

Visualizing “The Black Triangle” Through a Radiograph: An Analytical Study

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Abstract

Background: The distance from bone crest to contact point is an important parameter which influences papilla fill. **Aim:** The aim of this study was to assess the association between embrasure morphology and central papilla recession. **Methods:** The central papilla was visually assessed in 100 subjects, aged 18-35 years (mean age 27 years) using paralleling periapical radiographs of maxillary central incisors taken with radiographic grids. The following vertical distances were measured: the recession distance, i.e., Papilla Tip to Contact Point (PT-CP), Bone Crest to Contact Point (BC-CP), proximal Cemento Enamel Junction to Contact Point (pCEJ-CP), Bone Crest to Papilla Tip (BC-PT), and Bone Crest to proximal CEJ (BC-pCEJ). Interdental width (IW) was measured horizontally and Crown Width (CW) was also assessed using a software tool (Klonk Image Measurement tool). **Results:** Age, papilla recession status, PT-CP, BC-pCEJ, CW, PT-CP, IW, BC-CP were independent predictors of Clinically Observed Papilla Height (COPH). **Conclusion:** Gingival papillary height was significantly associated with BC-CP, IW and age in the present study. These factors should thus be considered while treating papilla recession cases.

Keywords: Black Triangle; Central Papilla Recession; Gingival Papillary Height; Embrasure Morphology; Clinically Observed Papilla Height (COPH).

Introduction

The concept of biologic width proposed by Garguilo [1] was derived from a histologic description of the so-called dentogingival complex. It has been shown that the average dimension of the dentogingival complex in natural teeth is 3mm at the facial aspect and 4.5mm at the interproximal aspect.

The interdental area is composed of the contact area, the interproximal embrasure, and the interproximal dentogingival complex. It is the primary site of dental diseases, including periodontitis and caries, as it is prone to the accumulation and retention of microbial plaque. The loss of the interdental papilla can lead to food impaction as well as esthetic and phonetic problems.

In 1959, Cohen [2] first defined the Col as the buccal and lingual peaks of the keratinized tissue with a non- or para-keratinized interproximal area. The interdental gingiva of the incisor region usually assumes a pyramid-shaped papilla, or it may also present a slight gingival col depending on the location of the contact area and the height of the gingiva [3].

The presence of the interdental papilla is determined by factors including the distance from the bone crest to contact point (BC-CP), position of the cemento-enamel junction (CEJ), distance from BC to CEJ, angles of roots of adjacent teeth, crown shape, and space between adjacent teeth. A recent study by Chow et al [4] confirmed that the appearance of the gingival papilla was significantly associated with age, tooth form/shape, proximal contact length, crestal bone height, and interproximal gingival thickness. Chang [5] previously established that the strongest determinant of the presence of the central papilla was the distance from the BC to the proximal CEJ (BC-pCEJ) and also found a statistically significant negative relationship between age and papilla height (PH). The embrasure morphology (i.e., the mesio-distal dimension bordered by the line between the proximal CEJ and adjacent teeth) [5] did not affect central PH in patients with papilla recession.

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Several previous studies [6] have evaluated factors affecting PH, Central PH, central clinically observable PH (COPH). The aim of this study was to evaluate the association between embrasure morphology and central papilla recession leading to black triangle formation.

Material and Methods

This was a retrospective study of 100 adults (63 males, 37 females) aged 18-35 years (mean age 27 years) with fully erupted, permanent dentition who were randomly selected from patients treated at the Department of Periodontics, New horizon dental college and research Institute, Bilaspur. Inclusion criteria were healthy gingiva with plaque and gingival indices of 0 to 1 respectively, well-aligned maxillary central incisors (i.e., no spacing, crowding, and intrusion/extrusion). Exclusion criteria were systemic conditions (including pregnancy) or a history of taking medications known to increase the risk of gingival hyperplasia, the presence of artificial crowns on central incisors, proximal/cervical restorations or abrasions, a history of surgery in the anterior maxillary area, or open contact or crowding. The protocol was approved by the Institute ethical committee and a written informed consent was obtained.

