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# UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES

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## THESIS APPROVAL PAGE FOR MASTER OF SCIENCE IN ORAL BIOLOGY

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INTER-EXAMINER REPRODUCIBILITY OF MEASURING GINGIVAL  
RECESSION USING THREE TECHNIQUES

by

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A thesis submitted to the Faculty of the  
Periodontics Graduate Program  
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# ABSTRACT

## Inter-Examiner Reproducibility of Measuring Gingival Recession Using Three Techniques

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**Introduction:** The periodontal probe (PP) is considered the gold standard for measuring gingival recession (GR), yet there are numerous opportunities to introduce variability into those measurements. One such potential scenario is diminished reproducibility when different providers assess GR at the same site. Given the availability of clinical alternatives such as the Castroviejo caliper (CC) and digital scanning (DS), a comparative analysis is warranted to challenge the established utility of the PP. **Objective:** The primary goal is to assess the inter-examiner reproducibility of GR with the PP, CC, and DS. A secondary aim is to evaluate the accuracy and practicality of DS compared to manual alternatives. **Methods:** GR was measured by three calibrated examiners using a PP, CC, and DS. Inter-examiner reproducibility of each measuring technique will be statistically evaluated using intraclass correlation (ICC) with a 95% confidence interval. **Results:** Eight patients with 44 sites of GR participated in the study. The ICC for the devices was 0.84 for PP, 0.85 for CC, and 0.94 for DS, indicating that the PP and CC had good reliability while the DS had excellent reliability. **Conclusions:** While each

technique presented individual clinical challenges, all instruments appeared to measure GR adequately; however, the DS showed superior reliability to the other devices. The unique precision of the DS shows widespread potential for clinical applications beyond GR measurements and deserves further investigation.

# TABLE OF CONTENTS

LIST OF TABLES .....	vii
LIST OF FIGURES .....	viii
LIST OF ABBREVIATIONS.....	ix
CHAPTER 1: Introduction .....	1
Defining the Problem.....	1
Measuring Devices.....	3
Purpose.....	7
CHAPTER 2: Materials and Methods .....	10
Subject Population .....	10
Study Procedures .....	10
Statistical Analysis.....	12
CHAPTER 3: Results .....	16
CHAPTER 4: Discussion.....	19
CHAPTER 5: Conclusions .....	22
APPENDIX A.....	23
REFERENCES .....	24

## LIST OF TABLES

<b>Table 1.</b> ICC for Initial Recession Measurements .....	17
<b>Table 2.</b> Descriptive Characteristics of All Methods at Initial Measurement.....	18

## LIST OF FIGURES

<b>Figure 1.</b> Gingival Recession Identification .....	2
<b>Figure 2.</b> Periodontal Probe .....	5
<b>Figure 3.</b> Castroviejo Calipers .....	6
<b>Figure 4.</b> Intraoral Video Scanner.....	8
<b>Figure 5.</b> Intraoral Scanner Measuring Recession.....	9
<b>Figure 6.</b> Periodontal Probe Measuring Recession.....	14
<b>Figure 7.</b> Castroviejo Calipers Measuring Recession.....	15

