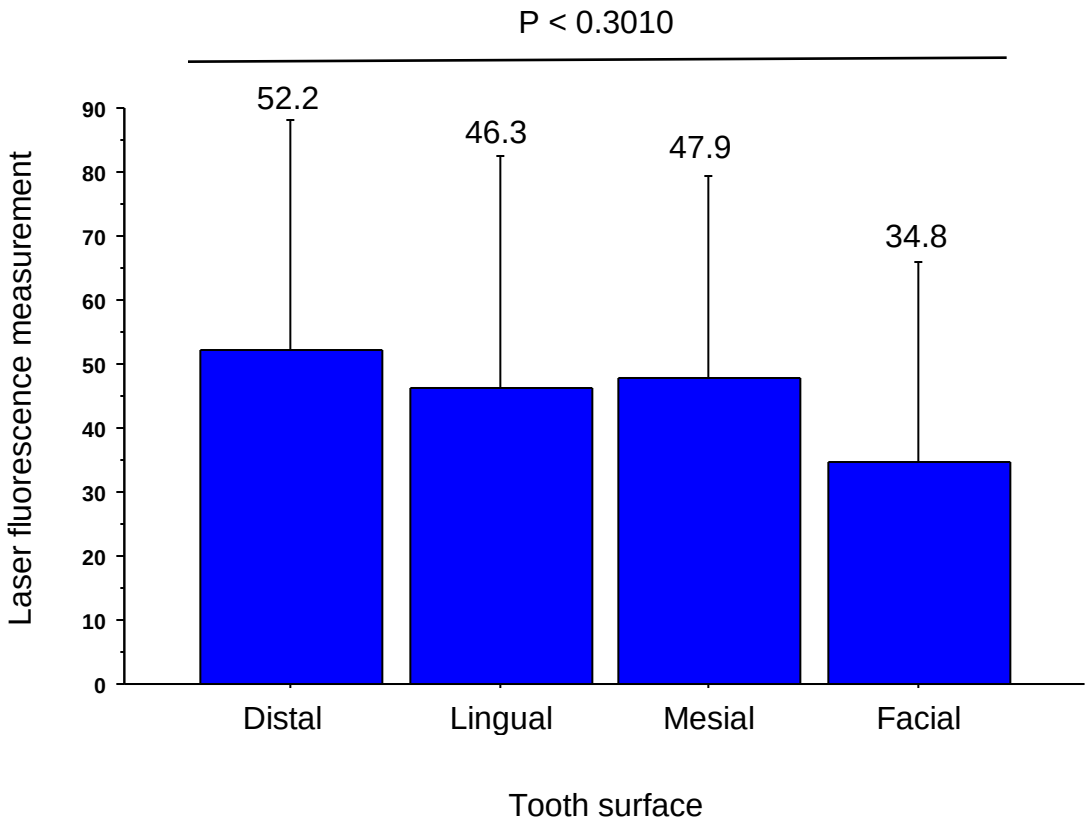
3.5. Comparison of laser fluorescence for each of the surfaces of teeth.

The mean amount of laser fluoresce for the distal surfaces of teeth was 52.2, for the lingual surfaces it was 46.3, for the mesial surfaces it was 47.9, and for the facial surfaces it was 34.8. There was no significant differences between the tooth surfaces and the amount of laser fluorescence (ANOVA, $P > 0.3010$, Power 0.313). The largest difference between the mean fluorescence for the tooth surfaces was distal (52.2) and facial (34.8) which was 33.3% (Figure 7).

3.6. Comparison of the laser fluorescence measurements and the presence of subgingival calculus.

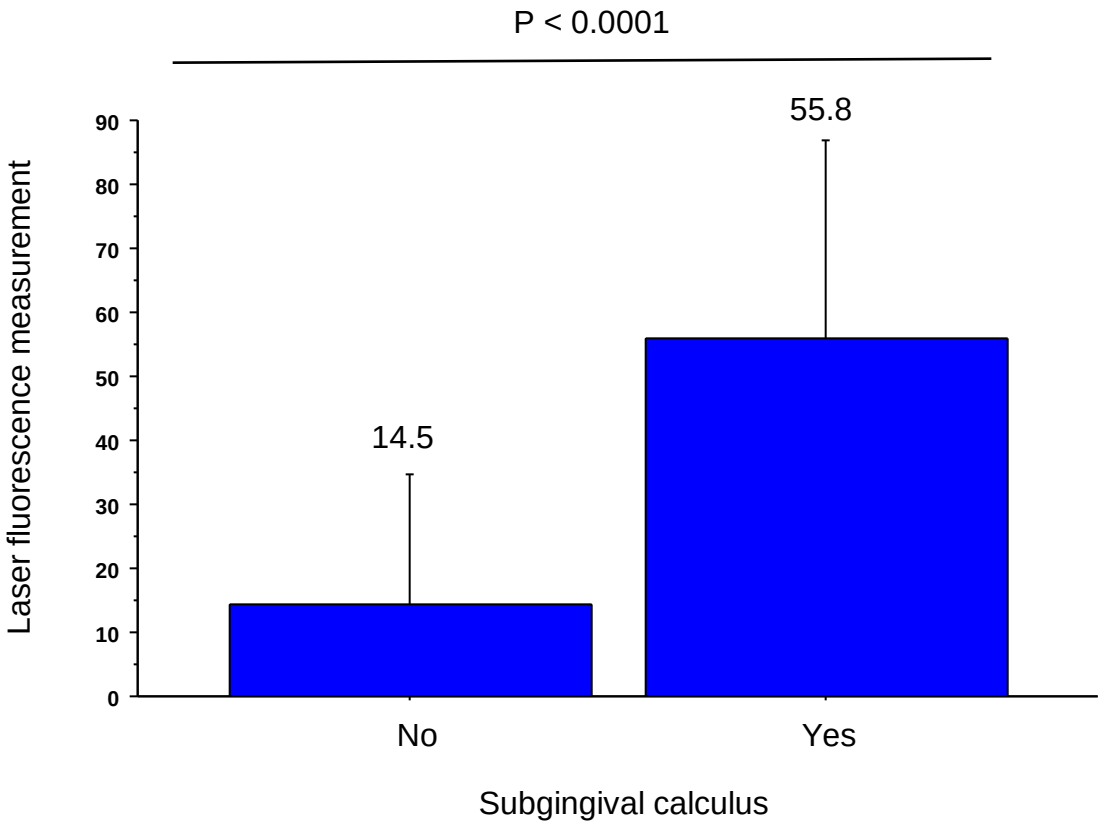
The mean amount of laser fluoresce for the tooth surfaces without subgingival calculus was 14.5, and for the surfaces with subgingival calculus it was 55.8. There was a significant difference between the laser fluoresce for the tooth surfaces with and without subgingival calculus (ANOVA, $P < 0.0001$, Power 1.000). The difference in the amount of laser fluoresce for the tooth surfaces with or without subgingival calculus was 384.8% (Figure 8).

Figure 7. Bar chart of laser fluorescence measurements and the surfaces of teeth.



The amount of laser fluoresce for the distal surfaces of teeth was 52.2, for the lingual surfaces it was 46.3, for the mesial surfaces it was 47.9, and for the facial surfaces it was 34.8. There was no significant differences between the tooth surfaces and the amount of laser fluorescence (P > 0.3010, Power 0.313). The largest difference between the mean fluorescence for the tooth surfaces was distal (52.2) and facial (34.8) which was 33.3%.

Figure 8. Bar chart of laser fluorescence measurements and the presence of subgingival calculus.



The mean amount of laser fluoresce for the tooth surfaces without subgingival calculus was 14.5, and for the surfaces with subgingival calculus it was 55.8. There was a significant difference between the laser fluoresce for the tooth surfaces with and without subgingival calculus (ANOVA, P < 0.0001, Power 1.000). The difference in the amount of laser fluoresce for the tooth surfaces with or without subgingival calculus was 384.8%.

