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# Reliability of trans-gingival probing in evaluating gingival thickness: a pilot study

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BOSTON UNIVERSITY  
SCHOOL OF MEDICINE

Thesis

**RELIABILITY OF TRANS-GINGIVAL PROBING IN EVALUATING  
GINGIVAL THICKNESS: A PILOT STUDY**

by

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B.S., University of Central Florida, 2013

Submitted in partial fulfillment of the  
requirements for the degree of  
Master of Science

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## **DEDICATION**

To my parents, who have offered their never-ending love and support through my pursuit of my goals.

## **ACKNOWLEDGMENTS**

This project would not have been possible without the support and counsel of several important people. First, I owe many thanks to my adviser and thesis reader, Dr. Theresa A. Davies, who spent many precious hours reading draft after draft of this document. Second, an expression of gratitude is in order for my principal investigator, Dr. Paul A. Fugazzotto, who offered me the opportunity to conduct this research with him. Third, I would like to thank Dr. Anya Rost for her invaluable guidance. Fourth, I would like to thank Jacob Daniel Morton for reading countless revisions and for his unconditional support. Finally, infinite thanks are due to my parents, siblings, and friends. They have given their love and support unreservedly throughout this process.

**RELIABILITY OF TRANS-GINGIVAL PROBING IN EVALUATING  
GINGIVAL THICKNESS: PILOT STUDY**

**LAURA PATRICIA CARRASCO**

**ABSTRACT**

**Introduction:** Gingival tissue thickness plays an important role in that it affects the health of natural teeth and prosthetics, periodontal health, gingival recession, underlying bone quality, and periodontal therapy. Therefore, various methods of gingival thickness assessment have been introduced. However, current modes of assessment are controversial in reliability and safety for patients.

**Objective:** The goal of this study was to evaluate the accuracy of using trans-gingival probing as means of determining gingival thickness.

**Materials and Methods:** Twenty subjects were included in this pilot study. The gingival biotypes were characterized as either thick or thin. The gingival assessment was conducted by two highly experienced periodontists. The patients were evaluated first by trans-gingival probing. Then, gingiva was reflected to obtain tension-free caliper measurement.

**Results:** It was observed that that the trans-gingival probing methods on average overestimates the caliper measurements by 0.025 mm and had no statistical significantly difference from the tension-free caliper (p-value= 0.77).

**Conclusions:** The data collected in this pilot study provides important evidence that the periodontal probe is an accurate means to measure gingival thickness.

## TABLE OF CONTENTS

TITLE.....	i
COPYRIGHT PAGE.....	ii
READER APPROVAL PAGE.....	iii
DEDICATION.....	iv
ACKNOWLEDGMENTS.....	v
ABSTRACT.....	vi
TABLE OF CONTENTS.....	vii
LIST OF TABLES.....	ix
LIST OF FIGURES.....	x
LIST OF ABBREVIATIONS.....	xi
INTRODUCTION.....	1
I. Overview.....	1
II. Literature Review.....	3
Thick Gingival Biotype.....	3
Thin Gingival Biotype.....	3
Prevalence of Gingival Biotype.....	7
Gingival Biotype and Periodontal Health.....	7
Gingival Biotype and Underlying Bone Morphology.....	8

Gingival Biotype and Periodontal Therapy .....	10
Gingival Thickness and Tooth Position .....	11
Gingival Biotype Assessment .....	13
Objective .....	15
METHODS .....	16
Study Design .....	16
Sample .....	16
Gingival Biotype Evaluation .....	17
Statistical Analysis .....	18
RESULTS .....	19
I. Tooth position .....	19
II. Tooth Arch Location .....	19
III. Gender .....	20
IV. Age .....	20
DISCUSSION .....	28
Limitations .....	34
Conclusion .....	35
REFERENCES .....	36
CURRICULUM VITAE .....	40

## LIST OF TABLES

Table	Title	Page
1	Characteristics of Gingival Biotypes	4
2	Bone Quality Index	10
3	Tooth position comparison of trans-gingival and tension-free caliper measurements	22
4	Tooth Arch thickness comparison of trans-gingival probing and tension-free caliper measurements	22
5	Mean gingival thickness in mm between male and female participants.	23
6	Mean gingival thickness of mid-buccal region in mm between younger (23 - 35) and older (36 -64) age group.	24

## LIST OF FIGURES

Figure	Title	Page
1	Thin Biotype	5
2	Thick Biotype	6
3	Tooth Location	12
4	Tooth position comparison of trans-gingival and tension-free caliper measurements	27
5	Tooth Arch thickness comparison of trans-gingival probing and tension-free caliper measurements	25
6	Mean gingival thickness in mm between male and female participants.	26
7	Mean gingival thickness of mid-buccal region in mm between younger (23 -35) and older (36 -64) age group.	27

## LIST OF ABBREVIATIONS

BMD .....	Bone mineral density
BQI.....	Bone quality index
CBCT .....	Cone beam computerized tomography
mm .....	Millimeter

## INTRODUCTION

### I. Overview

Attached gingiva is a major anatomic and functional feature of the periodontium. It is the portion of the oral mucous membrane bound to the tooth and alveolar arches of the maxilla and mandible. Gingival tissue thickness varies throughout the oral cavity. The term *gingival biotype* refers to the thickness and quality of the attached gingiva. Different gingival biotypes respond differently to inflammation and restorative treatment (Posnick, 2013). As a result of these biotypes, gingival topography plays an important role in the health of natural teeth and the efficacy of periodontal treatments. For this reason, it is critical that gingival biotype be assessed at the onset of treatment planning.

