

The Association between Embrasure Morphology and Central Papilla Recession: A Noninvasive Assessment Method

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Background: The distance from bone crest to contact point is only the most frequently studied of the many factors that influence whether interdental papilla are present. The purpose of this study was to discover the association between embrasure morphology and central papilla recession.

Methods: The central papilla was visually assessed in 310 adults using paralleling periapical radiographs of the maxillary central incisors. The following vertical distances were measured: the recession distance, i.e., papilla tip (PT) to contact point (PT-CP), bone crest (BC) to contact point (BC-CP), proximal cemento-enamel junction (pCEJ) to contact point (pCEJ-CP), papilla height (PH), and bone crest to proximal cemento-enamel junction (BC-pCEJ). Interdental width was measured horizontally. Subjects were divided into 4 groups according to interdental width and pCEJ-CP distance: long-narrow, short-narrow, long-wide, and short-wide.

Results: Statistical analysis revealed the following for all four study groups: a positive correlation between papilla recession distance and age, a positive correlation between bone crest-contact point distance and age, and a negative correlation between age and papilla height.

Conclusion: Central papilla recession as a result of aging occurs most frequently in the long-wide group, that is, among people who have both a wide interdental width and a long distance between the proximal cemento-enamel junction and the contact point. However, other factors also affect the likelihood of central papilla recession. Thus, there is a need for further study of the interaction among these causal factors.

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Key words: age factors, interdental papilla, radiography, dental morphology, embrasure

Today's dentists face esthetic standards that require a soft-tissue contour with an intact papilla and a symmetrical gingival outline, especially in the interdental area of the maxillary central incisors (defined as the central papilla).⁽¹⁾ The interdental area comprises the contact area, the interproximal embrasure, and the interproximal dentogingival complex.⁽²⁾

The interdental papilla is the gingival portion of the interdental area. However, the physiology of the papilla is more complex than that of other gingival regions.⁽³⁾ The interdental gingiva of the incisor region usually is shaped as a pyramidal papilla, or it may appear as a slight gingival col, depending on the location of the contact area and the height of the gin-

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giva.^(4,5) The presence of space below the contact area can lead to esthetic impairment, phonic problems, and food impaction.^(1,6,7) If papilla loss occurs due solely to soft-tissue damage, reconstructive techniques can completely restore it; but if severe periodontal disease and interproximal bone resorption cause the loss of interdental papilla, reconstruction is generally incomplete.^(3,6)

The morphologies of the interdental papilla and the osseous architecture housing the tooth can be categorized into two periodontal biotypes: the thin, scalloped periodontium, characterized by thin gingival tissue and long interdental papillae; and the thick, flat periodontium, characterized by a thick osseous structure, flat morphology, thick gingival tissue, and a short, wide papilla.⁽⁸⁻¹⁰⁾ Individuals with the thin periodontal biotype may have more soft-tissue recession than those with the thick periodontal biotype.⁽¹¹⁾ Although the interdental gingival tissue possesses biologic tissue memory, rebound of gingival tissue is more likely in the thick periodontium than in the thin, scalloped periodontium, where recession is often permanent.^(12,13)

In 1992, Tarnow et al. reported that when the distance between the contact point and the bone crest was 5 mm or less, the papilla was usually present; when this distance was 7 mm or more, the papilla was usually absent.⁽⁷⁾ In addition, other factors, such as age, angulation of the roots of adjacent teeth, the shape of the crown, the space between adjacent teeth, the volume of the embrasure space, and the course of the cementoenamel junction also help determine whether interdental papilla will be present.^(1,3,6,7,14-17) The author was unable to find a published study that focused on the relationship between age and papilla recession in different embrasure morphologies. Therefore, the purpose of this study is to use a simple, noninvasive method to elucidate the relationship between embrasure morphology and age-related central papilla recession.