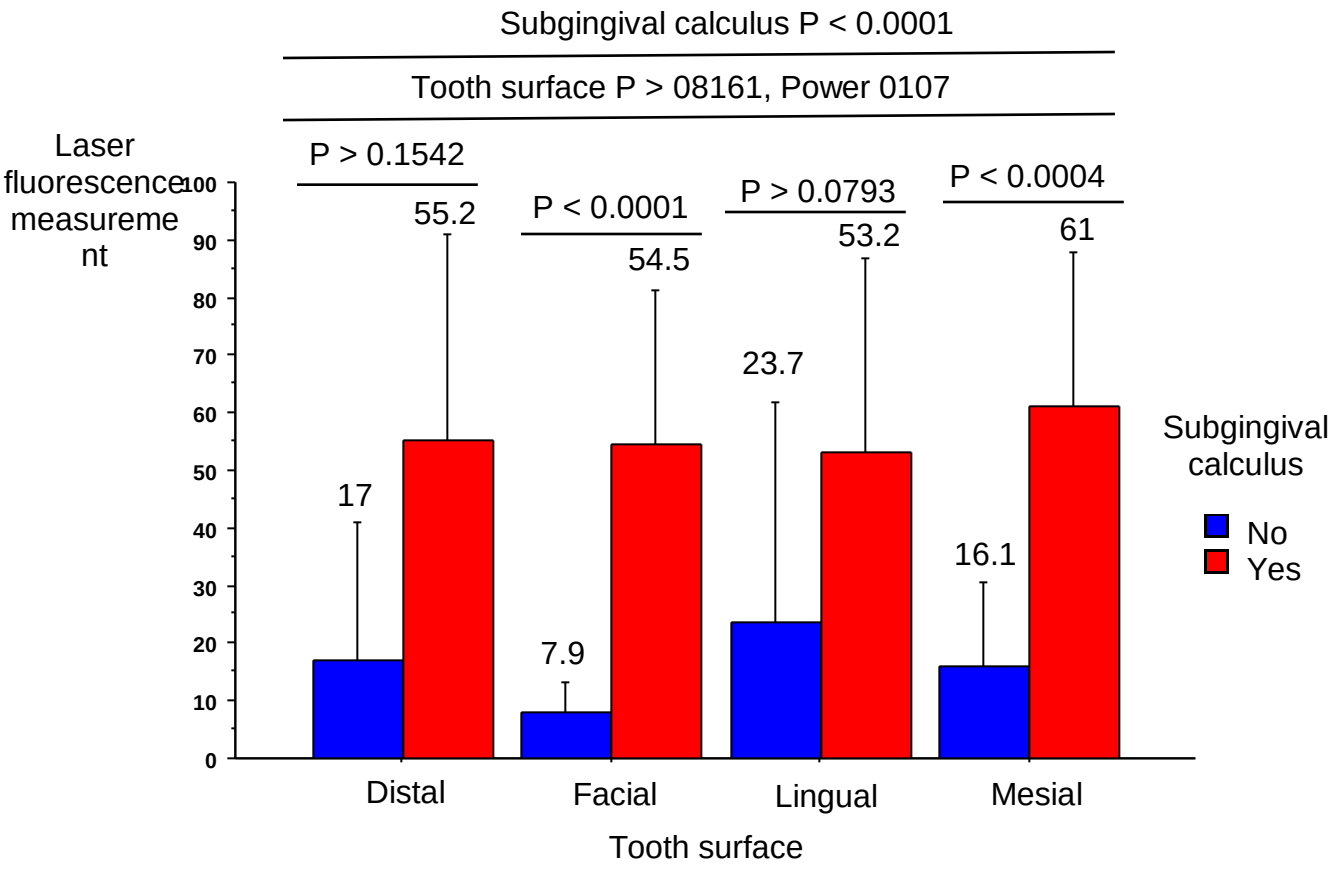
3.7. Comparison of the laser fluorescence measurements of tooth surfaces with and without subgingival calculus.

The mean amount of laser fluoresce for the surfaces of teeth with subgingival calculus was always high than the surfaces of teeth without subgingival calculus ($P < 0.0001$, Power 1.000). The amount of laser fluoresce from the surfaces of teeth were similar ($P > 0.8161$, Power 0.107). The amount of laser fluoresce for distal tooth surfaces with (55.2) and without (17) subgingival calculus was similar (Scheffe, $P > 0.1542$). The amount of laser fluoresce for facial tooth surfaces with (54.5) and without (7.9) subgingival calculus were different (Scheffe $P < 0.0001$). The amount of laser fluoresce for lingual tooth surfaces with (53.2) and without (23.7) subgingival calculus were different (Scheffe $P > 0.0793$). The amount of laser fluoresce for mesial tooth surfaces with (61) and without (16.1) subgingival calculus were different (Scheffe $P < 0.0004$) (Figure 9).

3.8. Comparison of the amount of subgingival calculus attached to the surfaces of teeth and laser fluoresce.

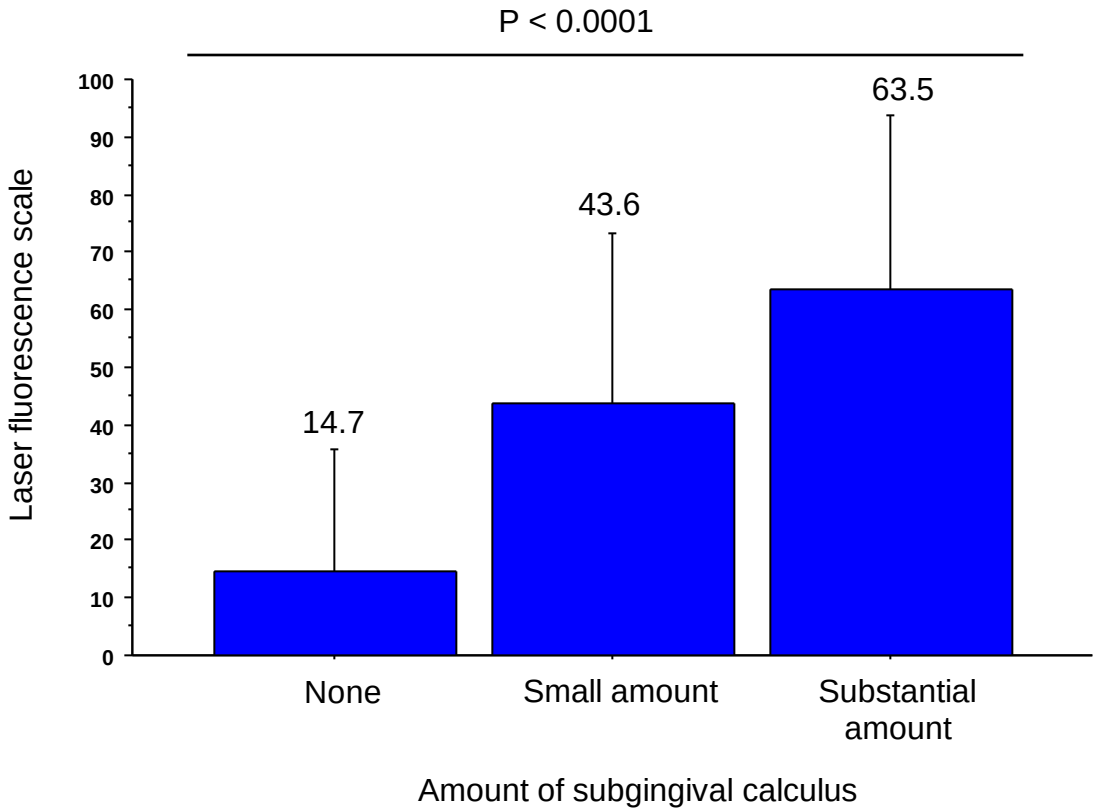
The amount of laser fluoresce increased according to the amount of calculus, no calculus (none) had a mean of 14.7, small amount was 43.6, and a substantial amount was 63.5. There was a correlation between the amount of subgingival calculus and the amount of laser fluorescence ($P < 0.0001$, Power 1.000). The difference between the individual three means was also significant. The difference between the fluorescence mean for no calculus and the presence of a small amount was 296.6%, between a small amount of calculus and a substantial amount was 145.6% (Figure 10).

Figure 9. Bar chart of the laser fluorescent measurement of tooth surfaces with and without subgingival calculus.



The mean amount of laser fluoresce for the surfaces of teeth with subgingival calculus was always high than the surfaces of teeth without subgingival calculus (P < 0.0001, Power 1.000). The amount of laser fluoresce from the surfaces of teeth were similar (P > 0.8161, Power 0.107). The amount of laser fluoresce for distal tooth surfaces with (55.2) and without (17) subgingival calculus was similar (Scheffe, P > 0.1542). The amount of laser fluoresce for facial tooth surfaces with (54.5) and without (7.9) subgingival calculus were different (Scheffe P > 0.0001). The amount of laser fluoresce for lingual tooth surfaces with (53.2) and without (23.7) subgingival calculus were different (Scheffe P < 0.0793). The amount of laser fluoresce for mesial tooth surfaces with (61) and without (16.1) subgingival calculus were different (Scheffe P < 0.0004).

Figure 10. Bar chart of the amount of subgingival calculus attached to the surfaces of teeth and laser fluoresce.



The amount of laser fluoresce increased according to the amount of calculus, no calculus (none) had a mean of 14.7, small amount was 43.6, and a substantial amount was 63.5. There was a correlation between the amount of subgingival calculus and the amount of laser fluorescence ($P < 0.0001$, Power 1.000). The difference between the individual three means was also significant. The difference between the fluorescence mean for no calculus and the presence of a small amount was 296.6%, between a small amount of calculus and a substantial amount was 145.6%

