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Factors Affecting Gingival Recession in the Esthetic Zone: A Human Cadaver Study

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Factors Affecting Gingival Recession in the Esthetic Zone: A Human Cadaver Study

by

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A Thesis submitted in partial satisfaction of
the requirements for the degree
Master of Science in Periodontics

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Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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CONTENTS

FIGURES

Figures Page

TABLES

ABBREVIATIONS

GR	Gingival Recession
PD	Probing Depth
BS	Bone Sounding
GT1	Gingival Thicnkess at the Sulcus
GT2	Gingival Thickness at the Bone Crest
BL	Bone Loss
BT1	Bone Thickness 1mm Apical to the Bone Crest
BT2	Bone Thickness 3mm Apical to the Bone Crest
Age	Age
D	Dehiscence
F	Fenestration
V	V-Shaped Defect
U	U-Shaped Defect
UU	UltraU-Shaped Defect

ABSTRACT OF THE THESIS

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Master of Science, Advanced Specialty Education Program in Periodontics
Loma Linda University, March 2014
Dr. Yoon Jeong Kim, Chairperson

The purpose of this study was to assess the correlation of gingival recession to the following parameters in fresh cadavers: gingival thickness, buccal bone loss, buccal bone thickness, shape of bony dehiscence defect, and age. A secondary aim was to evaluate predictors for gingival recession.

Sixteen fresh cadavers were used in this study. Gingival recession, facial gingival thickness, alveolar bone loss, and buccal bone thickness were measured at teeth #6-#11 and #22-#27. Sites with a dehiscence (D) or fenestration (F) were presented, and resultant bony defect shape was noted. The correlation of gingival recession to gingival thickness, buccal bone loss, buccal bone thickness, shape of dehiscence defect and age was evaluated using Spearman's rho correlation coefficient. The strongest predictors for gingival recession were identified through a multiple regression analysis performed on candidate predictors.

Gingival recession was found to be correlated to age and bone loss (rho=0.53, p<0.01; rho = 0.57, p<0.01, respectively). A statistically significant difference was found in the correlation between bone loss and gingival recession when comparing D/F sites and non-D/F sites (rho = -0.095, p = 0.667; rho = 0.646, p<0.001, respectively). After

correlating potential predictors with gingival recession, we found that the magnitude of correlations was different in males and females. Multiple linear regression analysis found that the strongest predictors for gingival recession in both males and females were underlying bone loss, bone thickness 3 mm apical to the bony crest, and age. Within gender groups, the predictive value for bone loss and age were found to be statistically significant ($p<0.01$).

Within the limitations of this study, we conclude that gingival recession is correlated to bone loss and age. Bone loss, bone thickness and age were the strongest predictors for gingival recession. The magnitude of effect of bone thickness 3mm apical to the bony crest was much greater in males than in females. Clinical studies of larger scale are needed to apply these findings to our clinical practice.

CHAPTER ONE

INTRODUCTION

Gingival recession is highly prevalent in adult populations, and has been shown to increase in both prevalence and severity with age.[1] The extent and severity of gingival recession was analyzed in a multivariate model of the first national periodontal and systemic examination survey (NPASES I) and was reported in 2010. A total of 84.6% of this adult population had at least one gingival recession. A linear regression analysis showed that age, gender, plaque index and tobacco consumption were associated with the extent of gingival recession.[2]

Studies have suggested certain risk factors for gingival recession such as anatomic and mechanical factors.[3,4] Gingival inflammation and periodontitis have also been shown to be associated with prevalence and severity of recession.[5,6]

Lost studied a correlation between gingival recession and alveolar bone loss. They evaluated gingival recession and dehiscence defects of 113 teeth in vivo and found the average soft tissue recession depth to be 2.7mm, and an average bone dehiscence depth of 5.4mm. Thus the average distance between the gingival margin and alveolar bone was 2.8mm. However, 16 teeth presented with a distance of 4mm or more (up to 7.5mm).[7] Based on the result, gingival recession cannot be explained by alveolar bone loss alone.

Studies have shown that gingival thickness affects the amount of recession around natural teeth. Olsson and Lindhe evaluated the relationship of crown form and the thickness of gingiva.[8] “Long narrow” incisors showed a narrow zone of keratinized gingiva, shallow probing depths and more gingival recession as compared to “short wide” central incisors. Muller showed that natural dentitions with thin biotype consisting of non-keratinized gingiva have more inherent risk for future recession when subject to trauma.[9] In a similar study, he also demonstrated that thickness of the masticatory mucosa strongly depends on periodontal phenotype.[10] Periodontal phenotypes were assigned to maxillary incisors in 40 individuals based on gingival thickness, gingival width, and ratio of crown width and length. There was, however no difference between periodontal phenotype groups in gingival recession in contrary to Olsson and Lindhe’s results.

