

The association between embrasure morphology and central papilla recession

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Abstract

Objective: To discover the association between embrasure morphology and central papilla recession.

Material and Methods: The central papilla was visually assessed in 330 adults using standardized periapical radiographs of the maxillary central incisors. The following vertical distances were measured: papilla recession [i.e., the distance from the papilla tip (PT) to the contact point (CP)], bone crest (BC) to contact point (BC–CP), proximal cementoenamel junction (pCEJ) to contact point (pCEJ–CP), and papilla height (PH). The horizontal distance measured was the inter-dental width. Subjects were divided into four groups according to inter-dental width and pCEJ-CP distance, respectively: narrow-long, narrow-short, wide-long, and wide-short.

Results: A statistically positive relationship was evident between central papilla recession and age, and a statistically negative relationship was evident between age and PH in all study groups.

Conclusions: Central papilla recession as a result of ageing is most frequently associated with a wide inter-dental width and long pCEJ–CP distance. However, other factors affect the likelihood of the presence of the inter-dental papilla, and further study of the interaction among these factors is warranted.

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In dentistry, increased aesthetic demands require a soft-tissue contour with an intact papilla and a symmetric gingival outline. The presence of a papilla between the maxillary central incisors is a key aesthetic factor in any individual (Kokich 2006). The inter-dental area comprises the contact area, inter-proximal embrasure, and inter-proximal dentogingival complex (Takei 1980). The interdental space is a physical space between adjacent teeth, which comprises four pyramidal embrasures: cervical, occlusal,

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buccal, and lingual. The inter-dental papilla occupies the cervical embrasure (Prato et al. 2004).

The inter-dental gingiva of the incisor region usually assumes the shape of a pyramidal papilla, or it may appear as a slight gingival col, depending on the location of the contact area and on the height of the gingiva (Cohen 1959, 1962, Fiorellini et al. 2006). The existence of a space below the contact area can lead to aesthetic impairment, phonic problems, and food impaction (Tarnow et al. 1992, Prato et al. 2004). If papilla loss occurs solely due to soft-tissue damage, reconstructive techniques can be completely restorative. If, however, severe periodontal disease and inter-proximal bone resorption cause the loss of inter-dental papilla, reconstruction is generally incomplete (Prato et al. 2004, Zetu & Wang 2005).

The morphologies of the inter-dental papilla and the osseous architecture housing the tooth can be categorized into two periodontal biotypes (Oschsenbein & Ross 1969, Becker et al. 1997, Weisgold 1997). The first periodontal biotype is the thin and scalloped periodontium, which is characterized by thin gingival tissue and long inter-dental papillae. The second periodontal biotype is the thick and flat periodontium, which is characterized by a thick osseous structure, flat morphology, thick gingival tissue, and a short, wide papilla. Individuals with the thin periodontal biotype may have more soft-tissue recession than those with the thick periodontal biotype (Olsson & Lindhe 1991). While the inter-dental gingival tissue possesses biologic tissue memory, rebound of gingival tissue is more likely in the thick

periodontium than in the thin and scalloped periodontium, where recession is often permanent (van der Velden 1982, Kan & Rungcharassaeng 2001).

It has been noted that papilla are almost always present when the distance between the contact point (CP) and bone crest (BC) is 5 mm or less, but that papilla are typically absent when the CP-BC distance is 7 mm or more (Tarnow et al. 1992). In addition to the CP-BC distance. other, less well understood, factors also help determine whether the inter-dental papilla will be present; these include angulation of the roots of adjacent teeth, crown shape, space between adjacent teeth, volume of the embrasure space, and the course of the cementoenamel junction (Tarnow et al. 1992, Choquet et al. 2001, Kurth & Kokich 2001, Gastaldo et al. 2004, Prato et al. 2004, Zetu & Wang 2005). The purpose of this study was to clarify the association between the embrasure morphology and central papilla recession by means of a method that is simple to use and is less invasive than the sounding method. The radiographic method presented herein is considered to be relatively noninvasive.

