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## Original Research Article

# The effect of horizontal and vertical dimensions of the interproximal space on the existence of interdental papillae – A clinical study

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## ABSTRACT

**Aim:** The aim of the present study was to determine the existence of inter dental papilla according to the vertical dimension, horizontal dimension and the combined effects of the vertical and horizontal dimensions of the interproximal space on the existence of interdental papilla.

**Materials and Methods:** 182 interdental sites of 42 periodontitis patients undergoing open flap debridement were included in the study. The existence of interdental papilla was determined based on the Papilla Presence Index (PPI). The vertical dimension (VD) was measured from the alveolar crest to the contact point using UNC-15 probe. Horizontal dimension (HD) was measured from the mesial surface of the distal tooth and the distal surface of the mesial tooth at the level of the alveolar crest using castroviejocaliper. Statistical analysis was done by using independent 't' test, Pearson's Chi-square test and Trend Chi-square test.

**Results:** The existence of papilla was significantly higher in  $VD \leq 5\text{mm}$  (91.5%) compared to  $VD > 5\text{mm}$  (9.8%) [ $p < 0.0001$ ]. The existence of papilla was significantly higher in  $HD < 2\text{mm}$  (97%) compared to  $HD \geq 2\text{mm}$  (1.2%) [ $p < 0.0001$ ]. The contribution of both vertical dimension and horizontal dimension to the existence of papilla was about 61.6% and thus the existence of papilla may be influenced by various other factors (about 38.4%) which were not included in this study.

**Conclusion:** The vertical and horizontal dimensions of the interproximal space gains significance in determining the existence of papilla and further research is needed to analyze the other factors influencing the papilla.

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## 1. Introduction

The interdental area is composed of the contact area, the interproximal embrasure and the interdental gingiva. Presence of an intact interdental papilla has always been considered as one of the most important components constituting aesthetics in dentistry. In periodontal health, the interdental papilla completely fills the gingival embrasure. The presence or absence of the interproximal papilla is of great concern to both the patient and dentist. Its

etiology includes loss of periodontal attachment resulting in recession, loss of height of the alveolar bone relative to interproximal contact, length of embrasure area, root angulations, interproximal contact position and triangular shaped crowns and course of cemento-enamel junction.<sup>1–4</sup> The effects of the open embrasure can lead to aesthetic impairment, food retention, plaque accumulation, and phonic problems.<sup>5</sup>

The interdental space is made by contact area and the interproximal embrasures which houses the interdental papilla.<sup>6</sup> This space can be divided into a vertical dimension between the contact point and the alveolar crest and

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a horizontal dimension between the mesial and distal surfaces of the adjacent teeth.<sup>7</sup> The presence or absence of papilla primarily depends on the distance between the interdental contact point and the interproximal crest of bone.<sup>1</sup> Interdental papillae are almost always present when the distance from bone crest to contact point is  $\leq 5$ mm (98%), 56% at 6mm distance and around 27% when the distance increases to 7mm or more.

Lost or deviated interdental contacts and an inappropriate interdental distance produce an unfavorable form of interdental papilla, which makes plaque control difficult and may lead to progression of periodontal diseases and an unaesthetic appearance for the patient. Various studies have been performed to determine whether the distance from the contact point to the crest of bone could be correlated with the presence or absence of interproximal papilla.<sup>1,8,9</sup>

The aim of the present study was to determine the existence of interdental papilla according to the vertical dimension, horizontal dimension and the combined effects of the vertical and horizontal dimensions of the interproximal space.

## 2. Materials and Methods

### 2.1. Subject selection

Ethical approval was obtained from Institutional Ethics Committee, Tamil Nadu Government Dental College, Chennai. A written informed consent was obtained from all the patients. Subjects were selected from patients who reported to the Out-patient department, Department of Periodontics, Tamil Nadu Government Dental College, Chennai. All patients who were enrolled in the study underwent Phase I therapy and were indicated for full thickness flap surgery.

### 2.2. Sample size

42 patients were enrolled in the study from the age group of 20 to 46 years of either sex. 182 interdental sites were selected based on inclusion and exclusion criteria, out of which 31 were anteriors and 151 were posteriors. Interdental sites mesial to canine were considered as anterior sites and distal to canine were considered as posterior sites.