In the literature, orthodontic tooth movement was also considered a risk factor for gingival recession.[11-14] When moving maxillary incisors labially in monkeys, Wennstrom found the height of keratinized gingiva was not associated with gingival recession.[12] They argued that the thickness of the gingiva seems to play a role for apical migration of the gingival margin. In a retrospective study, Melsen evaluated gingival recession after labial orthodontic movement of mandibular incisors in 150 adult patients.[13] There were about 3% of patients that developed more than 2mm of gingival recession although there was no significant increase in mean gingival recession. In the regression analysis, gingival biotype, categorized as thick (>2mm) and thin (<2mm), plaque and inflammation were shown to be significant predictors for gingival recession.

Kan et al. presented the association between the morphology of the dehiscence bony defect and peri-implant mucosa recession on immediate implant treatment.[15] They categorized dehiscence defects after extraction of teeth for immediate implant placement into V-shape (V), U-shape (U) and UltraU-shape (UU) categories. Interestingly, they found that U and UU shaped defects showed significantly more recession (>1.5mm) than V shaped defects one year after immediate implant placement and guided bone regeneration. This concept of defect shape with regard to gingival recession has yet to be investigated around the natural dentition.

Fu et al. studied tissue biotype and its relation to the underlying bone morphology.[16] On 22 fresh cadaver heads, they measured the thickness of both soft tissue and bone clinically and radiographically using cone beam computed tomography (CBCT). A simple linear regression model found a moderate correlation between gingival thickness and underlying bone thickness as measured with CBCT($R= 0.429$). However, no significant relationship was observed between gingival recession and soft tissue and bone thickness. Han evaluated buccal bone thickness at anterior teeth in relation to gingival biotype in 5 cadaver heads.[17] She measured buccal bone thickness at the alveolar crest, 3mm apical to the crest, and 6mm apical to the crest. The thickness of the buccal plate was the thinnest at the alveolar crest, ranging from 0.78mm-1.17mm. The thinnest buccal plate was noted at the maxillary lateral incisor position, and the thickest buccal plate was noted at the mandibular canine position. Unfortunately, a relationship between buccal bone thickness and gingival thickness was not found in this study due to small sample size.

Gingival recession has been shown to correlate with buccal bone loss.[7] Buccal bone thickness in cadavers has been previously reported.[17] However, to our knowledge, the correlation among the following factors has not been reported: gingival recession, gingival thickness, buccal bone loss, shape of dehiscence defect and buccal bone thickness. Understanding these clinical parameters would be helpful in identifying high-risk patients for gingival recession and planning any surgical procedure in the esthetic region.

The *primary* aim of this study was to assess the correlation of facial gingival recession of anterior teeth with gingival thickness, buccal bone loss, shape of dehiscence defects, and age. The *secondary* aim of the study was to evaluate predictors for gingival recession. The null hypotheses of this study are that gingival recession has no correlation with any of the tested variables, and that among the candidate predictors, there is no predictor for gingival recession.

CHAPTER TWO

MATERIALS AND METHODS

Study Sample

A total of 16 fresh cadaver heads were used in this study during academic use in the Loma Linda University Medical Center Otolaryngology Department. Four edentulous cadavers were excluded from the study and one cadaver was used only for calibration purposes. Thus, 5 male and 6 female cadavers were studied. Age was obtained and recorded for 10 of these cadavers, with a mean age of 72.5 years (range: 31-95 years). Maxillary and mandibular incisors and canines, teeth #6-#11 and #22-#27, were evaluated in this study.

Exclusion Criteria

Teeth were excluded from the study for the following reasons: the CEJ was not clearly visible, miller class IV recession defects,[18] facial probing depth of ≥4mm, grade III mobility, evidence of a free gingival graft, presence of fistula, severely rotated teeth (>30 degrees), or if traumatic tooth extraction caused buccal plate alteration.

Clinical Measurements

Two examiners performed clinical measurements. Prior to taking measurements, the two examiners participated in a calibration session on one cadaver. During the calibration session, each examiner measured all of the parameters on teeth #6-#11 and

#22-27 twice, and the intra-examiner and inter-examiner reliability were assessed using intra-class and inter-class correlation coefficients. Intra-examiner and intra-examiner error was also calculated. All linear measurements were recorded to the nearest 0.1mm except for bone sounding measurements, which were recorded to the nearest 0.5mm.

Gingival Recession

Gingival recession was measured on the facial aspect from the CEJ to the gingival margin (figure 1) with digital calipers (Salvin Dental Specialties Inc., Charlotte, NC).