In 1969, Ochsenein and Ross determined that gingival morphology could be divided into two groups: flat and scalloped gingival tissue (Ochsenein and Ross, 1969). They established that scalloped gingiva was associated with square teeth, whereas flat gingiva was associated with tapered teeth. Moreover, Ochsenein and Ross proposed that the gingival contour mirrors the contour of the underlying alveolar process. The term, “periodontal biotype,” was coined by Seibert and Lindhe, who described gingival tissue as either “thick-flat” or “thin-scalloped” biotypes (Abraham et al., 2014). Gingival biotype is correlated to a number of factors: tooth shape, tooth size, tooth position, tooth eruption, age, and gender.

Various studies have established the importance of gingival thickness and its critical role in oral health. Specifically, gingival thickness plays a crucial role in the health of natural teeth and prosthetics, periodontal health, gingival recession, underlying

bone quality, and periodontal therapy. The predictability of post-operative success has become critical to periodontal therapies, and as such, various gingival diagnostic methods have been developed. This pilot study aims to establish the accuracy of a periodontal probe as a means to measure gingival thickness by comparing it to a direct measure using a tension-free caliper.

## **II. Literature Review**

### **Thick Gingival Biotype**

Thick gingival biotype is the ideal gingival tissue. It is characterized by dense tissue with a gingival thickness of more than 2 millimeters (mm) (Figure 1, Table 1) (Fu et al., 2010; Abraham et al., 2014; Wolf and Hassel, 2006). Typically, the gingival topography is flat with thick contour underlying bony architecture. Those with thick gingiva tend to be more resistant to trauma and disease (Abraham et al., 2014). Additionally, thick gingival biotype tends to accompany teeth that are square in shape with larger and more stable attachment. Such teeth are more resistant to gum recession. Moreover, thick biotypes are ideal for restorative esthetics, especially in the esthetic zone, because they more effectively conceal the titanium posts of implants (Esfahrood et al., 2013).

### **Thin Gingival Biotype**

Thin gingival biotype is translucent and scalloped with a gingival thickness less than 1.5 mm (Figure 2, Table 1) (Fu et al., 2010; Abraham et al., 2014; Wolf and Hassel, 2006). The underlying bone contour tends to be a thin, and unlike the thicker biotype, the teeth are triangular in shape. Patients with thin gingiva tend to have compromised soft tissue in response to trauma and restorative procedures. Moreover, patients with thin gingival tissue are more likely to develop periodontal disease (Dhalkari et. al., 2014). Gingival recession is one of the most common complications among implants placed in thin biotypes. Further, significant alveolar resorption in the apical and lingual direction is

possible in patients with thin gingival biotypes (Abraham et al., 2014). As a result, the implant will be more visible, appear as a greyish color, and supplemental bone and soft tissue grafts surgical procedures may be required.

**Table 2. Characteristics of Gingival Biotypes, Amended from Esfahrood et al., 2013.**

<b>Characteristics</b>	<b>Thin</b>	<b>Thick</b>
<b>Gingival Thickness</b>	< 1.5mm	> 2mm
<b>Tooth Shape</b>	Square	Triangular
<b>Gingival Contour</b>	Scalloped	Flat
<b>Papilla Shape</b>	Long	Short
<b>Bone Thickness</b>	Thin	Thick
<b>Prevalence</b>	15%	85%



**Figure 1: Thin Biotype.** Shown is a thin-scalloped periodontium. Notice the triangular shape of the tooth and the presence of gingival recession. Figure taken from Abraham et al., 2014.



**Figure 2: Thick Biotype.** Shown is a flat-thick periodontium. Notice the square shaped teeth, bulky buccolingual thickness and the absence of receding gingival tissue. Figure taken from Abraham et al., 2014.

## **Prevalence of Gingival Biotype**

Gingival thickness varies between individuals as well as among various groups of teeth within an individual's oral cavity. General studies have found that 85% of the population has thick gingival phenotype and the remaining 15% has thin gingival biotype (Posnick, 2013; Kan et al., 2010). Thick gingival biotype is more prevalent among men, while thin gingiva is more common among women (Dibart,2011; Zawawi et al., 2012; Nirmal et al., 2012). Gingiva has also shown to be thicker among the youth, and as they age, the gingival thickness decreases. Consequently, thinner gingiva is seen more commonly among the elderly. It is also worth noting that general papillary height tends to be less among individual with thicker gingiva (Goodacre et al., 2005).

## **Gingival Biotype and Periodontal Health**

Healthy gingival tissue is generally characterized as *salmon pink* in color. Although among Blacks, a brownish hue is associated with healthy gingiva (Scheid, 2012). Moreover, healthy gingival tissue has firm attachment to the underlying alveolar process. Gingival biotypes have an influence on an individual's periodontal health. Studies have found that periodontal disease and gingival recession are more likely among those with thin gingival biotype (Abraham et al., 2014; Esfahrood et al., 2013; Grover et al., 2011).

Periodontal disease is classified as an infection of the periodontium, the tissue that supports, protects, and provides nourishment for an individual's teeth. Periodontal disease is prevalent among approximately 75% of adult Americans (Kim et al., 2006).

Periodontal diseases attack the individual's gingival sulcus, causing the deterioration of the periodontium. Periodontal diseases are classified as either gingivitis or periodontitis, depending on the progression of tissue damage (Scheid, 2012). Gingivitis is a mild, and more importantly, a reversible form of periodontal disease that primarily causes inflammation of the gums. If gingivitis goes untreated periodontitis occurs, resulting in the infection of the ligaments and bones supporting the teeth. Consequently, periodontitis leads to the loosening of teeth due to pocket depth and attachment loss (Scheid, 2012). Moreover, periodontal disease is the leading cause of tooth loss. Periodontal disease makes thin gingiva even more sensitive to inflammation, which results in increased gingival recession (Claffey et al., 1986). Gum recession occurs when the marginal gum tissue around the teeth recedes or pull away. The risk of recession among people with thin gingiva is also heightened after oral trauma or surgery (Kolte et al., 2014; Esfahrood et al., 2013). Receding gums allow for bacterial build-up that if left untreated, leads to tooth sensitivity, tooth decay, and exposure of tooth root.