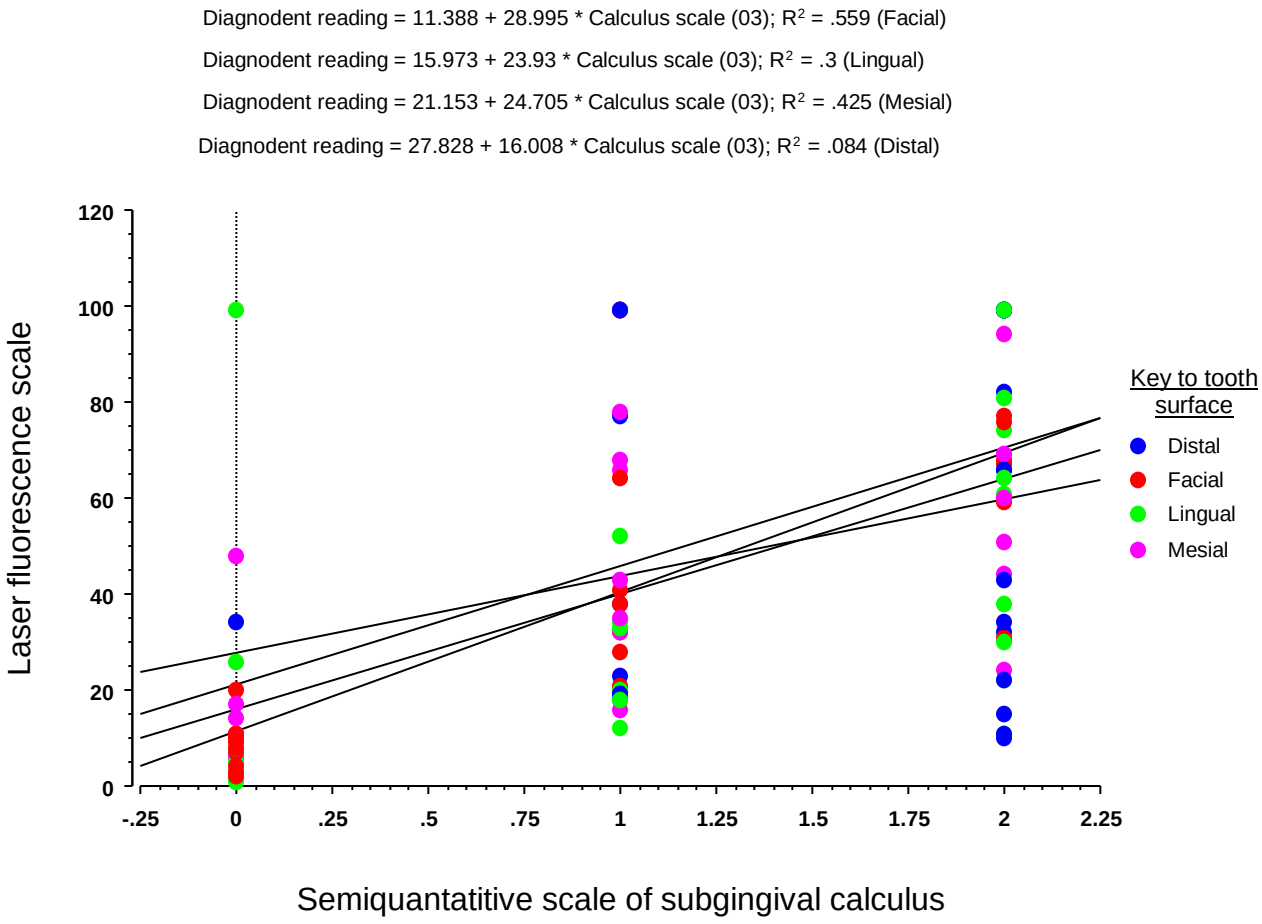
3.9. Regression analysis of the amount of subgingival calculus attached to the surfaces of teeth and laser fluorescence.

A regression correlation analysis between the amounts of subgingival calculus attached to the surfaces of teeth and laser fluorescence. As the semiquantitative scale of subgingival calculus increased, the amount of laser fluorescence increased (ANOVA, $P < 0.0001$, Power 1.0000). There was little difference between the amounts of subgingival calculus attached to the distal, mesial, lingual or facial surfaces of teeth (ANOVA, $P > 0.1594$, Power 0.272). The best linear regression fit between an increasing semiquantitative scale of subgingival calculus and increasing laser fluorescence was with the facial tooth surfaces ($R^2 = 0.559$). The worst linear regression fit between an increasing semiquantitative scale of subgingival calculus and increasing laser fluorescence was with the distal tooth surfaces ($R^2 = 0.084$) (Figure 11).

3.10. Comparison of the amount of laser fluorescence and the tactile explorer detection of subgingival calculus.

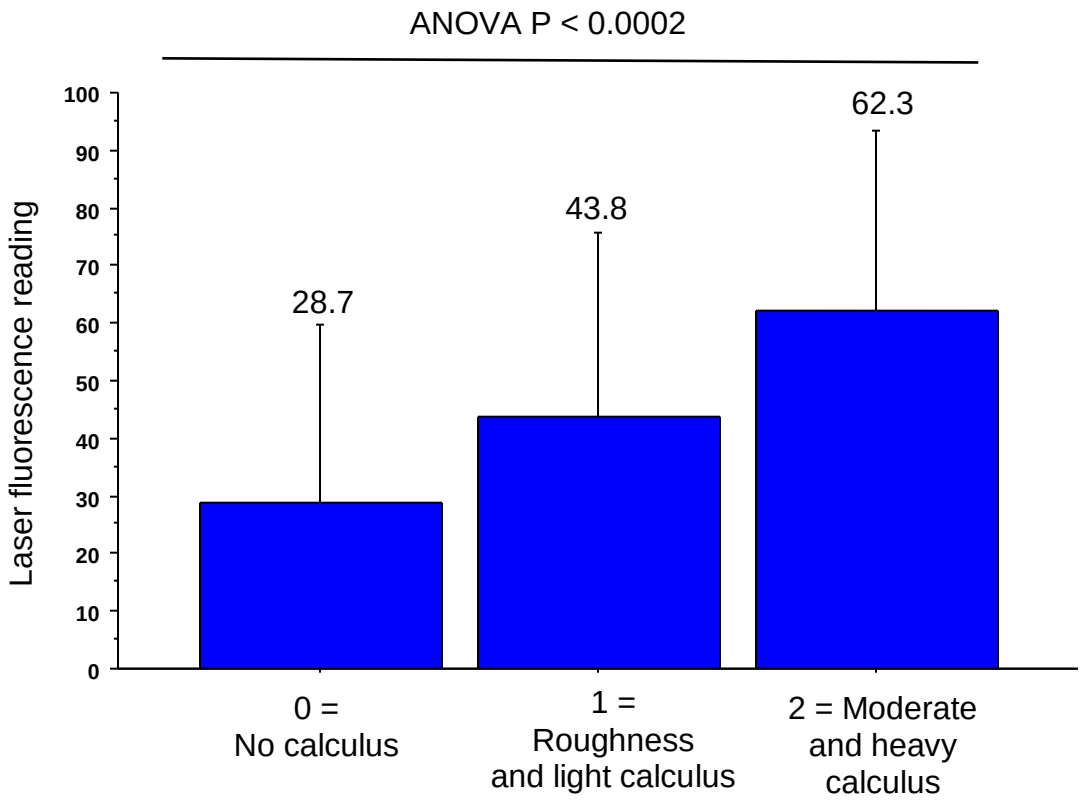
The amount of laser fluoresce increased according to the tactile explorer detection of subgingival calculus. No tactile explorer detection of subgingival calculus (none) had a mean of 28.7, a roughness and light detection of subgingival calculus was 43.8, which is an increase of 52.6%. The moderate or heavy tactile explorer detection of calculus was 62.3, which is a further increase of 42.2%. The amount of laser fluorescence increased as the tactile explorer detection of subgingival calculus increased (ANOVA, $P < 0.0002$, Power 0.982) (Figure 12).

Figure 11. Scattergram of the relationship between the amount of subgingival calculus attached to the surfaces of teeth and laser fluoresce.



A regression correlation analysis between the amounts of subgingival calculus attached to the surfaces of teeth and laser fluorescence. As the semiquantitative scale of subgingival calculus increased, the amount of laser fluorescence increased (ANOVA, $P < 0.0001$, Power 1.0000). There was little difference between the amounts of subgingival calculus attached to the distal, mesial, lingual or facial surfaces of teeth (ANOVA, $P > 0.1594$, Power 0.272). The best linear regression fit between an increasing semiquantitative scale of subgingival calculus and increasing laser fluorescence was with the facial tooth surfaces ($R^2 = 0.559$). The worst linear regression fit between an increasing semiquantitative scale of subgingival calculus and increasing laser fluorescence was with the distal tooth surfaces ($R^2 = 0.084$).

Figure 12. Bar chart of the laser fluorescence and tactile explorer category.



The amount of laser fluorescence increased according to the tactile explorer detection of subgingival calculus. No tactile explorer detection of subgingival calculus (none) had a mean of 28.7, a roughness and light detection of subgingival calculus was 43.8, which is an increase of 52.6%. The moderate or heavy tactile explorer detection of calculus was 62.3, which is a further increase of 42.2%. The amount of laser fluorescence increased as the tactile explorer detection of subgingival calculus increased (ANOVA, P < 0.0002, Power 0.982).

3.11. Comparison of the amount of subgingival calculus and gingival recession.

The amount of subgingival calculus had little or no correlation with the amount of gingival recession. Teeth with no subgingival calculus had a mean gingival recession of 1.75mm, teeth with a small amount of subgingival calculus had a mean gingival recession of 1.471mm, the teeth with a substantial amount of subgingival calculus had a mean gingival recession of 1.512mm (Figure 13). The amount of subgingival calculus appeared to have had little or no effect on the amount of gingival recession on the teeth (ANOVA $P > 0.6789$, Power 0.109) (Figure 13).