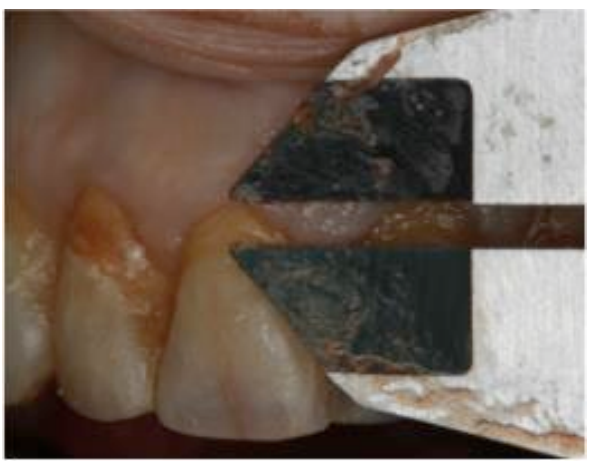


Figure 1. Gingival recession measurement

Gingival Thickness

Gingival thickness was measured at two locations, sulcus level (GT1) and alveolar crest level (GT2); locations were marked with a permanent marker on the buccal side of gingiva/mucosa before flap reflection. The depth of the gingival sulcus was measured with a periodontal probe (PCP UNC 15, Hu-Friedy) and the level of the alveolar crest was determined using the same probe. Subsequently, vertical releasing incisions were made at the distal aspect of teeth #6, #11, #22 and #27, and full mucoperiosteal flaps were raised from #6-#11 and #22-#27 and GT1 and GT2 was measured (figure 2) with a modified caliper (Pearson Dental, Sylmar, CA). Modification of caliper was done by removing internal spring to prevent compression of soft tissue during measurements.

Figure 2. Gingival thickness measurement

Alveolar Bone Level

Alveolar bone level was evaluated using two methods. Bone sounding (BS) was performed on the mid facial aspect of all teeth prior to flap reflection with a periodontal probe (PCP UNC15, Hu-Friedy). Bone level (BL) was measured from the CEJ at the mid facial aspect to the bone crest of every included tooth using the digital calipers after flap reflection (figure 3).

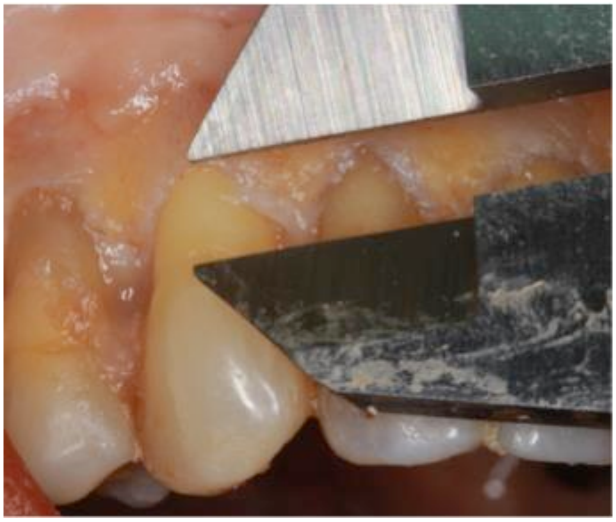
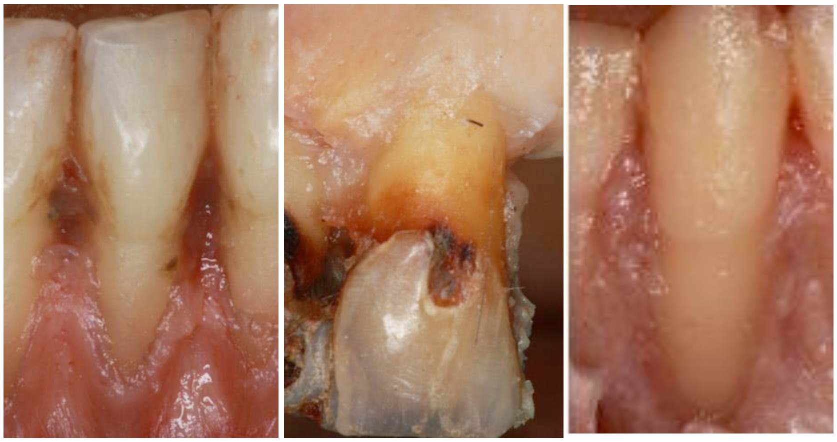


Figure 3. Alveolar bone level measurement

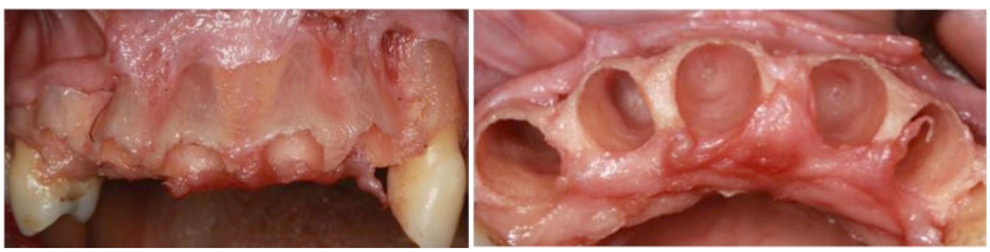
Bony Defect Shape

After flap reflection, facial dehiscence defects (D), if present, were categorized based on the following defect shapes (DS): V, U and UU[15] (figure 4). Presence of fenestration defects (F) was also recorded. Subsequently, all included teeth were extracted using elevator and forcep technique or periotome and mallet when necessary (figure 5).