## **LIST OF ABBREVIATIONS**

CAL – Clinical Attachment Level

CC – Castroviejo Caliper

CEJ – Cementoenamel Junction

CEREC – Chairside Economical Restoration of Esthetic Ceramic

CI – Confidence Interval

CL – Confidence Level

DS – Digital Scanner

FGM – Free Gingival Margin

GR – Gingival Recession

HIPAA – Health Insurance Portability and Accountability Act

ICC – Intraclass Correlation

IRB – Institutional Review Board

NPDS – Naval Postgraduate Dental School

PP – Periodontal Probe

RC – Root coverage

SD – Standard Deviation

STL – Stereolithography

UNC – University of North Carolina

WRNMMC – Walter Reed National Medical Military Center

# CHAPTER 1: Introduction

## DEFINING THE PROBLEM

Gingival recession is defined as “the migration of the gingiva to a point apical to the cementoenamel junction,” according to the American Academy of Periodontology<sup>1</sup>. It often poses functional and esthetic concerns for patients and dental providers. Patients may experience dentinal sensitivity, increased caries risk, and poor esthetics due to gingival recession<sup>2</sup>. Recession that results in a lack of attached tissue at a given site may pose a risk for future clinical attachment loss<sup>3</sup>. Treatment goals for teeth exhibiting recession are to increase root coverage and the zone of keratinized tissue, prevent further recession, address sensitivity, and improve esthetics<sup>4</sup>. Correction of recession is often accomplished by augmenting the existing soft tissue using various surgical techniques.

Determining the amount of gingival recession is accomplished by measuring the vertical distance from a fixed reference point to the crest of the gingiva in millimeters (**Fig. 1**). Typically, a tooth’s cementoenamel junction (CEJ) serves as the fixed point; however, in some patients, the CEJ may be challenging to visualize due to hard tissue abrasion or erosion. Fixed dental prostheses or restorations that hide or alter the CEJ require the dental provider to select a new reference that other providers may not use. Furthermore, Handelman et al. reported that using the CEJ as a reference does not accurately assess apical migration of the gingival margin. Difficulty in establishing a fixed and reproducible reference point can manifest as inaccuracies in pre-and post-surgical outcomes when treating gingival recession<sup>5</sup>.



**Figure 1. Gingival Recession Identification.** Recession is identified by measuring the distance between the cemento-enamel junction (CEJ) and the free gingival margin (FGM).

## MEASURING DEVICES

The instrument of choice for measuring gingival recession has traditionally been the periodontal probe (**Fig. 2**) due to its millimeter gradations and versatility<sup>6</sup>. Discrepancies associated with periodontal probing range from manufacturer calibration<sup>6, 7</sup> to operator technique<sup>6</sup> and force application<sup>8</sup>. Badersten et al. studied probing measurements and found intra- and inter-examiner reproducibility differences within 1.0mm 90% of the time. The measurement, however, varied significantly based on the tooth type, surface, and location<sup>9</sup>. Despite these discrepancies, the periodontal probe remains the gold standard for obtaining measurements due to limited alternative measuring options. Castroviejo calipers (**Fig. 3**) offer one alternative to traditional periodontal probes. They can provide a measurement resolution of 1.0 mm, similar to that of a standard periodontal probe. The calipers are bulkier and less practical for intraoral use than the periodontal probe. The advent of digital dentistry offers a more non-invasive solution to this problem. Three-dimensional intraoral video scanners (**Fig. 4**) can quickly capture and immediately display images chairside. Integrated program software allows the provider to visualize the CEJ or designate another reproducible fixed point. Schneider et al. suggests that intraoral scans have high intra- and inter-examiner reproducibility<sup>10</sup>.

The ability to overlay numerous stereolithography (STL) files allows practitioners to precisely track the location of the gingival margin over time. Viewing gingival tissues on a screen and manipulating the images in three dimensions suggests that digital measurements are more advantageous in preciseness and practicality (**Fig. 5**). Limitations to intraoral scanning include a patient's ability to accommodate the bulky camera in cases of limited or decreased opening and unfavorable position of the segment

to be scanned. To overcome these shortcomings, some researchers suggest scanning casts obtained from conventional intraoral dental impressions<sup>11</sup>.



**Figure 2. Periodontal Probe.** A standard UNC-15 periodontal probe with markings to identify millimeter increments up to 15 millimeters.