### 2.3. Inclusion criteria was set as

1. Patients who underwent Phase-I periodontal treatment 3 to 8 weeks prior to surgery.
2. Areas with Sulcular Bleeding Index (SBI)  $\leq 2$  and Papillary Bleeding Index (PBI)  $\leq 1$ .<sup>10,11</sup>
3. The existence of interdental papilla was determined based on the Papilla Presence Index (PPI) proposed by Cardaropoli et al, in 2004.<sup>12</sup>
4. The measured sites included the interproximal sites from periodontal flap surgery regions of selected

periodontitis patients undergoing flap surgery and the adjacent healthy interproximal areas

### 2.4. Exclusion criteria

1. Previous history of any periodontal surgery.
2. Previous history of orthodontic treatment.
3. H/o medications for systemic illness causing gingival enlargement.
4. Areas with no interdental contacts.
5. Areas with an exposed furcation.
6. Areas with prostheses and overhanging restorations.
7. Rotated /tilted/ malposed teeth.
8. Frenal attachment – IDP/ Papilla penetrating type.

### 2.5. Surgical procedure

Under local anesthesia (2% lidocaine with 1:80,000 adrenaline) full thickness flaps were elevated in the indicated site and the soft tissue above the alveolar crest was completely removed. The vertical dimension is the distance measured from the alveolar crest (closest to the occlusal side) to the contact point with UNC-15 probe in millimeters (Figure 1). After measuring the vertical dimension, the horizontal dimension was measured between the mesial surface of the distal tooth and the distal surface of the mesial tooth at the level of the alveolar using a Castroviejo caliper (Figure 2).

The defects if any were treated accordingly and the site was sutured and periodontal dressing was given.

### 2.6. Statistical analysis

Statistical analysis was done using SPSS (version 10). Mean and Standard deviation were estimated from the sample for VD (vertical dimension) and HD (horizontal dimension). Mean values were compared between papilla present and absent by using student's independent 't' test. Proportions of different characteristics were compared between papilla present and absent by using either Pearson's Chi-square test with Yate's continuity correction or Trend Chi-square test. Univariate and Multivariate Logistic Regression analysis were done to identify the significant factors contributing to papilla presence.

## 3. Results

42 patients were enrolled in the study from the age group of 20 to 46 years which included 25 males and 17 females. 182 interdental sites were included in the study, out of which 31 sites were anteriors and 151 sites were posteriors. Presence of papilla, vertical dimension and the horizontal dimension were recorded for all the 182 sites.

Table 1 shows the existence of interdental papilla according to various vertical dimensions (the distance from the contact point to the alveolar crest. When the distance

was 4mm, papilla was present in 100% of sites; when the distance was 5mm, papilla was present in 91% of sites; when the distance was 6mm, papilla was present in 16% of sites and when the distance is more than 6mm, the papilla was almost absent.

Table 2 shows the existence of interdental papilla according to various horizontal dimensions. When the distance was 1mm, papilla was present in 63.16% of sites; when the distance was 1.5mm, papilla was present in 68.42% of sites; when the distance was 2mm, papilla was present in 2% of sites and when the distance is more than 2mm, the papilla was almost absent.

Table 3 shows the comparison of mean values between papilla present and absent. The mean vertical dimension in papilla present was  $5.41 \pm 0.46$  and the mean vertical dimension in papilla absent was  $6.41 \pm 0.65$ . The mean difference between papilla present and papilla absent was 1.28 with a 95% confidence interval of 1.11 to 1.44. Similarly, the mean horizontal dimension in papilla present was  $1.40 \pm 0.24$  and the mean horizontal dimension in papilla absent was  $2.02 \pm 0.55$ . The mean difference between papilla present and papilla absent was 0.62 with a 95% confidence interval of 0.50 to 0.74.

Table 4 shows the proportion of vertical dimension ( $\leq 5\text{mm}$  /  $>5\text{mm}$ ) and horizontal dimension ( $< 2\text{mm}$  /  $\geq 2\text{mm}$ ) in papilla present / absent.