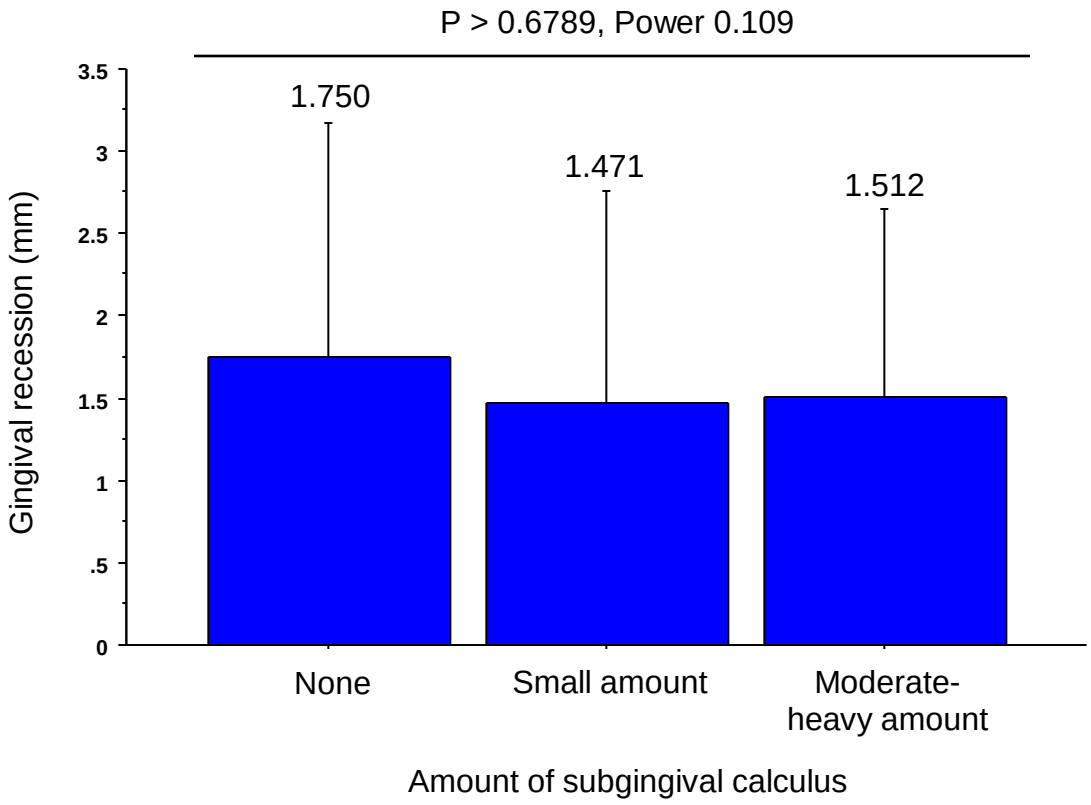
3.12. Comparison of the amount of subgingival calculus and gingival probing depth.

The amount of subgingival calculus had a correlation with the gingival probing depth. Teeth with no subgingival calculus had a mean probing depth of 4.58mm, teeth with a small amount of subgingival calculus had a mean probing depth of 5.588mm, teeth with a substantial amount of subgingival calculus had a mean probing depth of 5.791mm (Figure 14). The increasing amount of subgingival calculus appeared to increase the probing depth around teeth (ANOVA $P > 0.0075$, Power 0.823) (Figure 14).

3.13. Regression analysis of the relationship between probing depth and gingival recession.

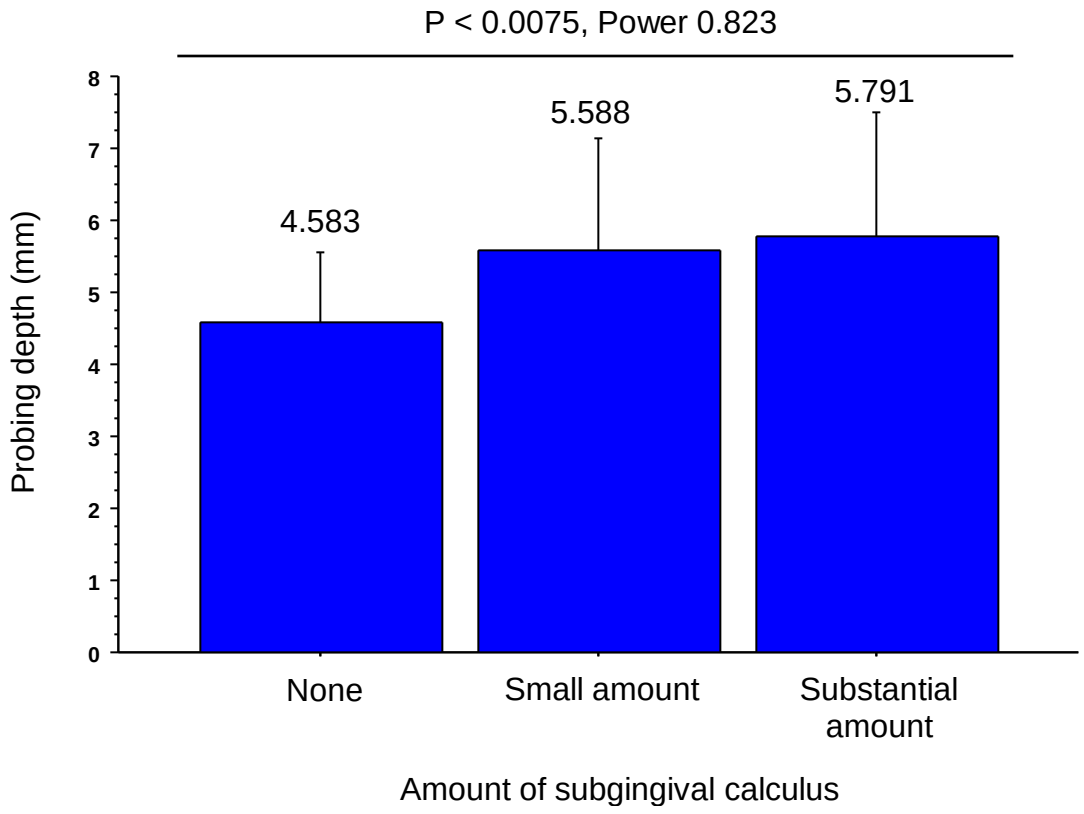
A linear regression correlation analysis between the amounts of probing depth and gingival recession found little or no correlation (ANOVA, $P > 0.4940$, Power 0.101) (Figure 15).

Figure 13. Bar chart of the amount of subgingival calculus and gingival recession.



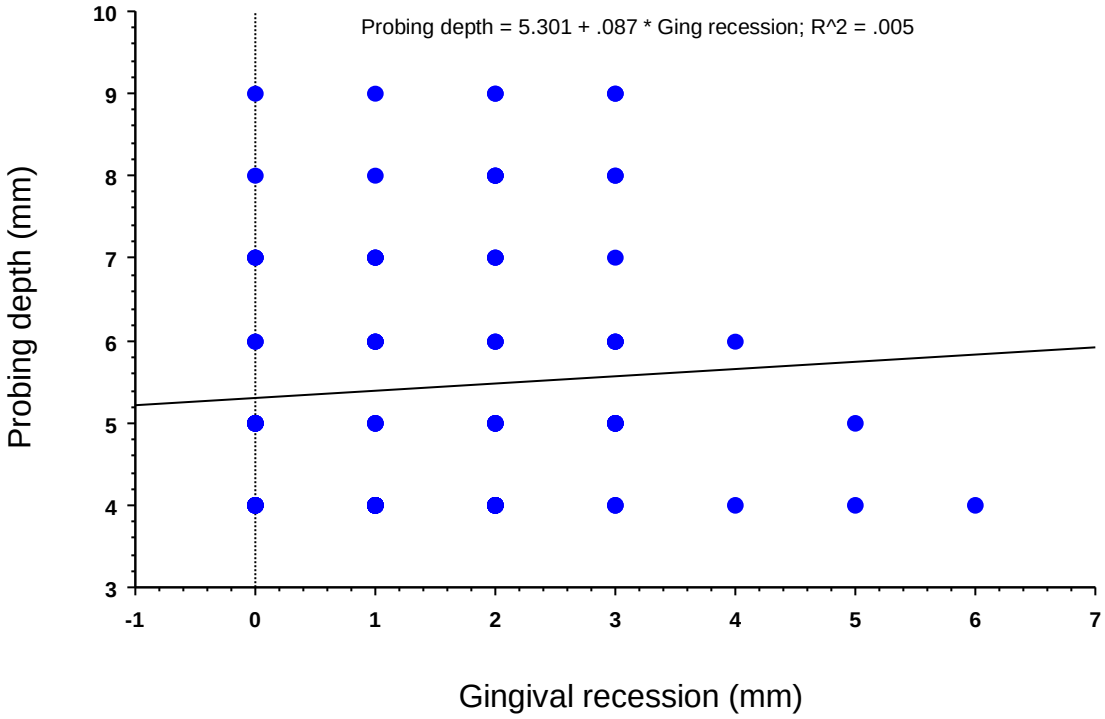
The amount of subgingival calculus had little or no correlation with the amount of gingival recession. Teeth with no subgingival calculus had a mean gingival recession of 1.75mm, teeth with a small amount of subgingival calculus had a mean gingival recession of 1.471mm, the teeth with a substantial amount of subgingival calculus had a mean gingival recession of 1.512mm. The amount of subgingival calculus appeared to have had little or no effect on the amount of gingival recession on the teeth (ANOVA P > 0.6789, Power 0.109).

Figure 14. Bar chart of the amount of subgingival calculus and gingival probing depth.