METHODS

Subjects

Between July 2004 and January 2006, 380 adults with fully erupted permanent dentition were randomly selected from the patient population of the dental department of the Chang Gung memorial hospital, Chiayi branch. Inclusion criteria were healthy

gingiva with a plaque-and-gingival index of 0-1⁽¹⁸⁾ and well-aligned natural-tooth maxillary central incisors. Exclusion criteria were systemic compromise (e.g., pregnancy or a history of taking medications known to increase the risk of gingival hyperplasia), central incisors with an artificial crown, proximal/cervical restorations or abrasion, a history of surgery in the anterior maxillary area, or open contact or crowding as observed visually without aid. Seventy subjects were excluded because of conditions such as an angular bone crest in the mesiodistal direction, open contact depicted on radiographs, or a distance from the bone crest to the contact area of more than 8 mm. There were 310 subjects included in the study.

Data collection

One periodontist performed visual examinations to detect a papilla between the central maxillary incisors. If no space was visible apical to the contact area, the papilla was recorded as present. If a space was visible apical to the contact area, it was filled with a temporary radiopaque restorative material (Cavition, GC Corporation, Tokyo, Japan). Periapical radiographs were obtained using a paralleling technique with a film holder (XCP, Rinn Corporation, Elgin, IL).^(16,17)

To verify the radiographic magnification, a 10-mm wire was bonded to the right central incisor on the labial surface of 20 subjects as an indicator of the magnification. The average magnification of the method was 1.06 times.

The subjects' sex and age were recorded. The following vertical distances were measured:

1. Papilla tip to contact point (PT-CP): the length of a vertical line from the apical margin of the space filled with the temporary hydraulic restorative to the apical point of the contact area. This distance is equal to the distance of papilla recession.

2. Proximal cementoenamel junction to contact point (pCEJ-CP): the length of a vertical line from the proximal CEJ line of the two central incisors to the apical point of the contact area.

3. Bone crest to contact point (BC-CP): the length of a vertical line from the bone crest to the apical point of the contact area.

4. Bone crest to papilla tip (BC-PT): the length of a vertical line from the crest of the bone to the papilla tip. This distance is also the papilla height.

5. Bone crest to proximal cemento-enamel junction (BC-pCEJ): the length of a vertical line from the crest of the bone to the proximal CEJ line of the two central incisors.

All vertical lines were measured along the long axis of an adjacent tooth.

Interdental width (W), the width between the two central incisors at the proximal CEJ level, was measured horizontally.

The vertical and horizontal distances were measured on periapical radiographs using an electric measuring ruler (Kinglife Corporation, R.O.C.). (Figures 1 and 2). In order to verify the reproducibility of measurements by the examiner, 5 periapical films were randomly selected, and the measurements for each were repeated 30 times. The standard deviations were all less than 0.16 mm.⁽¹⁹⁾

Subjects were divided into four groups according to their W and pCEJ-CP measurements, as fol-

lows: short-narrow (SN group: $W < 2$ mm and $pCEJ-CP < 4$ mm); long-narrow (LN group: $W < 2$ mm and $pCEJ-CP \geq 4$ mm); short-wide (SW group: $W \geq 2$ mm and $pCEJ-CP < 4$ mm); and long-wide (LW group: $W \geq 2$ mm and $pCEJ-CP \geq 4$ mm). (Figures 3)

Statistical analysis

Commercially available statistical software (SPSS version 11.5, SPSS, Chicago, IL) was used to analyze the data. Data are presented as mean \pm standard deviation. A Non-parametric Kruskal-Wallis Test was used to evaluate differences among the four study groups. Spearman rank correlation was used to measure associations between two variables, i.e., age and papilla recession. Receiver Operating Characteristic (ROC) analysis was used to define cutoff points for diagnostic tests, i.e., age > 29 and BC-CP distance > 5.1 mm. Logistic regression was applied when outcome variables were binary; i.e., logistic regression was applied to the odds of papilla recession. The level of statistical significance was set at $p < 0.05$.