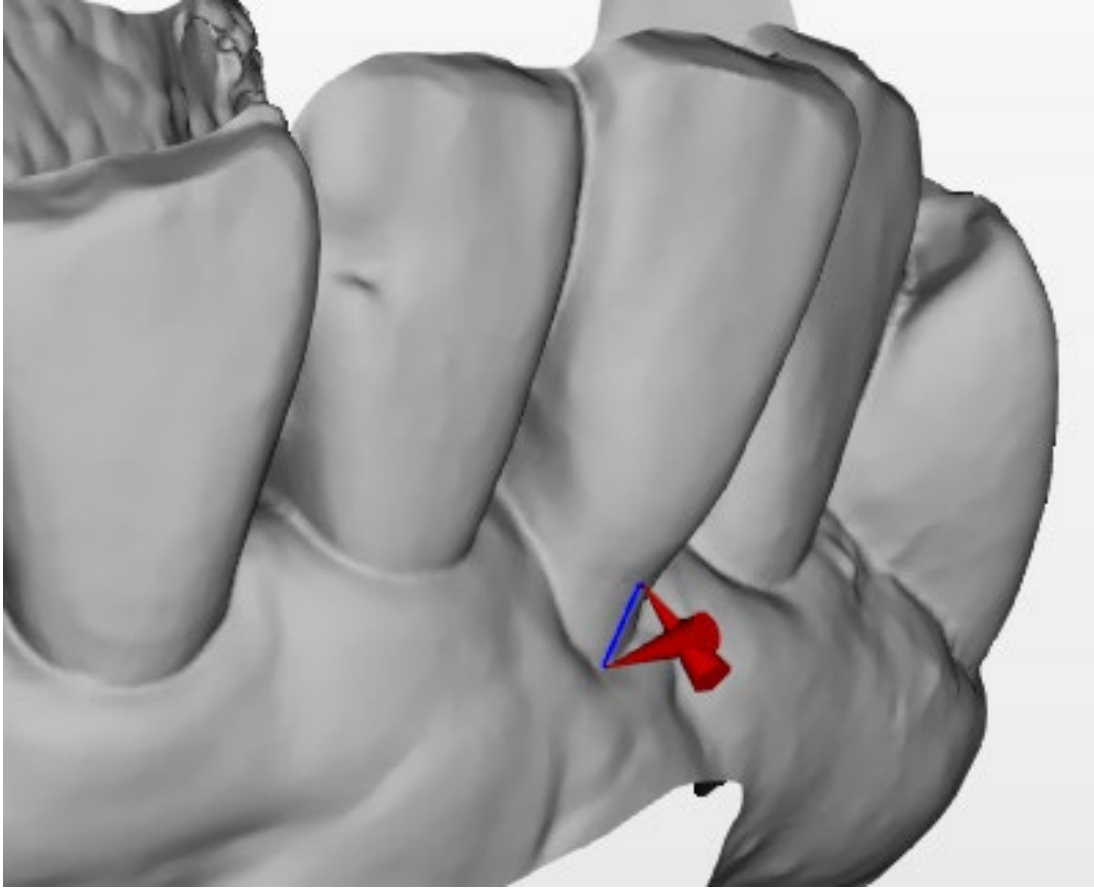
**Figure 3. Castroviejo Calipers.** A standard Castroviejo caliper with markings to identify millimeter increments up to 40 millimeters.

## **PURPOSE**

To the best of the authors' knowledge, there are no studies comparing inter-examiner reproducibility and instrument reliability between periodontal probes, calipers, and three-dimensional scanners from intraoral findings alone. This study seeks to determine the inter-examiner reproducibility between these three measuring techniques and determine if intraoral scanning is a viable alternative to traditional probing when measuring gingival recession. A follow-up study will evaluate intra-examiner reproducibility.



**Figure 4. Intraoral Video Scanner.** The base unit of the intraoral digital video scanner includes the video capturing handpiece, a touch screen, and keyboard. The unit has the ability to store data long-term.



**Figure 5. Intraoral Scanner Measuring Recession.** The red cones identify the CEJ and FGM. The program software measures the distance between the cones.

## **CHAPTER 2: Materials and Methods**

This is the first part of a two-part comparative study of the reproducibility of recession defect measurements obtained using three different measuring devices. In this part of the study, inter-examiner reproducibility was assessed. In the second part of the study, the intra-examiner reproducibility was evaluated. The WRNMMC Institutional Review Board approved this study (WRNMMC-2021-0365).