The measurements taken as the vertical dimension were categorized into two groups as  $> 5\text{mm}$  and  $\leq 5\text{mm}$  and the existence of papilla was compared among the two categories. It was found that the existence of papilla was significantly higher in  $\text{VD} \leq 5\text{mm}$  (91.5%) compared to  $\text{VD} > 5\text{mm}$  (9.8%) [ $p < 0.0001$ ]. Similarly, the measurements taken as the horizontal dimension were categorized into two groups as  $< 2\text{mm}$  and  $\geq 2\text{mm}$  and the existence of papilla was compared among the two categories. It was found that the existence of papilla was significantly higher in  $\text{HD} < 2\text{mm}$  (97%) compared to  $\text{HD} \geq 2\text{mm}$  (1.2%). [ $p < 0.0001$ ].

Table 5 and Table 6 shows the results of univariate and multivariate logistic regression analysis, which revealed both vertical dimension and horizontal dimension were negatively, significantly contributing to the existence of papilla. [ $p < 0.05$ ]. Total variation explained by the significant variables was 61.6%. The contribution of both vertical dimension and horizontal dimension to the existence of papilla was about 61.6% and thus the existence of papilla may be influenced by various other factors (about 38.4%) which were not included in this study.

#### 4. Discussion

Loss of papilla establishes a 'black triangle' which gives an aesthetically compromised appearance, leading to plaque accumulation, worsening the periodontal status and sometimes phonetic problems.

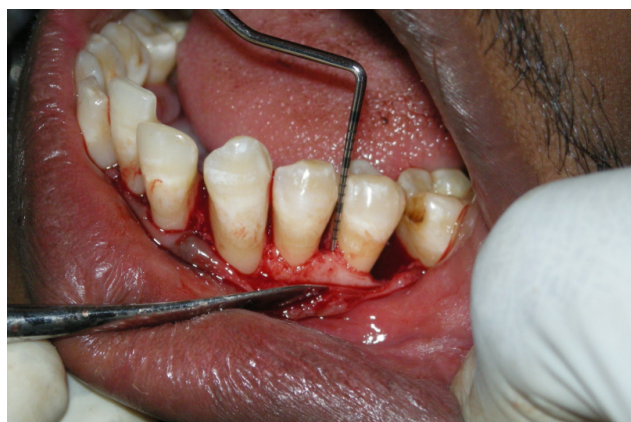


Fig. 1: Measurement of vertical dimension in 35 region



Fig. 2: Measurement of vertical dimension in 35 region



Fig. 3: UNC – 15 Probe and Castroviejo Caliper

Various factors affect the presence of papilla and among them the distance from the contact point to the crest of the bone gains significance and there are some studies suggestive of the role of the interproximal distance also.<sup>7,8</sup> So in this study both the vertical and horizontal dimensions were considered.

Other factors such as the shape of the crown, morphology of the embrasure, alignment of teeth, volume of embrasure space, periodontal biotype may influence the existence of papilla and were excluded in this study.

**Table 1:** Existence of Interdental Papilla According to Various Vertical Dimensions

	4mm	5 mm	6 mm	7 mm	8 mm
<b>PPI-1</b>	3	51	12	0	0
<b>PPI-2</b>	0	5	58	27	0
<b>PPI-3</b>	0	0	4	10	4
<b>PPI-4</b>	0	0	1	6	1
<b>Total Papilla</b>	<b>3</b>	<b>56</b>	<b>75</b>	<b>43</b>	<b>5</b>
<b>Papilla Present (%)</b>	<b>100%</b>	<b>91.07%</b>	<b>16%</b>	<b>0%</b>	<b>0%</b>

PPI - 1 = papilla present;  
PPI- 2,3,4 = papilla absent

**Table 2:** Existence of Interdental Papilla According to Various Horizontal Dimensions

	0.5 mm	1 mm	1.5 mm	2 mm	2.5 mm	3 mm	3.5 mm	4 mm
<b>PPI-1</b>	1	12	52	1	0	0	0	0
<b>PPI-2</b>	0	7	19	40	19	4	1	0
<b>PPI-3</b>	0	0	3	5	7	2	0	1
<b>PPI-4</b>	1	0	2	4	1	0	0	0
<b>Total Papilla</b>	<b>2</b>	<b>19</b>	<b>76</b>	<b>50</b>	<b>27</b>	<b>6</b>	<b>1</b>	<b>1</b>
<b>Papilla present (%)</b>	<b>50%</b>	<b>63.1%</b>	<b>68.4%</b>	<b>2%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>