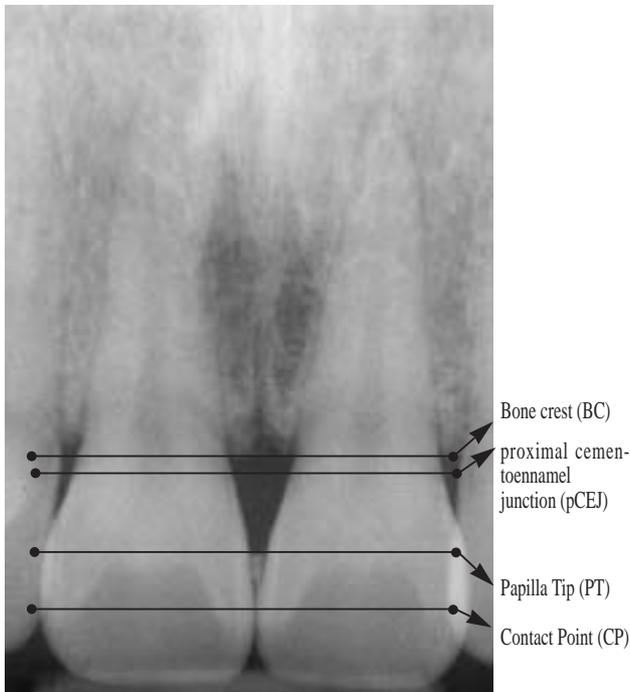


Fig. 1 The horizontal lines indicate the following locations, from top to bottom: bone crest (BC), proximal cemento-enamel junction (pCEJ), papilla tip (PT), and contact point (CP). The distance between PT and CP is PT-CP, the distance between pCEJ and CP is pCEJ-CP, the distance between BC and CP is BC-CP, the distance between BC and PT is papilla height, and the distance between BC and pCEJ is BC-pCEJ.

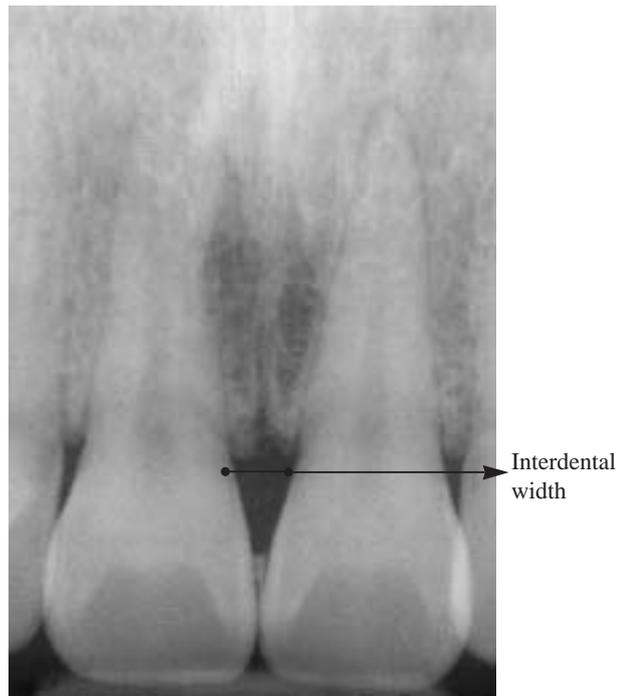


Fig. 2 Interdental width (W) is the horizontal distance between central incisors at the level of the proximal cemento-enamel junction.