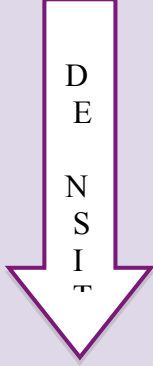
### **Gingival Biotype and Underlying Bone Morphology**

Ochsenbein and Ross' research on gingival tissue suggests that the gingival contour mirrors the contour of the underlying alveolar process (1969). More recent studies have confirmed that the gingival thickness indeed reflects the thickness of the underlying bone architecture (Fu et al., 2010; Aschheim, 2014; Ahmad, 2005; Chhina, 2015; Grover et al., 2011). The underlying bone morphology has an important relationship both with natural teeth and periodontal treatment planning. Natural teeth and

the bony structure that they are embedded in have a symbiotic relationship: the teeth stimulate the bone during mastication and biting. Conversely, when the tooth is no longer present, the alveolar bone lacks the needed stimulation and leads to bone resorption. Additionally, the gingival biotypes have variable blood supplies that perfuse the alveolar bone. Studies have found that thin gingiva tends to have less blood perfusion, leading to less underlying alveolar process support and increased susceptibility to bone loss (Zetu et al., 2005, Fu et al., 2010; Abraham et al., 2014). This is of particular importance to dental implants. The positive relationship between bone density and the success of dental implants has been well established. Studies have indicated a higher implant failure rate when the implant is placed in areas with poor bone quality (Buddula, 2013; Gulsahi, 2011; Porter et al., 2005). Moreover, the higher incidence of implant failure is thought to be attributed to the excessive bone resorption and delayed healing process is associated with poor bone density and quality, which is correlated to very thin gingival tissue (Van Steenberghe, 2003). Bone quality and quantity are not interchangeable terms. Bone quality refers to the skeletal size, the architecture, and trabecular bone tissue and matrix properties. Bone quantity, on the other hand, refers to the bone mineral density (BMD). Bone quality index (BQI) categorizes the bone quality into groups I to IV (Table 2) (Lee et al., 2011). Therefore, gingival biotype should be taking into consideration during treatment planning for best outcomes.

**Table 1. Bone Quality Index, Amended from Gulsashi, 2011.**

Type	Characteristics
I	Homogeneous compact bone, hard, dense, least amount of blood supply
II	Thick cortical bone with marrow cavity
III	Thin cortical bone with dense trabecular bone tissue
IV	Very thin compact bone with low density trabecular bone tissue



### **Gingival Biotype and Periodontal Therapy**

The gingival morphology has garnered considerable attention in periodontics due to the differing responses of different biotypes to inflammation, trauma, and surgery. As noted above, thinner gingival tissue is more susceptible to inflammation and tends to heal more slowly; this can have a profound influence on the outcome of various treatments. In terms of implant therapy, studies suggest that thicker gingiva has greater esthetic outcomes (Kassab, 2010; Goodacre et al., 2005; Askary, 2008). Therefore, biotype classification is a crucial component of ensuring the long-term success and esthetic outcomes of treatment.

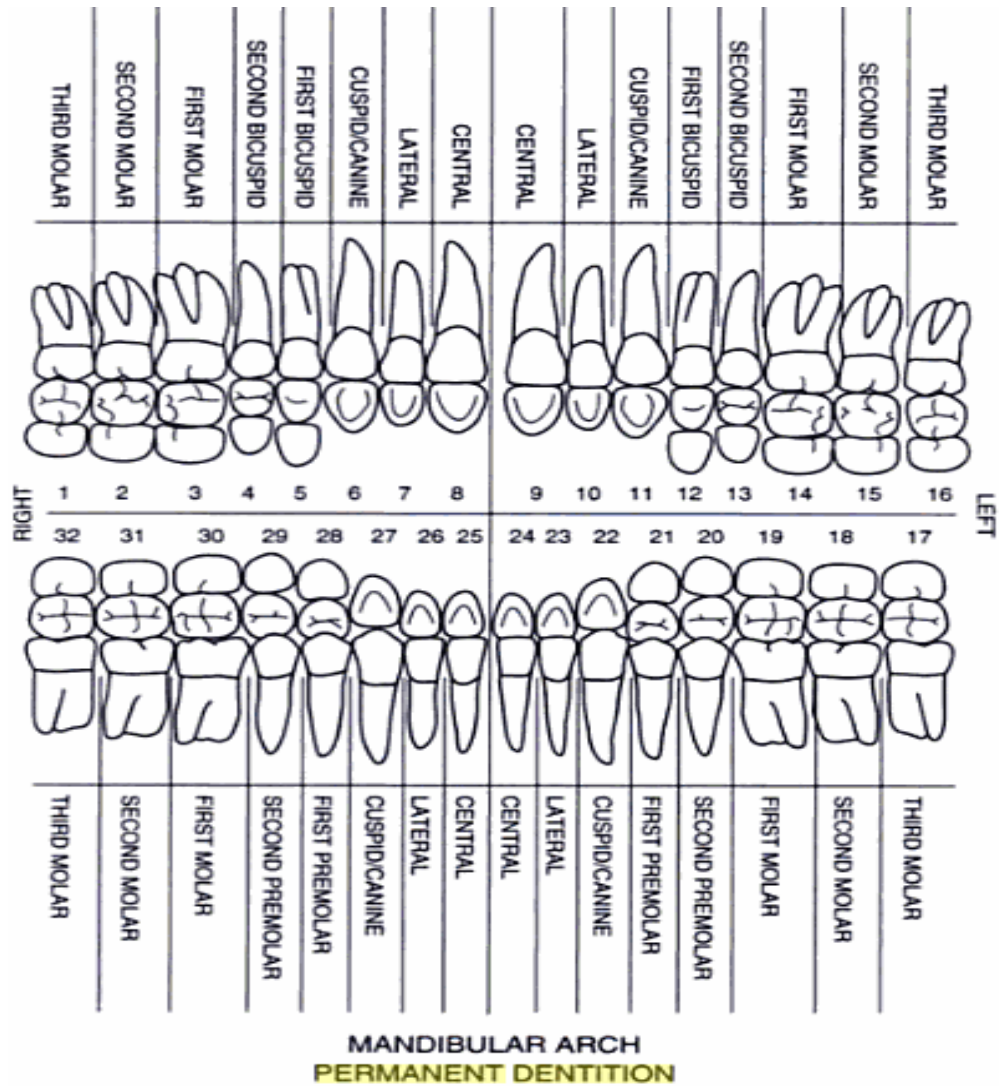
Gingival thickness is important for the overall health and attachment of natural teeth alongside successful implant therapy. In cases of either tooth root exposure or implant titanium post exposure due to recession, root coverage procedures would need to