PPI - 1 = papilla present;  
PPI- 2,3,4 = papilla absent

**Table 3:** Comparison of Mean values between Papilla Present and absent.

Variable	Papilla present Mean ± S.D	Papilla absent Mean ± S.D	Difference Mean [ 95% CI ]	P- value *
	( n = 66)	( n= 116)		
VD	5.41 ± 0.46	6.41 ± 0.65	1.28 [1.11 to 1.44]	< 0.0001 (sig)
HD	1.40 ± 0.24	2.02 ± 0.55	0.62 [0.50 to 0.74]	< 0.0001 (sig)

VD – Vertical Dimension  
HD – Horizontal Dimension  
\* Student's Independent t-test was used to calculate the P-value.  
Statistically significant at 0 < 0.05

**Table 4:** Proportion of VD (≤ 5mm / >5mm) and HD (< 2mm / ≥2mm) in Papilla present / absent.

Variable	Papilla present		Papilla absent		P value *
	No:	%	No:	%	
VD					
> 5mm	12	9.8 %	111	90.2 %	< 0.0001 ( sig)
≤ 5mm	54	91.5 %	5	8.5 %	
HD					
≥ 2mm	1	1.2%	84	98.8%	0.01 (sig)
< 2mm	65	97.01%	32	2.99%	

VD – Vertical Dimension  
HD – Horizontal Dimension  
\* Trend Chi- square was used to calculate the P – value  
Statistically significant at 0 < 0.05

**Table 5:** Results of Univariate Logistic Regression Analysis [Dependent variable – Papilla Present / Absent]

Independent variable	Regression Coefficient (b)	SE ( b)	P- value	Odds ratio [95% CI]
VD (mm)	- 4.04	0.55	< 0.0001 (sig)	0.02 [0.006to0.052]
HD (mm)	- 3.96	0.66	< 0.0001 (sig)	0.02 [0.005to0.07]
Region -Anterior	0.45	0.40	0.26 (NS)	1.57 [0.72to3.43]

VD – Vertical Dimension  
HD – Horizontal Dimension  
Note: Total variation explained by each variable (R<sup>2</sup>) as follows:  
VD – 53.3%; HD – 33.7%; Region – 0.7%.

**Table 6: I:**Results of Multiple Logistic Regression Analysis [Dependent variable – Papilla Present /Absent]

Significant Independent variables	Regression Coefficient (b)	SE ( b)	P- value	Odds ratio [95% CI]
VD (mm)	- 4.17	0.69	< 0.0001 (sig)	0.02 [0.004 to 0.06]
HD (mm)	- 4.80	1.05	< 0.0001 (sig)	0.008 [0.001to0.065]

1: Non – significant variable was Region ( P> 0.05)

2: Method of regression was forward step – wise addition.

3: Total variation explained by the model – R<sup>2</sup> = 61.6%

Different methods were followed by several authors to measure the interproximal dimensions, such as bone sounding and radiographic method. In accordance with Cho et al, a full thickness flap was elevated and the dimensions were measured in this study.<sup>7</sup> Yu- Jen Wu et al and Martegani et al, measured on standardized perapical radiographs.<sup>8,9</sup> Though this method is a non-invasive procedure and reliable, standardization and magnification are the disadvantages.

The vertical dimension is the distance from the base of the contact point to the crest of the alveolar bone. This was measured by UNC-15 probe. In all the earlier studies, this distance was measured by Williams probe.<sup>1,7-9</sup> In the present study UNC-15 probe was used as it clearly shows all these measurements (Figure 3). To minimize the measurement error, readings were recorded five times and the most repeated one is taken into consideration.<sup>7</sup>

The horizontal dimension is the distance between the mesial surface of the distal tooth and the distal surface of the mesial tooth at the level of the alveolar crest. Cho et al used a triangular ruler to measure the interproximal distance.<sup>7</sup> Martegani et al measured the horizontal dimension in radiographs.<sup>8</sup> In this study Castroviejo caliper was used to measure the interproximal distance (Fig – 3).