### **SUBJECT POPULATION:**

All eligible beneficiaries ages 18 or older evaluated at the Naval Postgraduate Dental School (NPDS) Periodontics Clinic and diagnosed with at least one gingival recession defect were eligible for enrollment in this study. Inclusion criteria dictated that the subjects have no medical contraindications to treatment and display gingival recession on anterior or premolar teeth with a visible CEJ on the facial/buccal surfaces. Exclusion criteria included molar teeth, conditions or situations in which the CEJ or the FGM is recently altered, recent soft tissue trauma at or near the recession site, and teeth adjacent to an extraction site within five weeks of surgery.

### **STUDY PROCEDURES:**

1. Initial phase:
  - a. Potential study subjects were either referred to NPDS Periodontics for periodontal treatment or were already receiving long-standing periodontal maintenance care in the department.
  - b. Potential subjects were provided a study brief by the provider conducting the exam during the screening exam.

2. Potential subjects were given a brief periodontal evaluation to determine if they meet the inclusion and exclusion criteria for the study. Those subjects meeting the study criteria were invited to participate in the study. It was clearly explained that participating in the study is completely voluntary and refusing to participate will not change their eligibility for dental care to which they are entitled.
3. Data collection phase:
  - a. If potential subjects agreed to be part of the study, a subject's comprehensive periodontal evaluation appointment was scheduled.
  - b. Full written disclosure of the study protocol was presented to the subject by a Study Investigator. Consent and HIPAA forms were completed and signed.
  - c. Once consent was obtained, the subjects were assigned a subject identifier, then populated into a Master List by a Study Investigator. All measurements of the gingiva were performed by each of three calibrated, board-certified periodontists and entered onto a Data Collection sheet by a Study Investigator. The number of the tooth in the oral cavity with recession was recorded. Two direct clinical measurements of a subject's gingival recession were obtained parallel to the vertical long-axis of the tooth from the gingival margin to the CEJ, starting at the most apical portion of the defect, first using a UNC-15 periodontal probe (**Fig. 6**) and then using Castroviejo calipers (**Fig. 7**). An intraoral optical impression (CEREC Primescan,

Dentsply Sirona, Bensheim, Germany) was obtained following the manufacturer's guidelines.

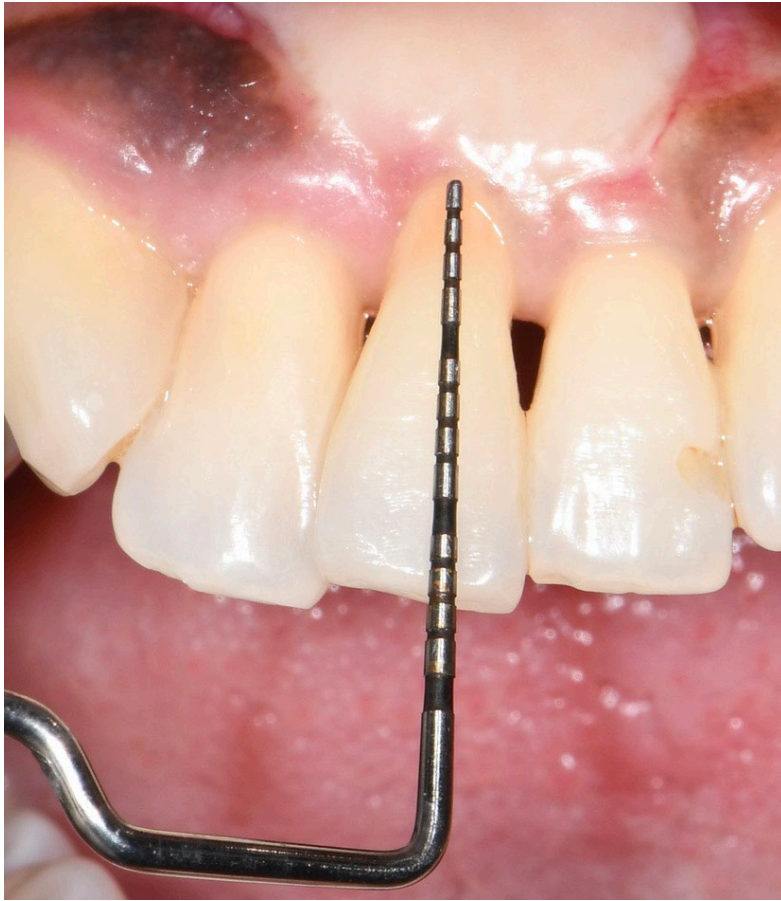
- d. The optical impression included one tooth on either side of the tooth/teeth with recession. The acquisition was done in four consecutive sequences starting on the occlusal surface and moving to the buccal, lingual, and proximal surfaces. The scanner was moved in a distal direction and rotated 20 degrees toward the buccal or lingual direction. The optical impression file was exported as an STL file and converted to an image using Oracheck Dentsply Digital software (Dentsply Sirona, Bensheim, Germany). Digital measurements were recorded from the image of the recession areas using the measurement tool available as part of the scanner's software.