Data Collection

All examinations were carried out by a single Periodontist trained in a calibration process as measured by Cohen's Kappa ($\kappa > 0.6$) to eliminate inter-examiner variability. Interdental papilla (central papilla) was visually recorded.

"Papilla present" was recorded if no space was visible apical to the contact area, and "papilla recession" was recorded if a space was visible apical to the contact area. The age and sex of each patient were recorded.

Periapical radiographs of maxillary central incisors were obtained using a paralleling technique with a radiographic grid and film holder. Measurements made on radiographs were performed using the grid lines present on radiograph. Vertical lines were measured along the long axis of an adjacent tooth. In all patients, the following vertical distances (in millimeters) were measured by visual examination by the same Periodontist: The length of a vertical line from the proximal CEJ (pCEJ); length of the two central incisors to apical CP (pCEJ-CP); the length of a vertical line from BC to apical CP (BC-CP); the length

of a vertical line from BC to pCEJ (BC-pCEJ); the length of a vertical line from the papilla tip (PT), defined as the apical margin of the space to CP (PT-CP); the length of a vertical line from the PT to BC (PH); the length of a vertical line from the PT to the pCEJ of the two central incisors (COPH); the width between the two central incisors at the pCEJ level (interdental width [IW]); the width between two central incisors at the BC level [crest width (CW)].

All measurements were taken twice and their mean was used in the data analyses. A third measurement was taken only if the difference between the first two measurements was >0.5 mm.

Statistical Analyses

The ANOVA test was performed to compare continuous variables between groups. The Pearson correlation test was performed to evaluate correlation between age and PT-CP.

Results

A total of 100 patients were included in the analysis. The median age of study patients was 27 years. Among patients, 67 patients (67%) had papilla recession, and 33 patients (33%) had papilla present. Patients with papilla recession were significantly older than those with papilla present and had significantly shorter PH and COPH, significantly longer BC-CP and BC-pCEJ, as well as significantly greater IW and CW. Simple and multiple linear regression models were constructed to determine which factors were associated with PH and COPH.

In the simple linear regression analysis, age, PT-CP, BC-pCEJ, and papilla recession status were significantly associated with PH (Table 1). In multiple linear regression analysis, papilla recession status and PT-CP were also significantly associated with PH. After controlling for papilla recession status, PH decreased by 0.36 mm for every 1-mm increase in PT-CP distance. In simple linear regression analysis, age, CW, papilla recession status, PT-CP, and BC-pCEJ were significantly associated with COPH. After controlling for confounding factors, COPH decreased by 0.06 mm for each year of increase in age.

COPH decreased by 0.55 mm for every 1-mm increase in PT-CP distance, and COPH decreased by 0.76 mm for every 1-mm increase in BC-pCEJ distance. For the 67 patients with papilla recession, the simple linear regression analysis showed that IW, CW, PT-CP and BC-pCEJ were significantly associated with PH (Table 1).

The analysis indicated that CW and PT-CP independently predicted PH. After controlling for PT-CP distance, PH increased by 0.57 mm for every 1-mm increase in CW. PH decreased by 0.23 mm for every 1-mm increase in PT-CP distance after controlling for CW.

After controlling for confounders, COPH decreased by 0.008 mm for each year increase in age, increased by 0.714 mm for every 1-mm increase in IW, decreased by 0.843 mm for every 1-mm increase in PTW, decreased by 0.259 mm for every 1-mm increase in PT-CP (P <0.001), and decreased by 0.352 mm for every 1-mm increase in BC-pCEJ. For the 33 patients with papilla, the simple linear regression analysis revealed that IW, CW, and BC-pCEJ were significantly associated with PH. The analysis indicated that IW and BC-pCEJ independently

predicted PH. After controlling for BC-pCEJ, PH increased by 1.008 mm for every 1-mm increase in IW. PH increased by 0.9 mm for every 1-mm increase in BC-pCEJ after controlling for IW. After controlling for age, COPH increased by 0.979 mm for every 1-mm increase in IW (P <0.001). Age had independent effects on COPH in all 100 patients and in the papilla recession and papilla present subgroups, which indicated age had direct effects on COPH.