In most of the studies, the papilla presence was recorded as present or absent.<sup>1,7-9</sup> In this study, Papilla Presence Index by Cardaropoli et al 2004, was used to record the existence of papilla. This may be useful in understanding the dimensions of the interproximal space.<sup>12</sup>

According to this study, when the vertical dimension was 6mm and 7mm, the PPI-2 score was about 78% (58/75) and 62.8%(27/75) respectively, and when the horizontal dimension was 2mm and 2.5mm, the PPI-2 score was about 80% (40/50) and 70.4% (19/27) respectively. These measurements revealed that though there was loss of papilla when vertical dimension was 6 & 7mm and horizontal dimension was 2 & 2.5mm, the chance of reconstructing the lost papilla might be predictably good, and beyond 7mm and 2.5mm, a complex treatment plan is needed.

According to earlier studies, when the measurement from the contact point to the crest of bone was 5mm, the presence of papilla was 98% (11/11), 98% (49/50) and 58.5% respectively.<sup>1,7,9</sup> In the present study 56 papillae had a vertical dimension of 5mm and papilla was present in

91% (51/56) which was almost similar to other studies. Tarnow and Yu Jen Wu selected periodontally healthy sites whereas in this study, sites were selected from periodontitis patients, which may be the reason for a difference of 7% in the presence of papilla. When the vertical distance was 6mm, the papilla was present in 56% (63/112), 51% (40/78) and 35.2% (19/54) respectively.<sup>1,7,9</sup> In the present study 75 papillae had a vertical dimension of 6mm and papilla was present in 16% (12/75).

According to Cho et al when the interproximal distance was 1mm, the presence of papilla was 77.8% (7/9).<sup>7</sup> In the present study 19 papillae had a horizontal dimension of 1mm and papilla was present in 63.1% (12/19). When the distance was 1.5mm, the papilla was present in 72.4% (21/29)<sup>7</sup> whereas in the present study 76 papilla had a horizontal dimension of 1.5mm and papilla was present in 68.42% (52/76). According to the present study, the percentage of papilla present was greater when the horizontal dimension was 1.5mm compared to 1mm or less. This may be due to the reason that teeth with root proximity possess very thin bone and in return, thin cancellous bone has a greater risk for resorption, decreasing the interproximal bone height and thereby the papillary disappearance. In the present study, since the interdental sites were selected from patients who had periodontitis, the greater risk of bone loss in interdental sites with horizontal dimension < 1.5mm might be the reason for loss of papilla.

In the present study 50 papillae had a horizontal dimension of 2mm and papilla was present only in 2% (1/50) in comparison to earlier study wherein when the distance was 2mm, the papilla was present in 53.7%(22/41).<sup>7</sup> This may be due to the combined effects of all the factors influencing the existence of papilla and further research awaited. Thus in this study the existence of papilla was decreasing with an increase in the horizontal dimension and was almost absent when it was >2mm.

Li -Ching Chang, revealed that the central papilla recession is significantly related to a wide (> 2mm of interproximal distance) and long (> 4mm of vertical distance) embrasure.<sup>4</sup> Similarly in the present study, it was found that the existence of papilla was significantly higher when VD is ≤ 5mm (91.5%) compared to VD > 5mm (9.8%) and the existence of papilla was significantly higher when HD < 2mm (97%) compared to HD ≥ 2mm (1.2%).

According to this study, when the measurements, VD x HD were 4 x 1, 1.5mm and 5 x 1, 1.5mm the papilla was present in 100% of the sites. When the measurements exceed 6mm of vertical dimension and 2 mm of horizontal dimension the papilla was almost absent. In each vertical dimension, an increase in the interproximal distance affected the existence of papilla, especially in 5mm of VD. In 6mm of VD, the VD had a significant influence than the HD.

Thus in the present study, the vertical dimension and horizontal dimension had a significant influence on the existence of papilla. In the present study, the interdental sites were grouped into anterior and posterior sites, to find whether there is any difference in the dimensions between the anteriors and posteriors. From an anatomic point of view, the anterior papilla is quite different from posterior. Anterior papilla takes up the pyramidal shape and a col is present in posterior papilla, depending upon the contact area.<sup>6</sup> According to this study, the region did not reveal any significance and further study needed with larger sample.

## 5. Conclusion

These measurements can be recorded as a routine clinical finding while doing a full thickness flap surgery and can be applied in further treatment plan for restoring the lost interdental papilla. The vertical and horizontal dimensions of the interproximal space gains significance in determining the existence of papilla and further research is needed to analyze the other factors influencing the papilla.

## 6. Conflict of Interest

The authors declare that there are no conflicts of interest in this paper.

## 7. Source of Funding

None.

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