The amount of subgingival calculus had a correlation with the gingival probing depth. Teeth with no subgingival calculus had a mean probing depth of 4.58mm, teeth with a small amount of subgingival calculus had a mean probing depth of 5.588mm, teeth with a substantial amount of subgingival calculus had a mean probing depth of 5.791mm. The increasing amount of subgingival calculus appeared to increase the probing depth around teeth (ANOVA P > 0.0075, Power 0.823).

Figure 15. Scattergram of the relationship between probing depth and gingival recession.



A linear regression correlation analysis between the amounts of probing depth and gingival recession found little or no correlation (ANOVA, P > 0.4940, Power 0.101).

4. DISCUSSION

4.1. Significance of this research.

Subgingival calculus contains mineralized microorganisms, calcium phosphate, calcium carbonate and magnesium phosphate (48). The firmly adherent attachment of subgingival calculus to teeth is often associated with gingival recession and periodontal disease (49). The sensitivity, specificity, accuracy, and precision of detecting subgingival calculus is an essential aspect of periodontal and dental treatment. The gold standard for subgingival calculus detection has always been tactile probing (50), but alternative methods including laser fluorescence have also been advocated (51). I investigated laser fluorescence and compared it with tactile probing to compare their benefits and limitations. This study is significant because it is the first study to investigate the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus.

4.2. Experimental approach.

In this study I collected 27 teeth and investigated 108 surfaces, I had to exclude one tooth (group #13) where no calculus was observed on any surface, and three surfaces because of subgingival root caries to avoid confounding data, which left a total of 101 surfaces of 26 extracted teeth that meet the investigation criteria. The presence of subgingival calculus was observed on 75 tooth surfaces (74.25%).

4.3. Subgingival calculus attached to the surfaces of extracted teeth.

I observed a correlation between the tooth surface and the presence of calculus (Chi-Square G-squared value $P < 0.0324$). The subgingival calculus was from most to least frequently observed on the Distal surface (92.0%), Lingual surface (76.9%), Mesial surface (70.8%) and Facial surface (57.7%) (Figure 1.). The pattern of subgingival calculus can be explained by the tooth brushing and oral health habits of the subjects who probably find the facial surface of teeth to be the easiest to clean, whereas the distal and lingual surfaces are more difficult to clean (52). My observations suggest that the increased difficulty of cleaning a tooth surface might increase the risk that the tooth surface will not be cleaned as effectively as the other tooth surfaces and this may allow a buildup of subgingival calculus. The impact of this observation is that more attention is needed to ensure that the surfaces of teeth which are most difficult for the patient to clean are checked for subgingival calculus and that it be cleaned if required before the severity of gingival recession and periodontal disease worsen.

4.4. Amount of subgingival calculus on the surfaces of extracted teeth.

I graded the subgingival calculus according to the following criteria: 0 = None (Figure 1), 1 = Small amount of calculus (Figure 2), 2 = Moderate to heavy amounts of calculus (Figure 3) and 3 = Cement retention and extensive amounts of calculus. Most of the teeth (78.2%) that I extracted had small or moderate amounts of calculus attached to the tooth surfaces. I observed a correlation between the presence of calculus and the amount of calculus (Chi-Square G-squared value $P < 0.0001$). There were 20 teeth surfaces with no calculus (n=0), 37 teeth surfaces had small amounts of calculus, 42 teeth surfaces had moderate-heavy

amounts of calculus, and only 2 tooth surfaces had cement and extensive amounts of calculus (Figure 4).

4.5. Comparison of the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus.

I found that the tactile probing had a similar sensitivity (0.594) compared to laser fluorescence (0.808) for the detection of subgingival calculus, (ANOVA $P > 0.293$, Power 0.172). The laser fluorescence was more specific (0.935) compared to tactile probing (0.680) for the detection of subgingival calculus (ANOVA $P < 0.0402$, Power 0.648). The tactile probing had a similar accuracy (0.786) compared to laser fluorescence (0.675) for the detection of subgingival calculus (ANOVA $P > 0.2575$, Power 0.167). The laser fluorescence had more precision (0.950) compared to tactile probing (0.851) for the detection of subgingival calculus (ANOVA $P < 0.0033$, Power 1.000) (Figure 5). My results indicate that by using both tactile probing and laser fluorescence the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus can be increased. An increase in the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus could help in the diagnosis and treatment of patients suffering from gingival recession and periodontal disease. This is by avoiding giving periodontal treatment when it is not necessary by avoiding the false positive detection of subgingival calculus, and by giving periodontal treatment when it is necessary by avoiding the false negative detection of subgingival calculus.

4.6. Comparison of the amount of subgingival calculus attached to the surfaces of teeth.

I observed that the semiquantative scale of subgingival calculus was highest (1.5) on the distal surfaces of teeth, less on the lingual (1.3) and mesial (1.1) and lowest on the facial surface of teeth (0.8). There was a difference between the amounts of subgingival calculus attached to the different surfaces of teeth (ANOVA $P < 0.0131$, Power 0.804) (Figure 6). The reduction in the subgingival calculus between the distal (1.5) and ligual (1.3) tooth surfaces was 13.3%. The reduction in the subgingival calculus between the lingual (1.3) and mesial (1.1) tooth surfaces was 15.4%. The reduction in the subgingival calculus between the mesial (1.1) and facial (0.8) tooth surfaces was 27.3% (Figure 6). My observations mirror the observations obtained for the subgingival calculus attached to the surfaces of teeth shown in Figure 1. My results suggest that the buildup of subgingival calculus is increased adjacent to the surfaces of teeth which are the most difficult for people to clean adequately to prevent a buildup of subgingival calculus.

4.7. Comparison of laser fluorescence for each of the surfaces of teeth.

I found the mean amount of laser fluorescence for the distal surfaces of teeth was 52.2, for the lingual surfaces it was 46.3, for the mesial surfaces it was 47.9, and for the facial surfaces it was 34.8. There was no significant differences between the tooth surfaces and the amount of laser fluorescence (ANOVA, $P > 0.3010$, Power 0.313). The largest difference between the mean fluorescence for the tooth surfaces was distal (52.2) and facial (34.8) which was 33.3% (Figure 7). These results suggest that it is not easy to rely solely on laser

fluorescence to detect subgingival calculus since the means (52.2 to 34.8) are very close to the 40 which is the cut off point for detecting subgingival calculus. Given this difficulty in interpreting the laser fluorescence measurements when used in isolation, I am recommending that laser fluorescence should always be used in conjunction with the tactile probing detection of subgingival calculus to improve the accuracy of detecting subgingival calculus. My results show that by using both tactile probing and laser fluorescence the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus can be increased.

4.8. Comparison of the laser fluorescence measurements and the presence of subgingival calculus.

I found the mean amount of laser fluoresce for the tooth surfaces without subgingival calculus was 14.5, and for the surfaces with subgingival calculus it was 55.8. There was a significant difference between the laser fluoresce for the tooth surfaces with and without subgingival calculus (ANOVA, $P < 0.0001$, Power 1.000). The difference in the amount of laser fluoresce for the tooth surfaces with or without subgingival calculus was 384.8% (Figure 8). My results indicate that the laser fluorescence can be helpful to detect subgingival calculus.

4.9. Comparison of the laser fluorescence measurements of tooth surfaces with and without subgingival calculus.

I observed that the mean amount of laser fluorescence for the surfaces of teeth with subgingival calculus was always high than the surfaces of teeth without subgingival calculus

(P < 0.0001, Power 1.000). The amount of laser fluorescence from the surfaces of teeth were similar (P > 0.8161, Power 0.107). The amount of laser fluoresce for distal tooth surfaces with (55.2) and without (17) subgingival calculus was similar (Scheffe, P > 0.1542). The amount of laser fluoresence for facial tooth surfaces with (54.5) and without (7.9) subgingival calculus were different (Scheffe P < 0.0001). The amount of laser fluoresce for lingual tooth surfaces with (53.2) and without (23.7) subgingival calculus were different (Scheffe P > 0.0793). The amount of laser fluoresce for mesial tooth surfaces with (61) and without (16.1) subgingival calculus were different (Scheffe P < 0.0004) (Figure 9). My results indicate that the laser fluorescence can be helpful to detect tooth surfaces which have or do not have subgingival calculus.

4.10. Comparison of the amount of subgingival calculus attached to the surfaces of teeth and laser fluoresce.

I found the amount of laser fluoresce increased according to the amount of calculus, no calculus (none) had a mean of 14.7, small amount was 43.6, and a substantial amount was 63.5. There was a correlation between the amount of subgingival calculus and the amount of laser fluorescence (P < 0.0001, Power 1.000). The difference between the individual three means was also significant. The difference between the fluorescence mean for no calculus and the presence of a small amount was 296.6%, between a small amount of calculus and a substantial amount was 145.6% (Figure 10). My results indicate that the laser fluorescence can be helpful to detect the amount of subgingival calculus attached to tooth surfaces.

4.11. Regression analysis of the amount of subgingival calculus attached to the surfaces of teeth and laser fluorescence.