be conducted in order to provide more stable attachment of the natural teeth and/or prosthetic to the underlying bony architecture. Research has found that with respect to root coverage procedures, there is a correlation between the optimal gingival flap thickness (0.8- 1.2 mm) and optimal treatment outcome: comprehensive root coverage (Abraham et al., 2014; Shepard, 2009; Kassab et al., 2010). Moreover, thickening gingival may play a role in preventing future gum recession in treated areas (Shepard, 2009). Therefore, there are various means to achieve thicker gingival from thinner gingiva. These soft tissue augmentations include acellular dermal matrix (also known as Alloderm), sub-epithelial connective tissue grafting, and guided tissue regeneration. Many studies have found that with the use of connective tissue grafts, or acellular dermal matrix, in conjunction with sub-epithelial connective tissue graft there is an increase in gingival tissue and greater mean root coverage (Shepard, 2008; Harris 2002).

### **Gingival Thickness and Tooth Position**

Gingival thickness varies throughout the oral cavity depending on its location (Figure 3). In general, studies have found that gingival thickness varies between the mandibular and maxillary arches; additionally, facial gingiva is thicker in the maxilla than in the mandible (Kolte et al., 2014; Cuny-Houchman et al, 2013; Muller et al., 2000; Nirmal et al., 2012). Some studies have also found the thinner gingiva is most prevalent in canines in the maxilla and the premolars of the mandibular bone (Nirmal et al., 2012; Cuny-Houchman et al., 2013). Further, abnormally positioned teeth lead to a variation in

gingival thickness, such as flattened or overemphasized gingival contour (Scheid and Weiss, 2012; Dhalkari and Ganatra, 2014).



**Figure 3: Tooth location.** Notice this is an example of maxillary and mandibular permanent dentition using the universal number system. These teeth positions will be referenced later in the results and discussion. Figure taken from Dietz, 1999.

## **Gingival Biotype Assessment**

A number of invasive and non-invasive methods have been used to measure gingival thickness (Abraham et al., 2014). These techniques include visual inspection, trans-gingival probing, ultrasonic devices, cone beam computerized tomography (CBCT), and the use of a tension-free caliper. Aside from visual evaluation, no single method of evaluation is considered more reliable than the other.

Visual evaluation is the simplest method of assessment. And, since it is non-invasive, it is commonly used to determine biotype based on distinguishing observable characteristics addressed in Table 2. Although commonly used, studies have shown that this method is not reliable because classification of biotypes is based on clinician's experience (Kan et al., 2010; Zawawi et al. 2012; Zeers et al., 2014).

On the other hand, trans-gingival probing also known as periodontal probing or bone sounding is an invasive procedure that requires local anesthetic. The periodontal probe has 1-millimeter marks. This tool not only provides gingival thickness, but also bone volume, which can be useful for periodontal therapy. This method has its limitations, such as precision of the periodontal probe, the angulation of the probe, and distortion of tissue during probing (Abraham et al., 2014; Esfahrood et al., 2013).

Ultrasonic devices are considered the least invasive and are extremely reliable. The measurement is acquired by measuring the time lapse between the start of the ultrasonic wave as it travels through the gingival tissue and its reflection back once it reaches the bone, creating a spike on the monitor. These devices, although they

demonstrate high accuracy, do possess some limitations, such as difficulty in determining the proper position for accurate measurements and discrepancies in reproduction of measurements (Kuriakose et al., 2012).

Cone beam computerized tomography (CBCT) has previously been used for hard tissue imaging. In 1998, CBCT machines were introduced into the field of dentistry to produce dental imaging (Kim et al., 2012). CBCT is a type of computerized tomography that has a cone shaped beam-emitting photons excited by 100 to 120 kV tube potential and 1.5 to 10 mA current, which is absorbed by a detector. A major concern when using CBCT to measure gingival thickness is that the method requires radiation exposure. Moreover, metal relics from prosthetics, restorations or implants may jeopardize the image quality. Further, CBCT alone cannot be used to determine gingival thickness. A radiographic stent, in addition to CBCT, is required (Gupta et al., 2014).

Lastly, a tension-free caliper can be used as a tool to assess gingival thickness, but only at the time of surgery. This method of assessment requires a gum flap reflected to obtain the measurement. Similarly to trans-gingival probing, tension-free calipers also require anesthetic injection for pain management. A study conducted by Kan et al showed statistically significant discrepancies in measurement accuracy between visual evaluation, trans-gingival probing, and caliper evaluation methods (2010).