In all 100 patients, there were moderate correlations between age versus BC-pCEJ such that there were potential indirect effects of age on COPH through BC-pCEJ. For the 67 patients with papilla recession, moderate correlations existed between age and BC-pCEJ (P<0.05). For the 33 patients with papilla present, age and IW were the only independent factors for COPH.

Table 1: Variables measured in papillary examination

		N	Mean	Std. Deviation
pCEJ-CP	0	33	4.65	.626
	1	47	4.93	.331
	2	20	4.92	.801
	Total	100	4.83	.547
BC-CP	0	33	6.40	.843
	1	47	7.29	.611
	2	20	7.67	.516
	Total	100	7.07	.828
BC-PT	0	33	6.40	.843
	1	47	6.29	.611
	2	20	5.67	.516
	Total	100	6.20	.714
BC-pCEJ	0	33	1.10	.211
	1	47	1.18	.372
	2	20	1.50	.447
	Total	100	1.22	.364
IW	0	33	2.850	.3375
	1	47	3.250	.3798
	2	20	3.667	.4082
	Total	100	3.200	.4661
CW	0	33	9.45	.438
	1	47	9.46	.458
	2	20	9.75	.524
	Total	100	9.52	.464

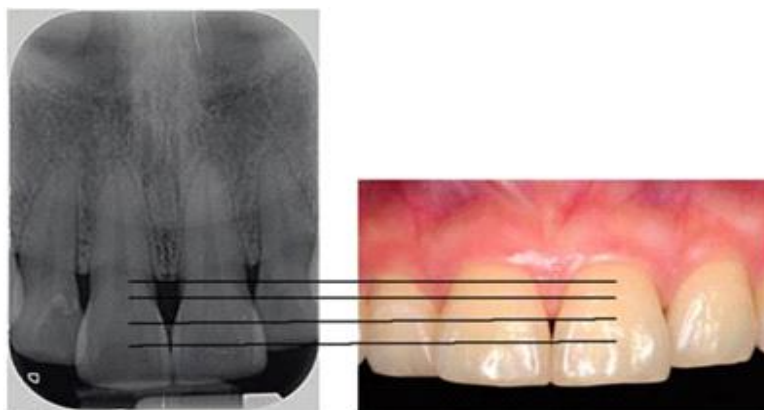


Fig. 1: Radiographic measurements
Horizontal lines indicate BC, pCEJ, PT, and CP (top to bottom)

Discussion

The recession of the interdental papilla, especially in the area of the central maxillary incisors, is of great concern to dentists and patients. Many factors account for the presence of the interdental papilla; the distance from bone crest to contact point is the most commonly studied of these, but there are many others [8].

There is an important need in esthetic dentistry to identify the risk factors for recession of the central papilla, including the association between embrasure morphology and central papilla presence [9]. This study evaluates factors impacting PH and COPH of the central papilla between two maxillary incisors.

Of the various factors studied, age and IW were associated with COPH in all patients regardless of recession status. Furthermore, the effects of age and IW on COPH decreased after recession occurred. These findings indicate that it may be possible to decrease or ameliorate the severity of central papilla recession by modifying variables associated with COPH.

Many factors affect PH, including root angulation, tooth alignment, and individual variations in bone shape [10].

Central papilla recession as a result of aging is most frequently associated with a wide IW and long pCEJ-CP. This study also revealed a positive relationship between age and papilla recession distance. Papilla recession distance was equal to the difference between BC-CP distance and papilla height; thus, the strongest negative relation between age and papilla height was observed.