A. B. C.

Figure 4. Shape of dehiscence defects. A: V-shape, B: U-shape, C: UltraU-shape.

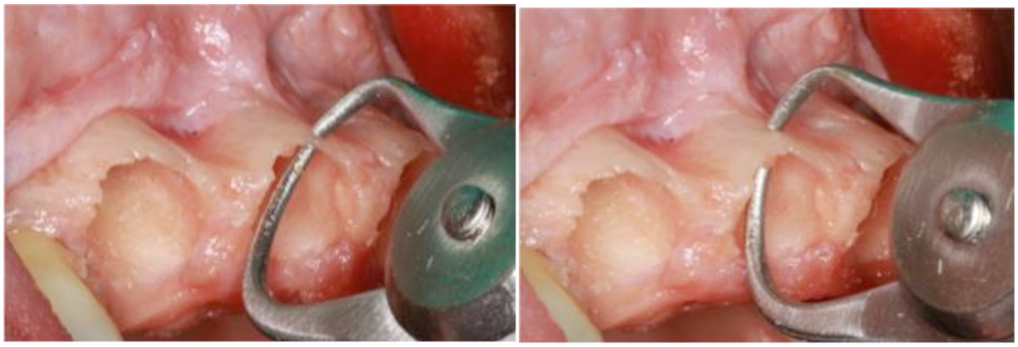


A. B.

Figure 5. Alveolar bone post-extraction. A: facial view, B: occlusal view.

Buccal Bone Thickness (BT):

The buccal bone thickness was measured at two different locations, 1mm apical to the alveolar crest (BT1) and 3mm apical to the alveolar crest (BT2) using the modified caliper (Pearson Dental, Sylmar, CA) (figure 6). Location of BT1 was the most coronal possible measurement as the caliper beaks were approximately 1mm in width.



A. B.

Figure 6. Bone thickness measurement. A: BT1 measured 1mm apical to the crest, B: BT2 measured 3mm apical to the crest.

Statistical Analysis

Intra-examiner and inter-examiner reliability were calculated using intra-class correlation coefficient. Mann-Whitney U Test was used to compare mean recession of maxillary and mandibular arches and of male and female subjects. Kruskall Wallis test was used to compare mean recession among tooth types. Spearman'srho correlation coefficient test was used to determine correlation between gingival recession, age, gingival thickness, alveolar bone loss, and buccal bone thickness, as well as the correlation between gingival recession and bone loss in dehiscence/fenestration sites and in non-dehiscence/fenestration sites. Kruskall Wallis test was used to determine if defect shape affected the distribution of gingival recession. Multiple linear regression analysis was conducted using the following predictor variables: gingival thickness, buccal bone loss, buccal bone thickness, and age to account for our dependent variable, gingival recession.

Hypotheses related to each predictor were tested at an alpha level of 0.05 and 95% confidence intervals were constructed around each beta coefficient. All analyses were performed with SAS version 9.2.3 (SAS institute in Cary, North Carolina).

CHAPTER THREE

RESULTS

Intra-examiner and inter-examiner reliability was calculated using intra-class correlation coefficient (table 1). Intra-class correlation coefficients as well as the inter-class correlation coefficient were high, with the intra-class correlation coefficient for examiner 1 being 0.994, and the intra-class correlation coefficient for examiner 2 being 0.995, and the inter-class correlation coefficient being 0.984. This demonstrates consistency within each examiner as well as between examiners. Table 2 shows calculated intra-examiner and inter-examiner error, which ranged from 0.11-0.16mm.

Table 1. Intra-examiner and inter-examiner reliability

Correlation	Coefficient	95% CI
Intra-class for Examiner 1	0.994	0.995-0.998
Intra-class for Examiner 2	0.995	0.991-0.997
Inter-class between examiner 1 and 2	0.984	0.971-0.990

Table 2. Intra-examiner inter-examiner error

Examiner	Error (mm)
Examiner 1	0.12
Examiner 2	0.11
Inter-examiner	0.16

Table 3 shows descriptives for recession of all examined teeth. Tooth #11 showed the highest mean recession (1.90mm), and #9 the least (1.03mm) in the maxilla. Tooth #11 also showed the largest range of recession (0-6.72mm), followed by #6 (0-4.52mm). Tooth #24 showed the highest mean recession (2.81mm) and #27 the least (1.59mm) in the mandible. Tooth #26 presents with the highest range (0-5.90mm) and #25 with the least (0-4.1mm).