## **Objective**

Considering the literature, there is consensus on the importance of gingival thickness for the overall health and stability of the oral cavity. Although various methods have been proposed for measuring gingival thickness, not all are held to equal reliability or comfort level. The literature review suggests that trans-gingival probing produces the most reliable measurement, while bypassing exposure to radiation and surgery in order to obtain gingival tissue values. Therefore, the goal of this study is to evaluate the accuracy of using trans-gingival probing in comparison to a tension-free caliper as means of determining gingival thickness. Moreover, it is our hope that this pilot study serves as a foundation for future research.

## **METHODS**

### **Study Design**

This study is a prospective randomized clinical study designed to assess the accuracy of periodontal probing as a means of determining gingival thickness. Precision of the periodontal probing tool was compared to a tension free caliper as the gold standard. Participants of this study were patients seeking periodontal treatment at one of three office locations located in Massachusetts and Rhode Island. This study is a pilot study and all patients gave written informed consent for their participation.

### **Sample**

The participants eligible for the study were identified from a population utilizing the Offices of Fugazzotto-Rost Periodontics and Dental Implants for periodontal therapy. This therapy included connective tissue grafts, implant placements and osseous surgery. A total of 20 (12 women, 8 men) adult patients (ages 23 -64) participated in this study. The following inclusion criteria were used: any patient undergoing periodontal surgery, eighteen and older. Patients were excluded from the study if they were: pregnant and lactating women or children under age eighteen. Patients were identified based on dental history, which was obtained from oral evaluation to determine need for periodontal therapy.

## **Gingival Biotype Evaluation**

The gingival biotype of each participant was assessed by two experienced periodontists. Twenty minutes prior to gingival assessment, patients were injected with either 4% Setocaine 1:100,000 epinephrine and 2% lidocaine 1:1000,000 epinephrine injections to numb the area. Patients' gingival tissue was evaluated by periodontal probing (bone sounding) in an area where the gum was going to be reflected approximately 2 mm below the gingival margin. Measurements were then rounded to the nearest 1 mm. Once the gum flap was reflected, a measurement was taken with the caliper right next to the measurement taken with the probe (which can be identified by a bleeding pointed created by the insertion of the probe) to avoid difference in thickness. The caliper measurement was taken to the nearest 0.5 millimeter. Gingival evaluation included the measurement of mid-buccal gingiva with a periodontal probe (University of North Carolina 15-millimeter periodontal probe) and a tension-free caliper (Medesy 4580) at the time of surgery (Figures 3 and 4). Mid-buccal gingiva is the gingiva that covers the mid-buccal surfaces of the teeth alongside the alveolar bone. The reliability of the periodontal probing as a means of classifying gingival biotype was compared to measurements using a tension-free caliper. A tension-free caliper was used to avoid excessive pressure on the gingival tissue. The gingival biotype was characterized thick if measurement was >2 millimeter and thin if < 1.5 millimeter.

### **Statistical Analysis**

Comparisons among the two modes gingival tissue assessment—trans-gingival probing and tension-free caliper—were analyzed using paired-t test and simple linear regression. P values < 0.05 were considered significant.

## RESULTS

This study included 20 patients (12 females, 8 males) seeking periodontal therapy requiring surgery, with a mean age of 46.85 (23 - 64). Gingival thickness was measured in a total of 15 maxillary teeth (1 central incisor, 9 bicuspid, 1 canine, 4 molar) and 5 mandibular teeth (5 molar). The measurements were recorded to tooth position, tooth arch location, gender, age, and the results were as follows:

The measurements collected by both periodontal probe and tension-free caliper are depicted in Tables 3- 6 and Figure 4- 7.

### **I. Tooth position**

Tooth position comparison between trans-gingival probing and direct measurement revealed that gingival thickness varied among the different crown morphologies (central incisor, molar, bicuspid and canine). Results show that the gingiva was thickest in the posterior portions of the oral cavity (molars and bicuspid). The results show that the periodontal probe on average overestimates the caliper measurements by 0.025 mm. However, the differences between the two methods were insignificant (p-value= 0.77) at the mid-buccal region (Table 3 & Figure 4).

### **II. Tooth Arch Location**

Comparing the gingival tissue thickness overlaying the mandibular and maxillary arch showed that the thinner gingival tissue on the mid-buccal site was located on the

mandibular alveolar bone. Moreover, comparison of the arch location by the two methods of measurement suggest that the mean difference in (0.03 mm) (p-value= 0.77) for maxillary arch and in the mandibular arch the mean difference was (0.0 mm) (p-value= 1) which was insignificant for both arches. (Table 4 & Figure 5).

### **III. Gender**

In terms of gingival biotypes and gender, both trans-gingival probing and caliper measurements methods indicated that the gingival tissue thickness among the female participants was thinner than the males (Table 5 & Figure 6).

### **IV. Age**

In differentiating between trans-gingival probing and caliper measurements both methods implied that the gingival tissue was significantly thicker among the younger (26 - 35) participants compared to the older age group (36 - 64) (Table 6 & Figure 7).