#### **STATISTICAL ANALYSIS**

Descriptive statistics (e.g., mean and standard deviations) were reported for gingival recession measurements for each combination of examiner and measurement method among the entire cohort at the initial visit. Inter-examiner agreement among the three raters was estimated for each measurement method at the initial visit using a two-way ICC with observations from single, rather than averaged, ratings. The ICC was evaluated as a measure of absolute agreement between examiners<sup>11</sup>. Agreement estimates were reported as the model-estimated ICC and a 95% confidence interval among the entire cohort.

In this study, a power analysis revealed that a minimum of 64 sites of recession were needed to estimate an inter-examiner intraclass correlation coefficient (ICC) of 0.90

with a desired confidence interval width of 0.08 ( $\pm 0.04$ ), assuming that each site is measured once by all three examiners for each of the three measurement methods at the initial visit. These estimates were derived from a recent study demonstrating high levels of inter-and intra-examiner agreement previously reported for related measurement methods<sup>11</sup>. Based on a study by Koo et al. (2016), the ICC scale was interpreted as values less than 0.50 indicating poor reliability, values between 0.50 and 0.75 indicating moderate reliability, values between 0.75 and 0.90 indicating good reliability, and values greater than 0.90 indicating excellent reliability<sup>12</sup>.



**Figure 6. Periodontal Probe Measuring Recession.** A UNC-15 periodontal probe is used to measure recession from the CEJ to the FGM.



**Figure 7. Castroviejo Calipers Measuring Recession.** Castroviejo calipers measure recession from the CEJ to the FGM.

## CHAPTER 3: Results

A total of 8 subjects were enrolled in the study. The raw data from 44 recession sites were used to calculate ICC and descriptive statistics. ICC shows that both the periodontal probe and the caliper have good reliability, while the intraoral scanner has excellent reliability (Table 1). We can infer that the intraoral scan is more reliable than the probe or calipers from this data. The upper and lower limits of the 95% CL indicated the range of the ICC for each device. Data from the descriptive statistics (Table 2) of all measuring devices during the initial measurements showed the highest mean reported by examiner 2 using the periodontal probe ( $2.3 \pm 1.2$ ), while the lowest means were reported by examiner 2 using the calipers ( $1.8 \pm 1.0$ ). Minor differences existed between examiners with the least difference found between examiner 1 and examiner 3. The largest discrepancy between examiners was with the use of the calipers.