I performed a regression correlation analysis between the amounts of subgingival calculus attached to the surfaces of teeth and laser fluorescence. As the semiquantitative scale of subgingival calculus increased, the amount of laser fluorescence increased (ANOVA, $P < 0.0001$, Power 1.0000). There was little difference between the amounts of subgingival calculus attached to the distal, mesial, lingual or facial surfaces of teeth (ANOVA, $P > 0.1594$, Power 0.272). The best linear regression fit between an increasing semiquantitative scale of subgingival calculus and increasing laser fluorescence was with the facial tooth surfaces ($R^2 = 0.559$). The worst linear regression fit between an increasing semiquantitative scale of subgingival calculus and increasing laser fluorescence was with the distal tooth surfaces ($R^2 = 0.084$) (Figure 11). My results indicate that the laser fluorescence can be helpful to detect the amount of subgingival calculus attached to tooth surfaces.

4.12. Comparison of the amount of laser fluorescence and the tactile explorer detection of subgingival calculus.

I observed that the amount of laser fluoresence increased according to the tactile explorer detection of subgingival calculus. No tactile explorer detection of subgingival calculus (none) had a mean of 28.7, a roughness and light detection of subgingival calculus was 43.8, which is an increase of 52.6%. The moderate or heavy tactile explorer detection of calculus was 62.3, which is a further increase of 42.2%. The amount of laser fluorescence increased as the tactile explorer detection of subgingival calculus increased (ANOVA, $P < 0.0002$, Power

0.982) (Figure 12). My results indicate that both the laser fluorescence and the tactile explorer can be used to detect the amount of subgingival calculus attached to teeth.

4.13. Comparison of the amount of subgingival calculus and gingival recession.

I found the amount of subgingival calculus had little or no correlation with the amount of gingival recession. Teeth with no subgingival calculus had a mean gingival recession of 1.75mm, teeth with a small amount of subgingival calculus had a mean gingival recession of 1.471mm, the teeth with a substantial amount of subgingival calculus had a mean gingival recession of 1.512mm (Figure 13). The amount of subgingival calculus appeared to have had little or no effect on the amount of gingival recession on the teeth (ANOVA $P > 0.6789$, Power 0.109) (Figure 13). My results indicate that gingival recession is not always a predictable indicator of a tooth surface with subgingival calculus.

4.14. Comparison of the amount of subgingival calculus and gingival probing depth.

I observed the amount of subgingival calculus had a correlation with the gingival probing depth. Teeth with no subgingival calculus had a mean probing depth of 4.58mm, teeth with a small amount of subgingival calculus had a mean probing depth of 5.588mm, teeth with a substantial amount of subgingival calculus had a mean probing depth of 5.791mm (Figure 14). The increasing amount of subgingival calculus appeared to increase the probing depth around teeth (ANOVA $P > 0.0075$, Power 0.823) (Figure 14). My results indicate that the probing depth increases when subgingival calculus is present, and that an increase in the amount of subgingival calculus, increases the probing depth.

4.15. Regression analysis of the relationship between probing depth and gingival recession.

I performed a linear regression correlation analysis between the amounts of probing depth and gingival recession found little or no correlation (ANOVA, $P > 0.4940$, Power 0.101) (Figure 15). My results indicate that the probing depth cannot be predicted by the amount of gingival recession.

4.16. Conclusions and future research directions

The gold standard for subgingival calculus detection has always been tactile probing. My investigation has demonstrated that there are benefits to using laser fluoresence in conjunction with tactile probing to detect subgingival calculus. My results indicate that by using both tactile probing and laser fluorescence the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus can be increased. An increase in the sensitivity, specificity, accuracy, and precision of detecting subgingival calculus could help in the diagnosis and treatment of patients suffering from gingival recession and periodontal disease. This is by avoiding giving periodontal treatment when it is not necessary by avoiding the false positive detection of subgingival calculus, and by giving periodontal treatment when it is necessary by avoiding the false negative detection of subgingival calculus.

If only one method of calculus detection was feasible for clinical use then skilled practicioners that are confident in their detection technique may be slightly more effective using an 11/12 ODU explorer due to its slightly higher accuracy. Unskilled practicioners may experience benefits with the use of a laser fluorescence device for calculus detection due to

the easy learning curve and less technique sensitivity. The laser fluorescence use of a quantitative value as detection feedback is an additional benefit for inexperienced operators because this reading is much less subjective than tactile touch. The detection quality provided by laser fluorescence would not be expected to be much different because any of the categories that favored explorer detection were not statistically significant.

Clearly, there is a need in investigate improved techniques for detecting subgingival calculus, which can further improve the diagnosis and care of patients with periodontal disease and gingivitis.

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6. STATISTICS AND DATA APPENDIX

Figure 1. Statistics for the bar chart of subgingival calculus attached to the surfaces of teeth.

Summary Table for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

Num. Missing	0
DF	3
Chi Square	8.093
Chi Square P-Value	.0441
G-Squared	8.781
G-Squared P-Value	.0324
Contingency Coef.	.272
Cramer's V	.283

Observed Frequencies for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M	Totals
N	2	11	6	7	26
Y	23	15	20	17	75
Totals	25	26	26	24	101

Percents of Row Totals for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M	Totals
N	7.692	42.308	23.077	26.923	100.000
Y	30.667	20.000	26.667	22.667	100.000
Totals	24.752	25.743	25.743	23.762	100.000

Percents of Column Totals for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M	Totals
N	8.000	42.308	23.077	29.167	25.743
Y	92.000	57.692	76.923	70.833	74.257
Totals	100.000	100.000	100.000	100.000	100.000

Percents of Overall Total for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M	Totals
N	1.980	10.891	5.941	6.931	25.743
Y	22.772	14.851	19.802	16.832	74.257
Totals	24.752	25.743	25.743	23.762	100.000

Expected Values for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M	Totals
N	6.436	6.693	6.693	6.178	26.000
Y	18.564	19.307	19.307	17.822	75.000
Totals	25.000	26.000	26.000	24.000	101.000

Expected Values for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M	Totals
N	6.436	6.693	6.693	6.178	26.000
Y	18.564	19.307	19.307	17.822	75.000
Totals	25.000	26.000	26.000	24.000	101.000

Post Hoc Cell Contributions for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M
N	-2.339	2.242	-.361	.439
Y	2.339	-2.242	.361	-.439

Cell Chi Squares for True positive, Tooth surface.
Row exclusion: Mark MacCawley dataset.svd

	D	F	L	M
N	3.057	2.771	.072	.109
Y	1.060	.961	.025	.038

Statistics for Figures 2 to 4. These are photographs, there were no statistics.

Figure 5. Statistics for the bar chart of the sensitivity, specificity, accuracy, and precision of laser fluorescence and tactile probing for the detection of subgingival calculus

Explorer tactile detection of calculus, splitting of data to get false positive and false negative means

Data rows 1-20

Descriptive Statistics
Split By: Explorer true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	42.211	32.715	7.505	19	0.000	99.000	0
Diagnodent reading, fn	33.000	1.414	1.000	2	32.000	34.000	0
Diagnodent reading, fp	15.000	22.106	11.053	4	1.000	48.000	0
Diagnodent reading, tn	17.750	15.196	7.598	4	0.000	34.000	0
Diagnodent reading, tp	67.222	27.271	9.090	9	18.000	99.000	0

Data rows 21-40

Descriptive Statistics
Split By: Explorer true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	39.684	34.768	7.976	19	2.000	99.000	0
Diagnodent reading, fn	25.500	10.607	7.500	2	18.000	33.000	0
Diagnodent reading, fp	11.000	•	•	1	11.000	11.000	0
Diagnodent reading, tn	4.000	2.646	1.528	3	2.000	7.000	0
Diagnodent reading, tp	52.308	34.779	9.646	13	11.000	99.000	0

Data rows 41-60

Descriptive Statistics
Split By: Explorer true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	54.533	39.641	10.235	15	2.000	99.000	0
Diagnodent reading, fn	62.000	46.357	26.764	3	10.000	99.000	0
Diagnodent reading, fp	12.667	6.658	3.844	3	7.000	20.000	0
Diagnodent reading, tn	50.500	68.589	48.500	2	2.000	99.000	0
Diagnodent reading, tp	70.429	30.773	11.631	7	24.000	99.000	0

Data rows 61-80

Descriptive Statistics
Split By: Explorer true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	44.900	32.785	7.331	20	3.000	99.000	0
Diagnodent reading, fn	22.000	8.485	6.000	2	16.000	28.000	0
Diagnodent reading, fp	17.000	•	•	1	17.000	17.000	0
Diagnodent reading, tn	5.000	2.646	1.528	3	3.000	8.000	0
Diagnodent reading, tp	58.714	29.169	7.796	14	20.000	99.000	0

Data rows 81-108

Descriptive Statistics
Split By: Explorer true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	46.143	32.995	6.235	28	8.000	99.000	0
Diagnodent reading, fn	58.600	32.424	14.500	5	18.000	99.000	0
Diagnodent reading, tn	10.200	2.280	1.020	5	8.000	14.000	0
Diagnodent reading, tp	52.667	31.777	7.490	18	12.000	99.000	0

Data rows Laser fluoresence

1-20

Descriptive Statistics
Split By: Diagnodent true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	42.211	32.715	7.505	19	0.000	99.000	0
Diagnodent reading, fn	29.000	7.394	3.697	4	18.000	34.000	0
Diagnodent reading, fp	48.000	•	•	1	48.000	48.000	0
Diagnodent reading, tn	11.857	13.108	4.954	7	0.000	34.000	0
Diagnodent reading, tp	79.286	14.534	5.493	7	66.000	99.000	0