Table 3. Gingival recession of all teeth (mm)

Tooth(N)	Mean	SD	Range
#6 (9)	1.49	1.41	0-4.52
#7 (9)	1.10	1.15	0-2.80
#8 (9)	1.06	1.24	0-3.86
#9 (9)	1.03	1.16	0-2.82
#10 (8)	1.68	1.69	0-4.66
#11 (8)	1.90	2.23	0-6.72
#22 (11)	2.04	1.90	0-5.15
#23 (10)	1.80	1.74	0-5.70
#24 (10)	2.81	1.67	0-5.36
#25 (10)	2.23	1.30	0-4.12
#26 (10)	2.09	1.86	0-5.88
#27 (11)	1.59	1.64	0-5.14

Fifty maxillary teeth were measured for recession and 62 mandibular teeth were measured. Mean recession was higher in mandibular teeth than in maxillary teeth (2.23mm +/- 1.76mm vs. 1.46mm +/- 1.48mm). This difference was statistically significant (Mann-Whitney U Test, $p = 0.01$). The range of recession was higher in maxillary teeth when compared to mandibular teeth (0-6.7mm v 0-5.9mm, respectively). Mean recession for maxillary centrals, maxillary laterals and maxillary canines was 1.05mm, 1.37mm, and 1.68mm respectively. Mean recession for mandibular centrals, mandibular laterals and mandibular canines was 2.52mm, 1.94mm, and 1.88mm, respectively (table 5). While difference in mean recession was observed among teeth with respect to tooth type, it was not statistically significant (Kruskall Wallis test $p = 0.58$).

Table 4. Gingival recession by arch (mm)

Arch (N)	Mean	SD	95% CI	Range
Maxilla (52)	1.46	1.48	1.03-1.89	0-6.72
Mandible (62)	2.23	1.76	1.80-2.78	0-5.88

Recession descriptives by gender was assessed (table 6). Forty-four teeth were measured for gingival recession in males and 70 teeth were measured in females. Mean recession was higher in males than females (1.83mm +/- 2.06mm vs. 1.73mm +/- 1.28mm); however, this difference was not statistically significant (Mann-Whitney U Test, $p = 0.33$). Males showed a greater range of recession than females (0-6.72mm vs. 0-5.7mm, respectively).

Table 5. Gingival recession by tooth type (mm)

Tooth type (N)	Mean	SD	Range
Central (38)	1.87	1.49	0-5.36
Lateral (36)	1.68	1.67	0-5.88
Canine (38)	1.79	1.78	0-6.72
Maxillary central (18)	1.05	1.06	0-3.86
Maxillary lateral (17)	1.37	1.41	0-4.66
Maxillary canine (17)	1.68	1.85	0-6.72
Mandibular central (20)	2.52	1.49	0-5.36
Mandibular lateral (20)	1.94	1.76	0-5.88
Mandibular canine (22)	1.88	1.76	0-5.70

Table 6. Gingival recession by gender (mm)

Gender (N)	Mean	SD	95% CI	Range
Male (5)	1.82	2.06	1.20-2.45	0-6.7
Female (6)	1.73	1.28	1.42-2.03	0-5.7

Note that gingival thickness 1mm apical to the gingival margin was not included in the statistical analysis. Because all cadavers presented with such thin gingival tissue along the gingival margin, this variable, GT1, was deemed immeasurable at the time of the study. Thus, GT2 was the only gingival thickness measured and reported. Correlations among the following variables were investigated in this study: GR, BS, BL, GT2, BT1, BT2 and age.

When analyzing Spearman's rho correlations among the measured variables, significant correlations were found (table 7). Recession was statistically significantly correlated with age and BL (rho = 0.532, p<0.01; rho = 0.573, p<0.01). The positive correlation between gingival recession and bone loss is shown in figure 7. Based on our results, we reject our primary null hypothesis that gingival recession is not correlated to any of the variables measured.

Table 7. Correlations between gingival recession and clinical parameters

		GR	BS	GT2	BL	BT1	BT2	Age
GR	rho	1.000	.019	.115	.573**	-.075	-.164	.532**
	N	114	114	114	114	106	109	108
BS	rho		1.000	-.022	.161	.242*	.306**	-.124
	N		114	114	114	106	109	108
GT2	rho			1.000	-.026	-.026	-.232*	.281**
	N			114-	114	106	109	108
BL	rho				1.000	-.065	.098	.141
	N				114	106	109	108
BT1	rho					1.000	.501**	-.008
	N					106	106	100
BT2	rho						1.000	-.133
	N						109	103
Age	rho							1.000
	N							110