Material and Methods

Subjects

Between July 2004 and December 2005, 360 adults with fully erupted, permanent dentition were randomly selected from the dental department of the author's institution. Inclusion criteria were healthy gingiva with a plaque-and-gingival index of 0-1 (Loe & Silness 1963) and with well-aligned maxillary central incisors (i.e., no spacing, no crowding, and no intrusion/extrusion). Exclusion criteria were systemic compromise that included pregnancy or a history of taking medications known to increase the risk of gingival hyperplasia, presence of an artificial crown on the central incisors, proximal/ cervical restorations or abrasions, a history of surgery in the anterior maxillary area, or open contact or crowding observed visually without aid. Thirty subjects were excluded because of conditions such as an angular BC in the mesiodistal direction, open contact evident on radiographs, and a CP-BC distance of more than 10 mm. The final number of subjects was 330.

One periodontist performed visual examinations to detect inter-dental papilla between maxillary central incisors (defined as central papilla). If no space was visible apical to the contact area, the papilla was recorded as being present without central papilla recession. If a space was visible apical to the contact area, which was gently filled with a temporary soft, radiopaque restorative material (Caviton, GC Corporation, Tokyo, Japan), it was recorded as central papilla recession. The age of each subject was recorded.

Periapical radiographs of maxillary central incisors of all subjects were obtained using a paralleling technique with an XCP film holder (Rinn Corporation, Elgin, IL). Further measurements made on the radiographs were carried out using an electric measurement ruler (King Life Technology, Taipei, Taiwan) (Figs 1 and 2).

Vertical distances measured on radiographs included h1, h2, h3, and h4. h1 represented the papilla tip to contact point distance (PT–CP). More specifically, the distance was the length of a vertical line from the apical margin of the space filled



Fig. 1. Periapical radiographs of maxillary central incisors of all subjects. The horizontal lines indicate the following locations, from top to bottom: bone crest (BC), proximal cementoenamel junction (pCEJ), papilla tip (PT), and contact point (CP). The distance between CP and PT is PT–CP (h1), the distance between CP and pCEJ is pCEJ–CP (h2), the distance between BC and CP is BC–CP (h3), and the distance between BC and PT is papilla height (h4)

with the temporary hydraulic restorative agent to the apical point of the contact area (the distance is the central papilla recession). h2 represented the proximal cementoenamel junction to contact point distance (pCEJ-CP); the length of a vertical line from the proximal CEJ line of two central incisors to the apical point of the contact area. h3 represented the BC to contact point distance (BC-CP); the length of a vertical line from the BC to the apical point of the contact area. Finally, h4 represented the BC to papilla tip distance (BC-PT): the length of a vertical line from the crest of the bone to the papilla tip (the distance is the papilla height). Vertical lines were measured along the long axis of an adjacent tooth.

Horizontal measurements included w2; the width between the two central incisors at the proximal CEJ level (interdental width).

All subjects were divided into four groups according to their w2 and h2 measurements, respectively: narrow-long (w2 ≤ 2 mm and h2 > 4 mm), narrow-short (w2 ≤ 2 mm and h2 ≤ 4 mm), wide-long (w2 > 2 mm and h2 > 4 mm), and wide-short (w2 > 2 mm and h2 ≤ 4 mm) (Fig. 3).

Statistical analyses

Commercially available statistical software (SPSS version 11.5; SPSS, Chicago,



Fig. 2. Additional radiograph measurements. The horizontal distance at the proximal cementoenamel junction is inter-dental width (w2).



Fig. 3. Subject groups. (a) Narrow-long group: $w2 \le 2 \text{ mm}$ and h2 > 4 mm; (b) narrow-short group: $w2 \le 2 \text{ mm}$ and $h2 \le 4 \text{ mm}$; (c) wide-long group: w2 > 2 mm and h2 > 4 mm; (d) wide-short group: w2 > 2 mm and $h2 \le 4 \text{ mm}$.

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	Narrow-long	Narrow-short	Wide-long	Wide-short	<i>p</i> -value
Subjects	82	110	86	52	
PR(-)/PR(+)	23/59	32/78	8/78	4/48	
Morphologic variables					
pCEJ-CP distance (h2)	4.64 ± 0.53	3.34 ± 0.47	4.77 ± 0.56	3.70 ± 0.23	< 0.01*
Inter-dental width (w2)	1.63 ± 0.29	1.57 ± 0.31	2.45 ± 0.40	2.35 ± 0.19	< 0.01*
Other variables					
Age	36.06 ± 13.04	40.69 ± 13.14	42.06 ± 12.48	46.40 ± 10.91	< 0.01*
PT–CP distance (h1)	2.18 ± 1.67	1.81 ± 1.29	3.03 ± 1.39	2.43 ± 1.32	< 0.01*
BC-CP distance (h3)	6.45 ± 1.06	5.42 ± 1.02	6.93 ± 1.17	6.17 ± 1.13	< 0.01*
BC-PT distance (h4)	4.27 ± 1.24	3.62 ± 0.92	3.9 ± 0.97	3.74 ± 1.02	< 0.01*

Results (except subject number) are expressed as the mean \pm SD.