**Table 3:** Tooth position comparison of trans-gingival and tension-free caliper measurements.

Dental Arch		Mean ± SD		
		Probe	Caliper	p-value
Maxillary	Incisor (n=1)	NA	NA	NA
	Bicuspid (n=9)	1.11±0.33	1.00±0.00	0.34659
	Molar (n=4)	1.38±0.48	1.25±0.29	0.63762
	Canine (n=1)	NA	NA	NA
Mandibular	Incisor (n=0)	NA	NA	NA
	Bicuspid (n=0)	NA	NA	NA
	Molar (n=5)	1.00±0.35	1.00±0.35	1
	Canine (n=0)	NA	NA	NA

**Table 4.** Tooth Arch thickness comparison of trans-gingival probing and tension-free caliper measurements

Method	Dental Arch	n=20	
		Range (mm)	Mean $\pm$ SD
Probe	Maxillary	1.5	1.17 $\pm$ 0.36
	Mandibular	1	1.00 $\pm$ 0.35
Caliper	Maxillary	1	1.13 $\pm$ 0.30
	Mandibular	1	1.00 $\pm$ 0.35
Probe vs. Caliper	Maxillary	Mean difference = 0.03 (p=0.77444)	
	Mandibular	Mean difference = 0.00 (p=1)	
	Both	Mean difference = 0.03 (p=0.77153)	

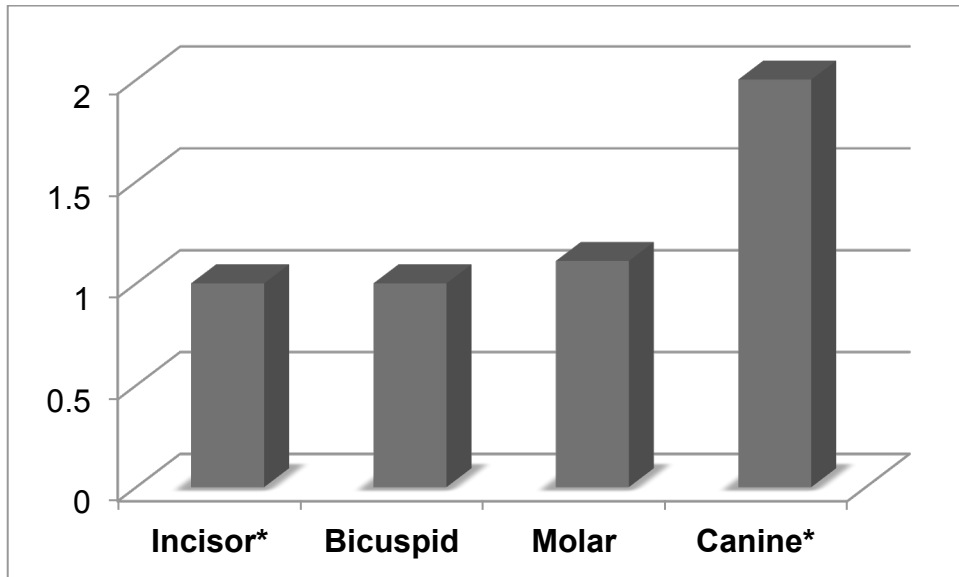
**Table 5.** Mean gingival thickness in mm between male and female participants.

Dental Arch	Male (M) n=8 Mean ± SD			Female (F) n=12 Mean ± SD		
	Probe	Caliper	p-value	Probe	Caliper	p-value
Max.	1.17±0.26	1.25±0.42	0.62131	1.17±0.43	1.00±0.25	0.08052
Man.	1.25±0.35	1.25±0.34	1	0.83±0.29	1.00±0.00	0.42265
Max. & Man.	1.19±0.26	1.25±0.38				
Male vs. Female	Probe	Mean difference = 0.10				
	Caliper	Mean difference = 0.25				

**Table 6.** Mean gingival thickness of mid-buccal region in mm between younger (23 - 35) and older (36 -64) age group

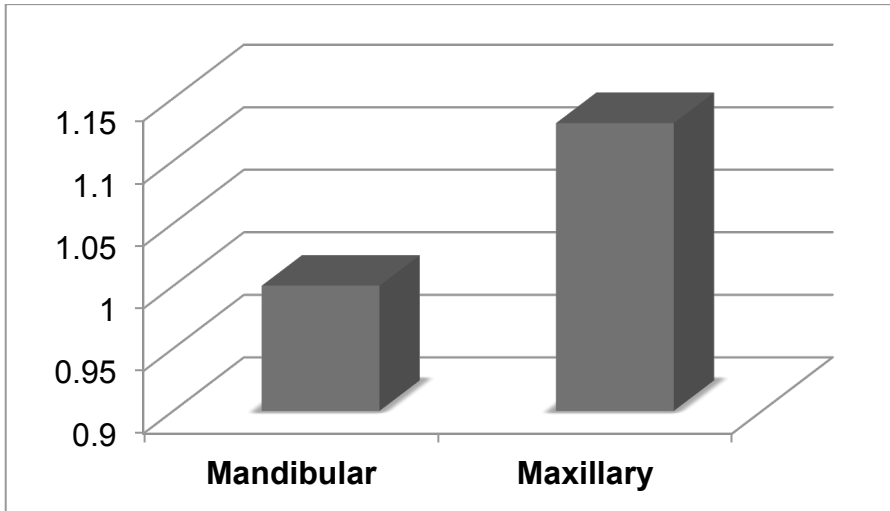
Dental Arch	23-35 years n=4 Mean ± SD			36-64 years n=16 Mean ± SD		
	Probe	Caliper	p-value	Probe	Caliper	p-value
Max.	1.00±0.00	1.33±0.58	0.42265	1.25±0.40	1.08±0.29	0.10392
Man.	1.00*	1.00*	NA*	0.88±0.25	1.00±0.00	0.391

\*n=1, There was one measurement for the mandible for subjects in the younger group therefore no SD or p-value.