Spearman Correlation * p<0.05 ** p<0.01

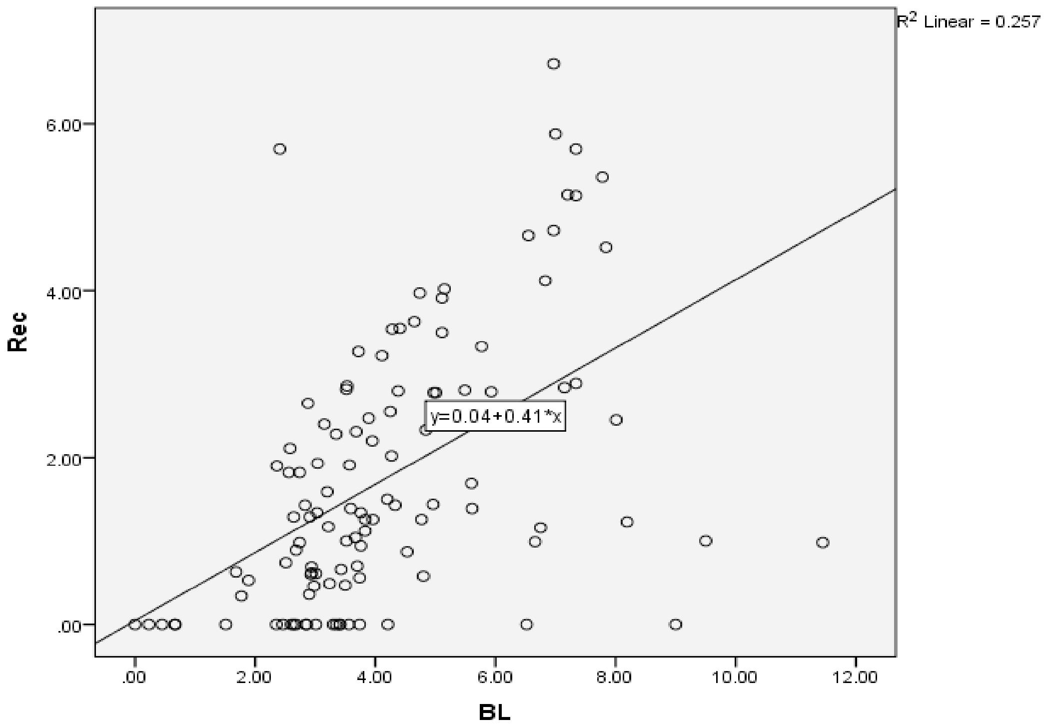


Figure 7. Correlation of bone loss and gingival recession

Table 8. Dehiscence/fenestration sites

Cadaver	Tooth	D/F	D Shape	GR	BL
1	24	D	U	2.45	8.01
2	10	D	U	3.50	5.11
3	23	D	V	1.00	9.50
	24	D	V	2.84	7.15
	25	D	V	3.33	5.77
	26	D	V	2.89	7.24
5	23	F		2.11	2.58
	24	D	U	1.39	5.61
	25	D	V	1.69	5.60
	26	F		1.29	2.91
7	6	D	U	4.52	7.84
	8	D	UU	3.86	5.47
	22	D	U	5.15	7.20
	23	D	U	5.70	7.34
8	11	D	UU	4.02	5.15
9	6	D	U	0.70	3.70
	22	D	UU	2.65	2.88
10	22	D	U	0.98	11.45
	23	D	U	0	6.52
	24	D	U	5.36	7.78
	25	D	U	1.23	8.19
	26	D	U	0.99	6.66
	27	D	UU	0	9.00

Table 9. Gingival recession and bone loss correlation in D/F and non-D/F sites

Group	rho	Sig	95% CI
With D/F (23)	-0.095	0.667	-0.52-0.38
Without D/F (91)	0.646	<0.01	0.48-0.78

Teeth presenting with dehiscence (D) or fenestration (F) defects and associated GR and BL are presented in table 8. Twenty-three D and F defects (N = 21, N = 2, respectively) were observed in total. Frequency of defect type is also presented in table 7 (V = 5, U = 12, UU = 4). The distribution of gingival recession was not affected by defect shape (Kruskal Wallis $p = 0.962$).

A significant correlation between bone loss and recession was noted in the non-D/F group (rho = 0.646, $p<0.001$) (table 9). However, this correlation was not significant in the D/F group (rho= -0.095, $p = 0.667$). A significant difference was found in the correlation between bone loss and gingival recession when comparing D/F sites and non-D/F sites.

Regression analysis (table 10) was performed on candidate predictors to ascertain which combination of variables contributed most to gingival recession, and the final resulting model showed BL, age, and BT2 (negative predictor) as the strongest predictors for gingival recession in both males and females, with age and bone loss having statistical significance within the male (BL $p = 0.000$, age $p= 0.000$) and within the female groups (BL $p=0.073$, age $p = 0.002$). Other predictors for gingival recession did not make it to the final model stage. Therefore, based on our results we reject the null hypothesis that among the candidate predictors measured no predictors for gingival recession exist.