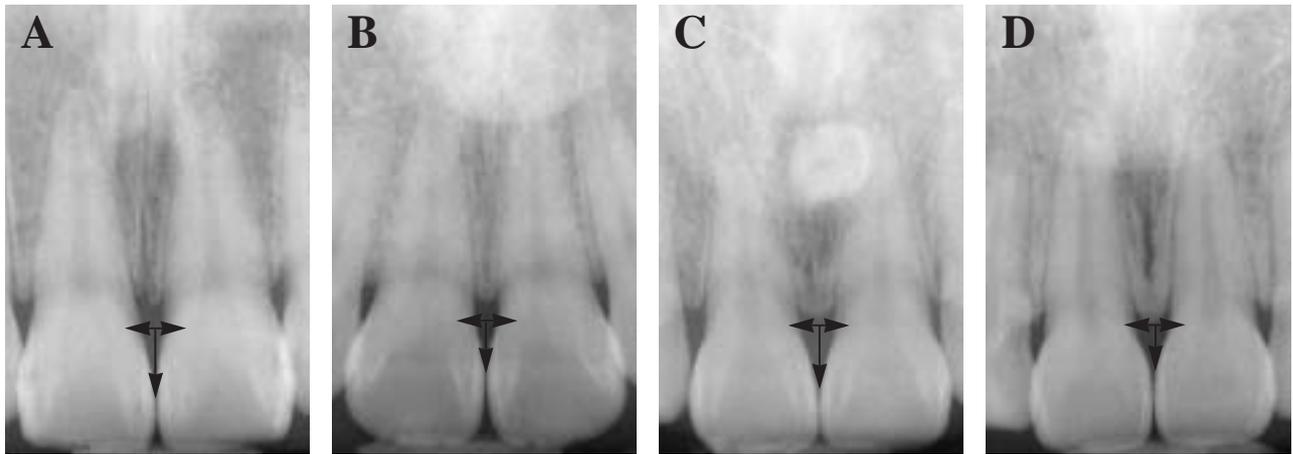


Fig. 3 The different embrasure morphologies, including: long-narrow, short-narrow, long-wide, and short-wide groups. (A) Long-narrow: $W < 2$ mm and $pCEJ-CP \geq 4$ mm. (B) Short-narrow: $W < 2$ mm and $pCEJ-CP < 4$ mm. (C) Long-wide: $W \geq 2$ mm and $pCEJ-CP \geq 4$ mm. (D) Short-wide: $W \geq 2$ mm and $pCEJ-CP < 4$ mm.

RESULTS

The 310 study subjects comprised 180 males and 130 females. The mean age in years was 39.7 ± 12.9 . The morphologic characteristics of the four groups are listed in Table 1. As Table 1 shows, many criteria-such as age, papilla recession distance, the vertical distance between bone crest and contact point, and papillary height-differed significantly among the four groups.

Table 2 shows the associations between various distances and age. Age was positively related to the distance of the recession and negatively related to papillary height in all groups. This relation was much stronger in the long-wide group than in the other groups.

The odds of papilla absence for the various groups are listed in Table 3. There was a lower risk of central papilla recession in the short-narrow group than in the other groups. This means that the likeli-

Table 1. The Morphologic and Non-morphologic Variables of the Four Study Groups

	Long-narrow mean \pm S.D.	Short-narrow mean \pm S.D.	Long-wide mean \pm S.D.	Short-wide mean \pm S.D.	<i>p</i> value
N	74	95	84	57	
Morphologic variables					
pCEJ-CP	4.61 ± 0.56	3.29 ± 0.46	4.68 ± 0.58	3.62 ± 0.26	$< 0.001^*$
interdental width (W)	1.56 ± 0.27	1.51 ± 0.29	2.36 ± 0.38	2.30 ± 0.22	$< 0.001^*$
pCEJ-CP/W ratio	3.02 ± 0.64	2.25 ± 0.49	2.01 ± 0.32	1.59 ± 0.15	$< 0.001^*$
Non-morphologic variables					
Age (in years)	34.3 ± 12.2	39.7 ± 13.1	39.9 ± 12.7	46.4 ± 10.9	$< 0.001^*$
PT-CP (papilla recession distance)	1.77 ± 1.30	1.99 ± 1.57	2.15 ± 1.23	2.53 ± 1.22	$< 0.001^*$
BC-CP	6.20 ± 0.86	5.36 ± 0.94	6.50 ± 0.77	5.89 ± 1.04	$< 0.001^*$
BC-PT (papilla height = PH)	4.21 ± 1.24	3.59 ± 0.92	3.98 ± 1.09	3.73 ± 1.01	$= 0.001^*$
PH in PR (-) [†] subgroup	5.77 ± 0.74	4.58 ± 0.65	6.12 ± 0.85	4.76 ± 0.67	$< 0.001^*$
PH in PR (+) [‡] subgroup	3.55 ± 0.71	3.15 ± 0.63	3.62 ± 0.62	3.59 ± 0.97	$< 0.001^*$