In the present study, the papilla was found to be present 100% of time when the BC-CP distance ranged between 3 and 6 mm, 81.8% of time when distance ranged between 6 and 7 mm and 25% of time when distance ranged between 7 and 8 mm. Chang [5] stated that when the BC-CP distance was 5 mm, the papilla was present 51% of the time, whereas at 7 mm, the papilla was present only 10% of the time.

In a recent study, Chow et al [4] reported that when all interdental variables in the anterior maxillary region were considered, BC CP distance was the only significant factor related to the presence of interdental papillae [4]. Saxena et al [11] did a study to ascertain the effects of vertical and horizontal distances between the maxillary central incisors on the presence of interproximal dental papilla and to assess the association between the embrasure morphology and central papilla recession. It was concluded that in

relation to maxillary central incisors, all the interdental variables had significant influences on the presence of interdental papillae, with distance from BC to CP being the strongest determinant of central papilla presence.

Kim SA et al [12] analyzed the dimensions of the embrasure space between the maxillary central incisors as potential factors influencing interdental papilla fill and height. They concluded that CP-BC was the only variable that showed a significant difference between the complete and deficient papilla groups ($P < 0.05$). When the CP-BC was less than 5 mm, the embrasure spaces between the maxillary central incisors were completely filled with interdental papilla.

The interdental papilla was always present when the IDW between maxillary central incisors ranged between 0.5 and 1.5 mm. The number of papillae that filled the interproximal space decreased with the increasing IDW, with the persistence of only 33.3% when the IDW ranged between 2.5 and 3.0 mm.

Furthermore, the percentage of interdental papilla presence was observed when both height and width, i.e., distance from BC to CP and IDW were considered. When the BC-CP distance ranged between 3 and 6 mm and IDW ranged between 0.5 and 1.5 mm, the percentage of papillae presence was 100%. The incidence of the interdental papilla further decreased with increasing BC-CP distance and IDW.

Loss of interdental papillary height is often the sequel of periodontal pathology, response to periodontal therapy or improvement of periodontal health [13]. The correct shape of inter proximal papilla is the key factor in anterior esthetics. Cosyn J et al¹⁴ did a study was to compare inter-proximal fill and papilla height between different embrasures. Embrasure fill was assessed by means of Jemt's papilla index and papilla height was registered following local anaesthesia by means of bone sounding by one clinician. Tooth-pontic and tooth-implant embrasures demonstrated comparable inter-proximal fill and papilla height ($\geq 58\%$ Jemt's score 3; mean papilla height ≥ 4.1 mm). Between missing teeth, embrasure fill and papilla height were lower regardless of the embrasure type. The implant-implant and implant-pontic embrasure demonstrated comparable outcome ($\leq 42\%$ Jemt's score 3; mean papilla height ≤ 3.3 mm; $p \geq 0.416$), which was significantly poorer when compared to the pontic-pontic embrasure (82% Jemt's score 3; mean papilla height 3.7 mm; $p \leq 0.019$). The re-establishment of a papilla was difficult when there was no tooth involved and concluded that a short papilla should be expected and implant-borne restorations

demonstrated the poorest outcome.

This study was carried out in a narrow range age group (18-35 years). Considering the positive relationship seen between age and papilla recession distance in this study, future clinical trials with a larger sample size, a broader age range and evaluating more variables are recommended to validate the results of this present study. Also advanced diagnostic radiographic tools such as digital radiography and Cone Beam computed Tomography (CBCT) can be incorporated for accurate diagnosis.

Conclusion

Based on the above study, in relation to maxillary central incisors, all the interdental variables viz., distance from CP-PT, CP-pCEJ, BC-CP and BC-PT and IDW, have significant influences on the presence of interdental papillae, with distance from BC to CP to be the strongest determinant of central papilla presence. A thorough understanding of the morphology of the interdental tissues is mandatory, for a clinician before treatment planning for the maxillary anterior area, so as to enhance the esthetic outcome for the patient [15].

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