Separate male and female predictor models were created as the size of correlations was found to be different when grouped by gender. BT2 had a much higher magnitude of effect on gingival recession in males than in females (table 10) (beta coefficient: -1.395 vs. beta coefficient: -0.565, respectively).

Table 10. Predictors of gingival recession by gender

Gender	Variable	beta coefficient	Sig.	95 % CI	
				Lower Bound	Upper Bound
Male	Constant	-2.365	0.007	-4.046	-0.683
	BL	0.396	0.000	0.205	0.587
	Age	0.056	0.000	0.032	0.079
	BT2	-1.395	0.094	-0.304	0.253
Female	Constant	-1.840	0.073	-3.859	0.178
	BL	0.327	0.001	0.131	0.524
	Age	0.034	0.002	0.013	0.055
	BT2	-0.565	0.149	-1.337	0.208

CHAPTER FOUR

DISCUSSION

In the present study, we found there was no difference in mean gingival recession between genders. This is in agreement with Ainamo[19] and Susin[20] who found that prevalence of recession is independent of sex. However, many studies showed that male patients develop more recessions than females.[21-23]

We found that gingival recession was correlated to bone loss and age after evaluating affects of gingival thickness, buccal bone loss, and buccal bone thickness and age on gingival recession. However, in the correlation graph between bone loss and gingival recession, seen in figure 7, equal variance is not evident. Thus, it is likely there is another factor affecting gingival recession unaccounted for in this study.

We also found that bone loss and age are positive predictors for gingival recession, whereas bone thickness 3mm apical to the alveolar crest is a negative predictor for gingival recession. Our finding that increasing age is a predictor for gingival recession is in agreement with Albander's NHANES study. They presented that the prevalence, severity and extent of gingival recession to increase with age.[21] Our result that increased buccal bone loss correlates with increased recession is in agreement with Lost's study, which found gingival recession to correlate, on average, to underlying buccal bone loss.[7] Our finding that buccal bone thickness is a predictor for gingival recession is in contrast to results of Fu's cadaver study. They found there was no correlation between gingival recession and labial bone thickness.[16] In the present study, the correlation between gingival recession and bone loss was significant (rho = 0.573, N = 114). This correlation was similar to the correlation of bone loss and gingival recession found by Lost (r = 0.661, N = 113).[7]

One of the three observed predictors for gingival recession was decreased bone thickness 3mm apical to the crest. It would be interesting to know at what particular thickness recession was prevalent, and at what thickness recession was the least likely. Unfortunately, due to a limited sample size, this determination could not be made. In the present study, buccal bone thickness of the maxillary anterior teeth 1mm apical to the bone crest ranged from 0.2-1.3mm, with a mean thickness of 0.48mm. This is in agreement with many studies evaluating buccal bone thickness. Fu found a mean thickness of 0.83mm (range, 0.3-1.6mm) when evaluating with calipers the buccal bone thickness of anterior teeth 2mm apical to the crest in 22 cadavers.[16] Januario found mean thickness to vary between 0.5-0.7mm when recording CBCT measurements of bone thickness 1mm and 3mm apical to the bone crest of anterior teeth in 250 subjects.[24] It is interesting to note that in his study, 85% of the sites presented with a wall thickness of <1mm, and 40-60% of sites presented with a wall thickness of <0.5mm. This finding is in agreement with Huynh-Ba's live human study evaluating 93 extraction sites, which found that in anterior sites 87% of the buccal bony walls were less than or equal to 1mm in width, and only 3% of sites were 2mm in width.[25]

We also found that the magnitude of effect of predictors varied based on gender, particularly the effect of bone thickness on gingival recession in males although the gender difference in gingival recession was not significant. Reasons for differences in predictor magnitude are merely speculative. They are perhaps due to hormonal differences or differences in microcirculation. Scardinia evaluated microcirculatory patterns in gingival tissue, and found that there are significant differences in capillary loop density in men and women and between different age groups. Furthermore, increase in loop density was different in menopausal females.[26]

In the present study, the correlation between gingival recession and bone loss was significant (rho = 0.573, N = 114). This correlation was similar to the correlation of bone loss and gingival recession found by Lost (r = 0.661, N = 113).[7] However, in the study, sites were not grouped into dehisced and non-dehisced sites. To our knowledge, the present study is the first to analyze differences in correlation between gingival recession and bone loss in dehiscence/fenestration sites and non-dehiscence/fenestration sites. The present study demonstrated a statistically significant difference in the correlation between bone loss and gingival recession when comparing the dehiscence/fenestration and non-dehiscence/fenestration sites. Furthermore, similar to the study by Lost, no significant differences in correlation of recession and bone loss were noted between different tooth types.[7]

The lack of correlation between bone sounding and bone loss in the present study was surprising. We speculate this discrepancy may be due to the angulation of the maxillary and mandibular anterior teeth studied. Many of the teeth were proclined facially, with facial root surfaces protruding facially beyond the bone crest. Unlike the vertical direction of a probe in infrabony defects, the angulation of the probe for anterior teeth may have introduced error. Future studies should be conducted evaluating the correlation of bone sounding and bone loss in anterior teeth to determine the accuracy of this parameter in a clinical setting.