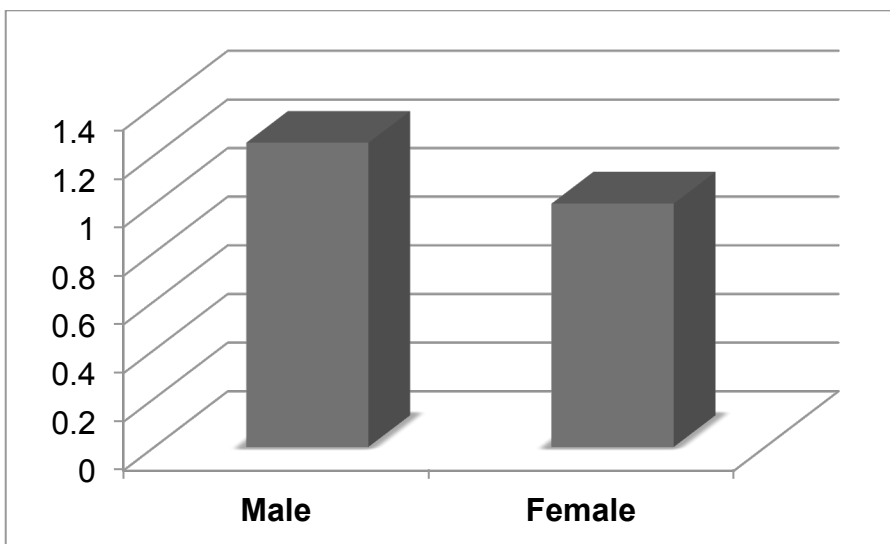


**Figure 4.** Tooth position comparison of trans-gingival and tension-free caliper measurements

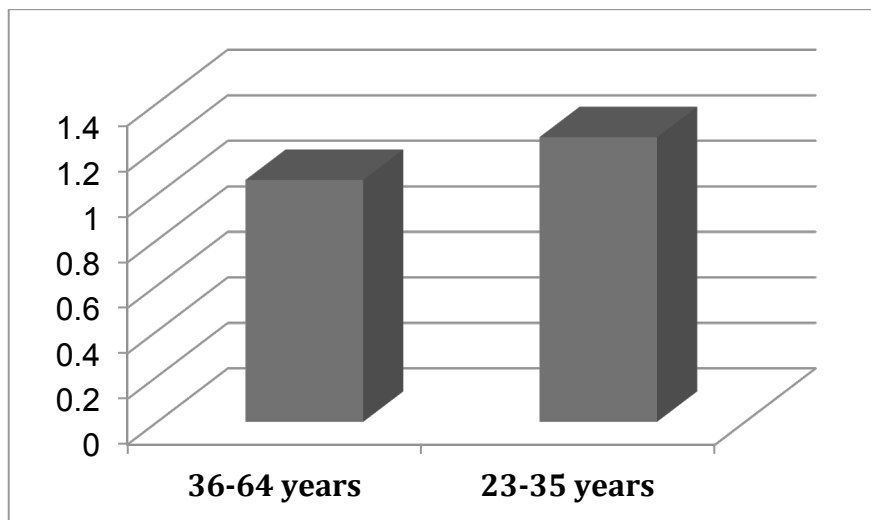
\*Means could not be calculated for canine and incisor tooth types because the data only included one canine and one incisor measurement. As a result, the canine and incisor measurements shown in the figure are not means; they are, instead, the actual measurements of the gingiva surrounding the canine and incisor teeth.



**Figure 5.** Tooth Arch thickness comparison of trans-gingival probing and tension-free caliper measurements



**Figure 6.** Mean gingival thickness in mm between male and female participants.



**Figure 7.** Mean gingival thickness of mid-buccal region in mm between younger (23 -35) and older (36 -64) age group.

## **DISCUSSION**

Gingival tissue thickness is an important parameter that affects the health of natural teeth and prosthetics, periodontal health, gingival recession, underlying bone quality, and periodontal therapy. Moreover, the knowledge of gingival biotype helps determine the need of soft tissue augmentation and avoidance of clinical attachment loss, implant failure, and or complication of periodontal treatment. Therefore, various methods of gingival thickness assessment have been introduced. However, the results of measurements and modes of assessment are controversial in reliability and safety for patients.

The gingival tissue is a major feature of the periodontium. It is characterized as soft tissue present in the oral cavity that is tightly bound to the tooth near where the root and crown join. Importantly, the tissue also covers the underlying bone. Gingival thickness varies from person to person and in different areas of the same mid-buccal cavity. Gingiva phenotype is also an indication of the underlying bony architecture. Moreover, different gingival biotypes respond differently to inflammation, trauma, and periodontal treatment. Gingiva tissue can be divided into two broad categories: thick or thin gingival biotypes. A thick gingival biotype is most commonly associated with healthy periodontal health. Thick gingival biotype is distinguished from thin biotype by flat and dense fibrotic soft tissue, greater resistance to inflammation and trauma, and thicker alveolar processes. Thin gingival tissue is characterized by highly scalloped and delicate soft tissue, increased susceptibility to inflammation and trauma, and thin underlying bone (Abraham et al., 2014). Understanding the differences in biotypes aid in

the development of periodontal treatment planning to ensure the long-term health of natural teeth, restorations, and prosthetics. This study aimed to evaluate the precision of using a periodontal probe as a means to assess gingival thickness by comparing it to a direct measurement using a tension-free caliper.

The soft tissue thickness of the periodontium is crucial in gingival biotype evaluation. There are various gingival diagnostic methods that are either invasive or non-invasive, including visual evaluation, cone beam computerized tomography, ultrasonic devices, trans-gingival probing (bone sounding), and calipers (Abraham et al., 2014).

A visual evaluation using a periodontal probe is the most common method used to determine tissue transparency and biotype. As noted in the literature review, this method is unreliable. This is likely due to the fact that there is no ubiquitous standardization for visual evaluation. Rather, knowledge is gained from the clinical experience of the practitioner. In a previous study visual evaluation grossly overestimated participants as having thick gingival biotype and underestimated classification of thin gingiva by approximately 30% when compared by direct assessment with a tension-free caliper (Kan et al., 2010). Their results showed this margin of error was seen in participants that had gingival thickness  $<0.6$  millimeter was classified as thin and thickness of  $> 1$  millimeter was seen as thick. These results are in agreement with a number of recent studies which found visual assessment as being statistically significantly different from direct measurement ( $P < .05$ ) (Cuny-Houchmand et al., 2013; Eghbali et al., 2009; Zawawi et al., 2012; Zeers et al., 2014). Thus, this mode lacks precision and reliability.