Data rows 21-40

Descriptive Statistics
Split By: Diagnodent true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	39.684	34.768	7.976	19	2.000	99.000	0
Diagnodent reading, fn	26.000	10.770	3.590	9	11.000	38.000	0
Diagnodent reading, tn	5.750	4.113	2.056	4	2.000	11.000	0
Diagnodent reading, tp	82.833	25.756	10.515	6	41.000	99.000	0

Data rows 41-60

Descriptive Statistics
Split By: Diagnodent true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	54.533	39.641	10.235	15	2.000	99.000	0
Diagnodent reading, fn	24.000	14.000	8.083	3	10.000	38.000	0
Diagnodent reading, fp	99.000	•	•	1	99.000	99.000	0
Diagnodent reading, tn	10.000	7.616	3.808	4	2.000	20.000	0
Diagnodent reading, tp	86.714	15.692	5.931	7	66.000	99.000	0

Data rows 61-80

Descriptive Statistics
Split By: Diagnodent true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	44.900	32.785	7.331	20	3.000	99.000	0
Diagnodent reading, fn	23.167	5.154	2.104	6	16.000	30.000	0
Diagnodent reading, tn	8.000	6.377	3.189	4	3.000	17.000	0
Diagnodent reading, tp	72.700	21.494	6.797	10	43.000	99.000	0

Data rows 81-108

Descriptive Statistics
Split By: Diagnodent true false positives
Row exclusion: Mark MacCawley dataset.svd

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Diagnodent reading, Total	46.143	32.995	6.235	28	8.000	99.000	0
Diagnodent reading, fn	21.444	7.892	2.631	9	12.000	35.000	0
Diagnodent reading, tn	10.200	2.280	1.020	5	8.000	14.000	0
Diagnodent reading, tp	74.857	20.346	5.438	14	43.000	99.000	0

Sensitivity mean calculations for explorer

Sensitivity = True positives / (True positives + False negatives)

Explorer Rows 1-20 = 9/(9+2) = 0.818

Explorer Rows 21-40 = 13/(13+2) = 0.866

Explorer Rows 41-60 = 7/(7+3) = 0.70

Explorer Rows 61-80 = 14/(14+2) = 0.875

Explorer Rows 81-108 = 18(18+5) = 0.783

Mean = 0.808

Specificity mean calculations for explorer

Specificity = True negatives / (True negatives + False positives)

Explorer Rows 1-20 = 4/ (4+4) = 0.5

Explorer Rows 21-40 = 3/(3+1) = 0.75

Explorer Rows 41-60 = 2/(2+3) = 0.4

Explorer Rows 61-80 = 3/(3+1) = 0.75

Explorer Rows 81-108 = 5/(5+0) = 1.0

Mean = 0.680

Accuracy mean calculations for explorer

Accuracy = (True positives + True negatives) / (Positives + Negatives)

Explorer Rows 1-20 = (9+4)/(13+6) = 0.684

Explorer Rows 21-40 = (13+3)/(14+5) = 0.842

Explorer Rows 41-60 = (7+2)/(10+5) = 0.733

Explorer Rows 61-80 = (14+3)/(15+5) = 0.85

Explorer Rows 81-108 = (18+5)/(18+10) = 0.821

Mean = 0.786

Precision mean calculations for explorer

Precision = True positives / (True Positives + False positives)

Explorer Rows 1-20 = 9/(9+4) = 0.692

Explorer Rows 21-40 = 13/(13+1) = 0.929

Explorer Rows 41-60 = 7/(7+3) = 0.7

Explorer Rows 61-80 = 14/(14+1) = 0.933

Explorer Rows 81-108 = 18/(18+0) = 1.0

Mean = 0.950

Sensitivity mean calculations for laser fluorescence

Sensitivity = True positives / (True positives + False negatives)

Laser fluorescence Rows 1-20 = 7/(7+4) = 0.636

Laser fluorescence Rows 21-40 = 6/(6+9) = 0.4

Laser fluorescence Rows 41-60 = 7/(7+3) = 0.7

Laser fluorescence Rows 61-80 = 10/(10+6) = 0.625

Laser fluorescence Rows 81-108 = 14/(14+9) = 0.609

Mean = 0.594

Specificity mean calculations for laser fluorescence

Specificity = True negatives / (True negatives + False positives)

Laser fluorescence Rows 1-20 = 7/(7+1) = 0.875

Laser fluorescence Rows 21-40 = 4/(4+0) = 1

Laser fluorescence Rows 41-60 = 4/(4+1) = 0.8

Laser fluorescence Rows 61-80 = 4/(4+0) = 1

Laser fluorescence Rows 81-108 = 5/(5+0) = 1

Mean = 0.935

Accuracy mean calculations for laser fluorescence

Accuracy = (True positives + True negatives) / (Positives + Negatives)

Laser fluorescence Rows 1-20 = (7+7)/(8+11) = 0.737

Laser fluorescence Rows 21-40 = (6+4)/(13+6) = 0.526

Laser fluorescence Rows 41-60 = (7+4)/(8+7) = 0.733

Laser fluorescence Rows 61-80 = (10+4)/(10+10) = 0.7

Laser fluorescence Rows 81-108 = (14+5)/(14+14) = 0.679

Mean = 0.675

Precision mean calculations for laser fluorescence

Precision = True positives / (True Positives + False positives)

Laser fluorescence Rows 1-20 = 7/(7+1) = 0.875

Laser fluorescence Rows 21-40 = 6/(6+0) = 1

Laser fluorescence Rows 41-60 = 7/(7+1) = 0.875

Laser fluorescence Rows 61-80 = 10/(10+0) = 1

Laser fluorescence Rows 81-108 = 14/(14+0) = 1

Mean = 0.851

ANOVA Table for Sensitivity Laser

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Sensitivity Exp	1	.021	.021	2.031	.2493	2.031	.172
Residual	3	.031	.010				

ANOVA Table for Specificity Exp

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Specificity Laser	1	.179	.179	12.073	.0402	12.073	.648
Residual	3	.044	.015				

ANOVA Table for Accuracy Laser

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Accuracy Exp	1	.012	.012	1.944	.2575	1.944	.167
Residual	3	.018	.006				

ANOVA Table for Precision laser

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Precision Exp	1	.018	.018	74.558	.0033	74.558	1.000
Residual	3	.001	2.418E-4				

ANOVA Table for Data

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Group	3	.238	.079	3.502	.0251	10.507	.734
Residual	36	.816	.023				

Means Table for Data
Effect: Group

	Count	Mean	Std. Dev.	Std. Err.
a Sensitivity	10	.701	.144	.046
b Specificity	10	.807	.216	.068
c Accuracy	10	.730	.096	.030
d Precision	10	.900	.119	.037

Fisher's PLSD for Data
Effect: Group
Significance Level: 5 %

	Mean Diff.	Crit. Diff	P-Value	
a Sensitivity, b Specificity	-.106	.137	.1231	
a Sensitivity, c Accuracy	-.029	.137	.6660	
a Sensitivity, d Precision	-.199	.137	.0054	S
b Specificity, c Accuracy	.077	.137	.2603	
b Specificity, d Precision	-.093	.137	.1762	
c Accuracy, d Precision	-.170	.137	.0162	S

Means Table for Data
Effect: Laser or Explorer
Split By: Group
Cell: a Sensitivity

	Count	Mean	Std. Dev.	Std. Err.
Explorer	5	.808	.071	.032
Laser	5	.594	.114	.051

Means Table for Data
Effect: Laser or Explorer
Split By: Group
Cell: b Specificity

	Count	Mean	Std. Dev.	Std. Err.
Explorer	5	.680	.236	.106
Laser	5	.935	.093	.042

Means Table for Data
Effect: Laser or Explorer
Split By: Group
Cell: c Accuracy

	Count	Mean	Std. Dev.	Std. Err.
Explorer	5	.786	.074	.033
Laser	5	.675	.087	.039

Means Table for Data
Effect: Laser or Explorer
Split By: Group
Cell: d Precision

	Count	Mean	Std. Dev.	Std. Err.
Explorer	5	.851	.144	.064
Laser	5	.950	.068	.031

Figure 6. Statistics for the bar chart of the amount of subgingival calculus attached to the surfaces of teeth

ANOVA Table for Calculus scale (03)
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Tooth surface..2	3	6.911	2.304	3.773	.0131	11.319	.804
Residual	97	59.227	.611				

Means Table for Calculus scale (03)
Effect: Tooth surface..2
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
D	25	1.520	.653	.131
L	26	1.269	.827	.162
M	24	1.083	.830	.169
x	26	.808	.801	.157

Scheffe for Calculus scale (03)
Effect: Tooth surface..2
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
D, L	.251	.623	.7266	
D, M	.437	.635	.2874	
D, x	.712	.623	.0177	S
L, M	.186	.629	.8715	
L, x	.462	.617	.2163	
M, x	.276	.629	.6711	

Figure 7. Bar chart of laser fluorescence measurements and the surfaces of teeth.

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Tooth surface..2	3	4230.309	1410.103	1.236	.3010	3.707	.313
Residual	97	110689.116	1141.125				

Means Table for Diagnodent reading
Effect: Tooth surface..2
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
D	25	52.160	36.035	7.207
L	26	46.346	36.154	7.090
M	24	47.917	31.431	6.416
x	26	34.808	31.064	6.092

Scheffe for Diagnodent reading
Effect: Tooth surface..2
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value
D, L	5.814	26.922	.9446
D, M	4.243	27.466	.9786
D, x	17.352	26.922	.3445
L, M	-1.571	27.207	.9988
L, x	11.538	26.657	.6793
M, x	13.109	27.207	.5996

Figure 8. Statistics for the bar chart of laser fluorescence measurements and the presence of subgingival calculus.