The average gingival thickness approximately 3mm apical to the bone crest of maxillary anterior sites in our study was found to be 0.45mm (range, 0.1-1.2mm). Many in-vivo human and cadaver studies have been conducted to evaluate gingival thickness. Muller evaluated gingival thickness of 40 individuals using an ultrasonic measuring device, and found the average gingival thickness 1-2mm apical to the gingival margin to be 0.85mm (range, 0.70-1.00mm).[27] Using a caliper after tooth extraction, Fu found the average gingival thickness approximately 2mm apical to the bone crest in 22 cadavers to be 0.5mm (range, 0.1-1.2mm).[16] A recent human study using endodontic reamers at 180 anterior sites found the average gingival thickness at the bone crest of maxillary anterior teeth to be 1.1mm (range, 0.1-2.5mm).[28]

Although we used fresh cadavers, significant soft tissue change was still observed. Furthermore, gingival flaps of cadavers did not behave as gingival tissue in vivo. Mucoperiosteal flaps were not easily separated from the underlying alveolar bone, resulting in distortion and destruction of flaps at the gingival margin during flap reflection. This is why, although two gingival thickness measurements were planned, one at the level of the sulcus, GT1, and one at the alveolar bone level,GT2, only gingival thickness at the alveolar bone level, GT2, was recorded. Furthermore, gingival thickness was measured at the bone crest, which was determined through bone sounding. Our correlations found that bone sounding was not highly correlated to bone loss. Thus, it is safe to say that the gingival thickness measurements taken were not always made at the alveolar crest level. For these reasons, it is our opinion that soft tissue measurements in this study are not as valid as those of other parameters. In fact, we believe that inability to obtain accurate soft tissue measurements is an inherent limitation of any cadaver study.

The lack of correlation between recession and bone loss when grouped into dehiscence/fenestration sites may be explained by the sample size (N = 23), or by the fact that in sites with severe bone loss, other factors such as gingival thickness play a more important role in preventing gingival recession. Note that in table 8, sites with severe bone loss did not consistently present with gingival recession. Cadaver 10, for example, presented with bony dehiscences (up to 11.45mm of bone loss), yet presented with minimal recession (up to 1.23mm, excluding tooth #24). Some cadavers, however, did present with bony dehiscences coincident with gingival recession. Cadaver #7, for example, presented with dehiscences with up to 7.84mm of bone loss, and also presented with substantial gingival recession (up to 5.7mm). In the present study, each tooth was treated independently. However, in terms of the measured variables, each cadaver may present in a unique manner. A larger sample size would permit the construction of a more accurate statistical model, which could account for more than one observation in each cadaver.

Another limitation of the study was the inability to obtain medical or dental records of the individual cadavers. We were not able to evaluate the cadavers' previous medical, dental or social history, nor were we able to obtain a record of their daily oral hygiene practices. Gingival recession can be associated with the presence of calculus, and being deprived of dental care[29] toothbrush duration[29] and frequency[30] have been shown to be possible causes of gingival recession. A recent systematic review on orthodontic therapy and gingival recession found that proclined teeth or teeth moved out of the alveolar process may be associated with a higher tendency toward gingival recession.[14] These are all potential predictors for gingival recession. A clinical study should be conducted including comprehensive medical, dental and social history to ascertain all significant predictors for gingival recession.

Clinical implications of this study include the validations that gingival recession is correlated to bone loss on average and that gingival recession is found more often in older individuals. Another clinical implication may be that men are more prone to gingival recession than females, as factors affecting gingival recession have a greater magnitude of effect on males than on females. Lastly, the unreliability of using bone sounding as a clinical method of estimating bone level was also shown in this study.

CHAPTER FIVE

CONCLUSION

Within the limitations of this cadaver study, we conclude that gingival recession is significantly correlated with buccal bone loss and age. When grouped into dehiscence/fenestration and non-dehiscence/fenestration sites, a significant correlation was noted between gingival recession and bone loss in non-dehiscence/fenestration sites. A significant difference was also found between the correlations of gingival recession and bone loss when comparing dehiscence/ fenestrations with non-dehiscence/fenestration sites. We also conclude that among the candidate predictors evaluated in this study, bone loss and bone thickness and age are the strongest predictors for gingival recession, with bone loss and age being statistically significant in males and in females. Furthermore, the magnitude of affect of bone thickness 3mm apical to the bony crest was found to be greater in males than in females.

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