Another noninvasive approach is cone beam computerized tomography (CBCT). This low-dose radiographic method provides a three-dimensional visual of oral structures. When used in conjunction with a radiographic stent, CBCT produces precise measurements of gingival tissue and alveolar bone with an average difference of 0.6-millimeter from the actual thickness (Jung et al., 2002). Studies have also indicated that CBCT measurements are as accurate as using trans-gingival probe (Mohan et al., 2011).

In terms of the invasive methods of gingival evaluation ultrasonic devices are considered the least invasive but also most expensive. Ultrasonic devices gives rise to gingival thickness by measuring the time lapse from the beginning of an ultrasonic wave as it travels through the gingival tissue and its reflection back from the underlying bone. Many studies using ultrasonic devices to obtain gingival thickness measurements have used one of two types of radio frequency ultrasonic probes—A-scan or B-scan. Recent studies have found that this method has its limitations in its reliability due to the importance of position of probe and the knowledge for interpretation (Kuriakose et al., 2012). Some studies found that using ultrasonic devices to access posterior parts of the mid-buccal cavity was not possible (Issrani et al., 2013; Zeers et al., 2014).

Another invasive method is trans-gingival probing, which requires anaesthetizing the gingiva to follow-up with the use of a periodontal probe. The calibrated periodontal probe has markings in 1-millimeter increments. Due to the 1-millimeter increments, studies have found that trans-gingival measurements are overestimated by 0.5-millimeter (Savitha et al., 2005; Bednarz, 2011).

Lastly, another invasive method of assessment is using a tension-free caliper. As noted in the literature review, this method cannot be used for pretreatment assessment because it can only be done at the time of surgery (Esfahrood et al., 2013). The tension-free caliper has markings to the nearest 0.01-millimeter.

Trans-gingival probing has many favorable features in contrast to the other methods of gingival measurements:

- Cost effective
- Easy access to any location around all teeth
- Ease of interpretation
- Rounded tip to avoid tissue trauma
- No exposure to radiation
- Minimally invasive
- No need for surgery to establish biotype

Hence this study sought to establish the reliability of using a periodontal probe to determine gingival biotype by comparing its values to a direct measurement with a tension-free caliper.

As noted in the literature review, gingival thickness varies throughout the oral cavity. Trans-gingival probing and the tension-free caliper measurements in this study demonstrated thickness variation between canine, molar, bicuspid and incisors. As seen in this study, thickness of the gingival tissue is dependent on the type of teeth. Gingiva was thick in the posterior teeth. These results are confirmed by findings in other studies,

which concluded that different morphology of the tooth crown gives rise to varying gingival thickness (Muller et al., 2000).

Aside from tooth crown morphology, the literature indicates that gingival tissue overlaying the maxillary arch is thicker compared to the mandibular arch. Analysis of the gingival thickness in the present study showed that the gingiva in the maxilla was thinner than the mandible. On the contrary, results in study conducted by Savitha et al. (2005) found that the gingival tissue overlaying the maxilla thinner than the mandible.

In terms of gender, the present study demonstrated that, in general, the males had thicker gingiva in the mid-buccal region than females. These findings are consistent with other studies that evaluated gingival thickness in the mid-buccal region and found a significant difference between genders (Bharamappa et al., 2013; Kolte et al., 2014; Vandana et al., 2005). The variance in gingival tissue between young and old is attributed to the thinning of oral epithelium as a result of aging. Conflicting results were seen in a study that found that the thickness of the palatal mucosa increased with age (Waraaswapati et al., 2005). Despite the opposing findings, the difference may not be sufficient to compare facial gingiva with palatal masticatory mucosa because more recent studies such as Yaman et al (2014) found that there is not statistical significance between palatal masticatory mucosa and gender.

This study found there was no statistical significance ( $p$ -value= 0.77) between a periodontal probe and a tension free caliper in mid-buccal region of the gingiva. But the trans-gingival measurements were overestimated in the majority of sites. This overestimation can be attributed to the values obtained by the periodontal probe with the

1-millimeter markings. Since the discrepancy in the measurements was minimal, the trans-gingival probing method was found to be reliable. The reliability seen in this study is supported by the findings of a number of recent studies (Yaman et.al., 2014; Savitha et al., 2005).

## **Limitations**

This study has a number of limitations. First, the study had a small sample size. A larger sample size would give rise to greater validity to the results. Therefore, the results of this study should be taken as a preliminary data for future research. Secondly, due to the 1-millimeter markings of the periodontal probe, the measurements were rounded up. Thus, precision of measurement is of concern. Thirdly, angulation is subjective and thus, measurements may be inaccurate. Fourthly, the potential of volumetric changes post administration of local anesthetic was not accounted for thus measurements may have been inaccurate.

## **Conclusion**

Given the importance of gingival thickness, a reliable means of assessment is crucial. From the studies described above visual assessment is the most common mode of evaluation, and yet, has the greatest discrepancy among all tools of measurement. Not many studies have looked into the assessment of the precision of a trans-gingival periodontal probe in determining gingival thickness. This pilot study provides important evidence that the periodontal probe is an accurate means to measure gingival thickness. Due to the limitations of the study, the results are not statistically significant, but the data suggests that the periodontal probe can be used to produce accurate measurements of gingival thickness.

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## CURRICULUM VITAE