**Table 1. ICC for Initial Recession Measurements.**

<b>Measuring Device (mm)</b>	<b>ICC</b>	<b>95% CL</b>
Periodontal Probe	0.84	0.75, 0.904
Caliper	0.85	0.748, 0.913
Intraoral Scanner	0.94	0.856, 0.972

**Table 2. Descriptive Characteristics of All Methods at Initial Measurement**

<b>Measurement Method</b>	<b>Summary</b>	<b>Examiner 1</b>	<b>Examiner 2</b>	<b>Examiner 3</b>
Periodontal Probe	Mean (SD)	2.1 (1.1)	2.3 (1.2)	2.1 (1.2)
Caliper	Mean (SD)	1.8 (1.0)	2.1 (0.9)	1.9 (1.0)
Intraoral Scanner	Mean (SD)	1.8 (1.2)	2.1 (1.1)	1.8 (1.1)

## CHAPTER 4: Discussion

This study shows that the intraoral digital scanner was superior in reliability compared to the periodontal probe and calipers for the examiners. These results were consistent with findings from similar studies. Fageeh et al. (2019) compared the reproducibility of a William's periodontal probe intraorally, caliper measurements on a cast, and digital models taken from a scanned model cast. They found that the use of the digital scanner reduced measurement variation compared to the other two devices, even when taken from stone model casts.

Success with reproducibility of the scanner may be related to the software's ability to allow the examiner to zoom in and rotate the oral scan, allowing for a more magnified view without obstructing the FGM or the CEJ. A disadvantage of the scanner's digital software is that the lifelike colors of the scan are lost when the STL is transferred into Oracheck, making subtle changes and alterations in the CEJ difficult to interpret. Intraoral measurements using periodontal probes and calipers may be influenced by the visual acuity of the examiner or the use of magnification loupes. Additional factors influencing intraoral measurements include light availability, saliva contamination in the field, or access to the recession site. Studies on probing highlight that clinicians have a more difficult time with the probe as they move more posterior in the arch and near the distal surface of teeth<sup>8</sup>. The calipers offer a unique challenge in that the measurement is taken intraorally but read extraorally. The examiner has to balance holding the calipers perfectly still on the recession site while changing fields of view to read the measurements from the extraoral gauge. A similar learning curve exists for the

scanner as it is recommended that the user looks up at the acquisition screen when scanning instead of looking into the oral cavity. The bulkiness of the scanner wand can be challenging to manipulate intraorally and may be uncomfortable for the subject. Nevertheless, even with little training on the intraoral scanner, all three examiners in this study achieved excellent reproducibility compared to the more widely used measurement devices.

The reproducibility of the intraoral scanner has a magnitude of clinical correlations. The ability to store data from the scans aids in tracking the progression of recession, which is correlated with clinical attachment loss. By comparing multiple, highly reproducible scans, clinicians may be able to detect tissue destruction sooner and intervene before surgical treatment is needed. In a military setting, this could reduce the number of service members put on light duty or taken away from daily work due to the need for surgical recovery. The ability to store and transfer data from the scans is also helpful in a transient population like the military, where members must move every 2 to 3 years and attempt to continue treatment with a new provider. Accurate measurement tracking between providers promotes continuity of care for the subject. Finally, the ability to assess the data from the scans later may mean less chair time is required by the subject, allowing the service member to return to their duties faster.

The desired sample size of 64 recession sites identified in the power analysis could not be reached. An IRB modification request was submitted and approved to increase recruitment; however, only 44 sites of recession were measured for preliminary analysis. Other factors affecting data collection were the onset of an infectious disease pandemic that forced the closure of dental facilities and limited subject referrals. As this

research continues, the goal is to reach the recommended 64 recession sites and perhaps increase the subject pool.

## **CHAPTER 5: Conclusions**

The objective of this study was to determine the inter-examiner reproducibility between the periodontal probe, calipers, and an intraoral video scanner. This study found that all three devices are reliable for measuring gingival recession, but the intraoral video scanner had excellent reliability compared to the probe and calipers among examiners, suggesting that variations in measurements can be reduced by using the intraoral digital scanner. Future research should further investigate intraoral scanner reproducibility in periodontics and the potential for clinical applications beyond recession measurements.

# APPENDIX A

## DATA COLLECTION SHEET

DATE	
SUBJECT ID	
EXAMINER ID	

Initial / Follow-up (Circle One)
-------------------------------------

Measurements: CEJ to FGM	Tooth #	Tooth #	Tooth #	Tooth #	Tooth #	Tooth #
Periodontal Probe						
Calipers						
Intra-oral Scan						

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