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
True positive	1	33056.884	33056.884	39.977	<.0001	39.977	1.000
Residual	99	81862.542	826.894				

Means Table for Diagnodent reading
Effect: True positive
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
N	26	14.462	20.355	3.992
Y	75	55.840	31.085	3.589

Scheffe for Diagnodent reading
Effect: True positive
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
N, Y	-41.378	12.985	<.0001	S

Figure 9. Statistics of the bar chart of the laser fluorescent measurement of tooth surfaces with and without subgingival calculus.

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Tooth surface..2	3	809.181	269.727	.313	.8161	.938	.107
True positive	1	22636.156	22636.156	26.243	<.0001	26.243	1.000
Tooth surface..2 * True positive	3	900.239	300.080	.348	.7907	1.044	.114
Residual	93	80217.296	862.552				

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
True positive	1	33056.884	33056.884	39.977	<.0001	39.977	1.000
Residual	99	81862.542	826.894				

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Micro Calc (Y/N)	3	35882.943	11960.981	14.679	<.0001	44.038	1.000
Residual	97	79036.483	814.809				

Means Table for Diagnodent reading
Effect: Tooth surface.
Split By: True positive
Cell: N
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
D	2	17.000	24.042	17.000
F	11	7.909	5.300	1.598
L	6	23.667	37.988	15.508
M	7	16.143	14.554	5.501

Means Table for Diagnodent reading
Effect: Tooth surface.
Split By: True positive
Cell: Y
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
D	23	55.217	35.611	7.426
F	15	54.533	26.790	6.917
L	20	53.150	33.600	7.513
M	17	61.000	26.779	6.495

Scheffe for Diagnodent reading
Effect: True positive
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
N, Y	-41.378	12.985	<.0001	S

Scheffe for Diagnodent reading
Effect: Tooth surface.
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
D, F	17.352	26.922	.3445	
D, L	5.814	26.922	.9446	
D, M	4.243	27.466	.9786	
F, L	-11.538	26.657	.6793	
F, M	-13.109	27.207	.5996	
L, M	-1.571	27.207	.9988	

Scheffe for Diagnodent reading
Effect: Micro Calc (Y/N)
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
N, n	25.924	40.414	.3488	
N, Y	-21.979	39.328	.4737	
N, y	-19.470	38.244	.5547	
n, Y	-47.903	23.271	<.0001	S
n, y	-45.393	21.389	<.0001	S
Y, y	2.510	19.257	.9869	

Scheffe for Diagnodent reading
Effect: True positive
Significance Level: 5 %
Split By: Tooth surface.
Cell: D
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value
N, Y	-38.217	53.662	.1542

Scheffe for Diagnodent reading
Effect: True positive
Significance Level: 5 %
Split By: Tooth surface.
Cell: F
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
N, Y	-46.624	16.996	<.0001	S

Scheffe for Diagnodent reading
Effect: True positive
Significance Level: 5 %
Split By: Tooth surface.
Cell: L
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
N, Y	-29.483	33.202	.0793	

Scheffe for Diagnodent reading
Effect: True positive
Significance Level: 5 %
Split By: Tooth surface.
Cell: M
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
N, Y	-44.857	22.417	.0004	S

Figure 10. Statistics for the bar chart of the amount of subgingival calculus attached to the surfaces of teeth and laser fluoresce.

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calc amount	2	36845.113	18422.556	23.124	<.0001	46.249	1.000
Residual	98	78074.313	796.677				

Means Table for Diagnodent reading
Effect: Calc amount
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
a 0	24	14.667	21.200	4.327
b 1	34	43.588	29.685	5.091
c 2	43	63.488	30.338	4.627

Scheffe for Diagnodent reading
Effect: Calc amount
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
a 0, b 1	-28.922	18.705	.0010	S
a 0, c 2	-48.822	17.876	<.0001	S
b 1, c 2	-19.900	16.101	.0110	S

Figure 11. Scattergram of the relationship between the amount of subgingival calculus attached to the surfaces of teeth and laser fluoresce.

ANOVA Table for Calculus scale (03)
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Diagnodent reading	1	21.883	21.883	48.952	<.0001	48.952	1.000
Residual	99	44.256	.447				

ANOVA Coefficients Table for Calculus scale (03)
Row exclusion: Mark MacCawley dataset.svd

	Coef	Std. Error	t-Test	P-Value
Intercept	.545	.111	4.898	<.0001
Diagnodent reading	.014	.002	6.997	<.0001

ANOVA Table for Diagnodent reading
Split By: Tooth surface.
Cell: D
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calculus scale (03)	1	2624.001	2624.001	2.115	.1594	2.115	.272
Residual	23	28541.359	1240.929				

ANOVA Table for Diagnodent reading
Split By: Tooth surface.
Cell: F
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calculus scale (03)	1	13483.885	13483.885	30.414	<.0001	30.414	1.000
Residual	24	10640.153	443.340				

ANOVA Table for Diagnodent reading
Split By: Tooth surface.
Cell: L
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calculus scale (03)	1	9801.314	9801.314	10.283	.0038	10.283	.884
Residual	24	22876.571	953.190				

ANOVA Table for Diagnodent reading
Split By: Tooth surface.
Cell: M
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calculus scale (03)	1	9663.875	9663.875	16.282	.0006	16.282	.981
Residual	22	13057.958	593.544				

Figure 12. Statistics for the bar chart of the laser fluorescence and tactile explorer category.

ANOVA Table for Diagnodent reading
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Explorer cat	2	18125.682	9062.841	9.176	.0002	18.352	.982
Residual	98	96793.743	987.691				

Means Table for Diagnodent reading
Effect: Explorer cat
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
a 0	31	28.710	30.950	5.559
b 1	37	43.757	32.043	5.268
c 2	33	62.273	31.172	5.426

Figure 13. Statistics for the bar chart of the amount of subgingival calculus and gingival recession.

ANOVA Table for Ging recession
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calc amount	2	1.236	.618	.389	.6789	.778	.109
Residual	98	155.715	1.589				

Means Table for Ging recession
Effect: Calc amount
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
a 0	24	1.750	1.422	.290
b 1	34	1.471	1.285	.220
c 2	43	1.512	1.142	.174

Figure 14. Statistics for the bar chart of the amount of subgingival calculus and gingival probing depth.

ANOVA Table for Probing depth
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Calc amount	2	23.647	11.823	5.146	.0075	10.291	.823
Residual	98	225.185	2.298				

Means Table for Probing depth
Effect: Calc amount
Row exclusion: Mark MacCawley dataset.svd

	Count	Mean	Std. Dev.	Std. Err.
a 0	24	4.583	.974	.199
b 1	34	5.588	1.559	.267
c 2	43	5.791	1.712	.261

Scheffe for Probing depth
Effect: Calc amount
Significance Level: 5 %
Row exclusion: Mark MacCawley dataset.svd

	Mean Diff.	Crit. Diff	P-Value	
a 0, b 1	-1.005	1.005	.0499	S
a 0, c 2	-1.207	.960	.0095	S
b 1, c 2	-.202	.865	.8445	

Descriptive Statistics
Row exclusion: Mark MacCawley dataset.svd

	Probing depth	Ging recession
Mean	5.436	1.554
Std. Dev.	1.577	1.253
Std. Error	.157	.125
Count	101	101
Minimum	4.000	0.000
Maximum	9.000	6.000
# Missing	0	0
Variance	2.488	1.570
Coef. Var.	.290	.806
Range	5.000	6.000
Sum	549.000	157.000
Sum Squares	3233.000	401.000
Geom. Mean	5.232	•
Harm. Mean	5.053	•
Skewness	.841	.827
Kurtosis	-.461	.880
Median	5.000	1.000
IQR	2.250	1.000
Mode	4.000	1.000
10% Tr. Mean	5.222	1.457
MAD	1.000	1.000

Figure 15. Statistics for the scattergram of the relationship between probing depth and gingival recession.

ANOVA Table for Ging recession
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Probing depth	1	.744	.744	.471	.4940	.471	.101
Residual	99	156.207	1.578				

ANOVA Table
Probing depth vs. Ging recession
Row exclusion: Mark MacCawley dataset.svd

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	1.179	1.179	.471	.4940
Residual	99	247.653	2.502		
Total	100	248.832			

Regression Coefficients
Probing depth vs. Ging recession
Row exclusion: Mark MacCawley dataset.svd

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	5.301	.252	5.301	21.073	<.0001
Ging recession	.087	.126	.069	.687	.4940

Confidence Intervals
Probing depth vs. Ging recession
Row exclusion: Mark MacCawley dataset.svd

	Coefficient	95% Lower	95% Upper
Intercept	5.301	4.802	5.800
Ging recession	.087	-.164	.337

Residual Statistics
Probing depth vs. Ging recession
Row exclusion: Mark MacCawley dataset.svd

# >= 0	40
# < 0	61
SS[e(i) - e(i-1)]	503.988
Durbin-Watson	2.035
Serial Autocorrelation	-.027