Abbreviations: *: Statistically significant; PR (-)[†]: Without papilla recession; PR (+)[‡]: With papilla recession

Table 2. The Correlation between Age and Bone Crest-contact Point Distance (BC-CP Distance), Papilla Height and Papilla Recession Distance

		Age	
		Spearman rank correlation	p value
BC-CP Distance	Long-narrow	0.426	< 0.001*
	Short-narrow	0.477	< 0.001*
	Long-wide	0.287	0.009*
	Short-wide	0.455	< 0.001*
Papilla height	Long-narrow	-0.350	0.002*
	Short-narrow	-0.276	0.007*
	Long-wide	-0.458	< 0.001*
	Short-wide	-0.199	0.138
Papilla recession distance	Long-narrow	0.543	< 0.001*
	Short-narrow	0.560	< 0.001*
	Long-narrow	0.608	< 0.001*
	Short-wide	0.595	< 0.001*

*: Statistically significant

hood of papilla recession in the long-narrow group was 1.04 times the likelihood of papilla recession in the short-narrow group, but the odds in the long-narrow group were not statistically significant. The odds of papilla recession in the long-wide group and the short-wide group were 2.64 and 3.14, respectively (Table 3). Because a previous study by the author showed that age and BC-CP distance can affect the incidence of papilla presence,^(16,17) further analysis was done after adjustment by age and BC-CP distance. There was no statistical significance in the odds for the four groups after adjustment by age and BC-CP distance (values of age > 29 and BC-CP distance > 5.1 mm were obtained from the ROC analysis used to define cutoff points for diagnostic tests in previous study)⁽²⁰⁾ (Table 3).

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

Table 3. The Risk of Papilla Recession among the Four Study Groups

	Odds ratio	95% C.I.	p value
Non-adjustment by age and bone crest-contact point distance			
Short-narrow	1.00	-	-
Long-narrow	1.04	0.54-2.01	0.91
Short-wide	3.14	1.24-7.75	0.013*
Long-wide	2.64	1.24-5.59	0.011*
Adjustment by age and bone crest-contact point distance			
Short-narrow	1.00	-	-
Long-narrow	1.03	0.40-2.63	0.96
Short-wide	1.49	0.51-4.36	0.47
Long-wide	1.53	0.57-4.11	0.40
Age ≤ 29	1.00	-	-
Age > 29	10.66	5.25-21.65	< 0.001*
BC-CP ≤ 5.1	1.00	-	-
BC-CP > 5.1	5.82	2.50-13.56	< 0.001*

*: Statistically significant

most commonly studied of these, but there are many others.^(1,3,6,7,14-17) 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.

The author excluded subjects with a BC-CP distance greater than 8 mm, because all such subjects would have central papilla recession. Subsequently, the embrasure morphologies of the study subjects were classified into four groups according to pCEJ-CP distance and pCEJ width, respectively: long-narrow, short-narrow, long-wide, and short-wide. There were many more subjects in the SN group than any of the other groups. There was a positive relationship between age and BC-CP distance, owing to physical bone resorption.⁽¹⁷⁾ The relationships between BC-CP distance and age were statistically significant in all four study groups (LN, SN, LW, SW).

The relationships between papilla height and age were statistically significant for the LN, SN, and LW groups, but not for the SW group. Study results reveal that papilla height decreases with age. Vandana and Savitha observed that the gingivae of younger individuals were significantly thicker than

those of older individuals. This is because the papilla is constituted by a dense connective tissue covered by oral epithelium. Aging changes the oral epithelium by thinning it and diminishing keratinization. Traumatic oral hygiene or genetic factors may also contribute to the inverse relationship between age and papillary height.^(6,21-23)

The 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 LW group. This finding may reflect greater bone volume loss at the same height of bone crest resorption in the wide groups (LW and SW) than in the narrow groups (LN and SN). Also, the LW group had narrower widths than the short-wide group, so the height of the black triangle (i.e., papilla recession distance) was greater in the LW group. (The area of the black triangle is approximately equal to PT width \times PT-CP height \times 0.5).

In previous studies, papillary height was measured by sounding, with the patient under local anesthesia; however, this method is invasive and only allows for buccal measurement.^(1,7,15) The author developed a noninvasive method of measurement that was accurate, simple to use, and easily accepted by subjects.^(16,17) The method uses Caviton, a temporary radiopaque restorative material. Lee's study suggests another noninvasive method: using a radiopaque material (a 2:1 mixture of an endodontic sealer and barium sulfate) and periapical radiographs to measure the length of the interdental papilla in relation to the crestal bone. This method would enable more accurate prognoses for a regenerated papilla.⁽²⁴⁾

The results of this study revealed that the likelihood of central papilla recession can be ranked according to embrasure morphology as follows (in ascending order): SN, LN, LW, and SW. In a previous study, the author found that age and BC-CP distance had some effect on central papilla presence.⁽²⁰⁾ After adjusting for age and BC-CP distance, the groups can be ranked according to the odds of central papilla recession for each as follows (in ascending order): SN, LN, SW, and LW. Differences between the odds of papilla recession for the two analyses may arise from differences in mean age and mean BC-CP distance for the four study groups.

Additionally, age and BC-CP distance may have a greater effect on central papilla presence than embrasure morphology. Consequently there was no statistical significance in all groups after adjustment.

This study found the occurrence of a black triangle to be significantly related to age on account of to the increasing distance between bone crest and contact point and decreasing papilla height, especially in the long-wide group. Even so, other factors also helped determine whether the interdental papilla would be present or not. Further study of the interrelations among these factors is needed.

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利用非侵入性方法研究牙間楔縫形態與正中牙間乳頭退縮之關係

張儷卿

背景： 隨著時代的進步，病患對美觀的要求也日益增高，而牙間乳頭的完整是影響美觀的因素之一。如果牙齒接觸點之下出現空隙，也就是所謂的牙間乳頭退縮，這會造成食物殘渣容易堆積，也會影響發音與美觀；而牙醫師與病患最介意的區域就是上顎正中門齒的牙間乳頭 (central papilla)。當正中牙間乳頭出現退縮 (central papilla recession)，影響美觀甚巨。大部份有關牙間乳頭的研究都在探討“齒槽脊-牙齒接觸點的距離” (bone crest-contact point distance) 與牙間乳頭出現 (papilla presence) 之間的關係，較少探討到其它影響因子，而針對正中牙間乳頭的研究更是少見。本研究的目的就是要利用非侵入性的方法，來探討牙間楔縫形態與正中牙間乳頭退縮之關係。

方法： 利用 x 光以平行法照攝 (Paralleling periapical radiography) 上顎正中門齒區，如果正中乳頭出現退縮，便利用 x 光不透性之暫時充填材料 (Cavition) 將牙間縫隙填滿。之後在 X 光片上測量一些垂直與水平距離 (如：bone crest-contact point distance, interdental width 等等)，並將收集的樣本分成四組：窄短組、窄長組、寬短組與寬長組 (narrow-short, narrow-long, wide-short and wide-long groups)，之後再進一步做統計分析。

結果： 發現正中乳頭的高度與年齡成負相關，而正中牙間乳頭退縮與年齡成正相關，尤其以“寬長組”較其它組相關性來得較強。

結論： 不過由於許多因子會影響牙間乳頭的出現，所以有必要進一步研究這些因子之間對牙間乳頭的交互作用。

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關鍵詞： 年齡，牙間乳頭，放射線攝影，牙齒形態，牙間楔縫

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