*Statistically significant.

Statistical method: ANOVA.

PR(-), without central papilla recession; PR(+), with central papilla recession; h1, papilla tip to contact point (PT-CP); the distance is the central papilla recession; h2, proximal cementoenamel junction to contact point (pCEJ-CP); h3, bone crest to contact point (BC-CP); h4, bone crest to papilla tip (BC-PT); the distance is the papilla height; w2, inter-dental width; the width between the two central incisors at the pCEJ level.

IL, USA) was used to analyse the data, which is presented as the mean \pm standard deviation. A parametric ANOVA (analysis of variance) test was used to compare differences between the means of two or more groups (i.e., among the four study groups). The Pearson correlation was used to measure associations for two variables such as the relationship between age and recession. Logistic regression and multi-logistic regression were applied when outcome variables were binary such as the odds of recession. The level of statistical significance was p < 0.05.

Results

There were 330 subjects in this study (193 males, 137 females; mean age 40.8 years). The morphologic differences of the four groups that were established according to w2 and h2 measurements

are summarized in Table 1. Significant differences were apparent between the groups in criteria that included age, central papilla recession, CP–BC vertical distance, and papillary height.

Tables 2 and 3 present the data concerning the association between the central papilla recession and age. Age was positively related to papillar recession and negatively related to papillary height in all groups. This relationship was much stronger in the wide-long group than in the other groups.

The odds of central papilla recession among the groups are listed in Table 4. There was a lower risk of central papilla recession in the narrow-short group than in the other groups. The likelihood of papilla recession in the narrow-short group was 0.95 times the likelihood of papilla recession in the narrow-long group. The odds of papilla recession in the wide-long group and the wide-short group were 3.85 and 4.69, respectively.

Considering the differences in mean age among the four study groups (Table 1), further analysis of odds of central papilla recession was carried out after adjustment by age. The results revealed that the groups could be ranked according to their odds of central papilla recession (in ascending order): narrow-short, narrow-long, wide-short, and wide-long (Table 5).

Discussion

The presence or absence of the interdental papilla is of great concern to dentists and patients (Tarnow et al. 1992), especially in the area of the central maxillary incisors. Many factors affect the presence of inter-dental papilla; the distance from BC to CP is the most

Table 2.	Relationship	between	age	and	central	papilla	recession
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	Age		Age (controlling for h3)		
	Pearson's correlation	<i>p</i> -value	Pearson's correlation	p value	
Papilla recession					
Narrow-long	0.566	< 0.001*	0.369	0.001*	
Narrow-short	0.571	< 0.001*	0.374	< 0.001*	
Wide-long	0.655	< 0.001*	0.555	< 0.001*	
Wide-short	0.530	< 0.001*	0.373	0.007*	

*Statistically significant.

Statistical method: correlation.

h3, the distance between bone crest and contact point (BC-CP distance).

Table 3. Relationship between age and central papilla height

	Age		Age (controlling for h3)		
	Pearson's correlation	p value	Pearson's correlation	p value	
Papilla height					
Narrow-long	-0.343	0.002*	-0.369	0.001*	
Narrow-short	-0.275	0.004*	-0.374	< 0.001*	
Wide-long	-0.423	< 0.001*	-0.555	< 0.001*	
Wide-short	-0.225	0.108	-0.373	0.007*	

*Statistically significant.

Statistical method: correlation.

Table 4.	Odds	of	central	papilla	recession
among t	he four	stu	dy group	os	

	Exp (B)	95% CI	<i>p</i> -value
Narrow-long	1.00	_	_
Narrow-short	0.95	0.50-1.79	0.874
Wide-long	3.80	1.59-9.10	0.003*
Wide-short	4.69	1.51-14.45	0.007*

*Statistically significant.

Statistical method: logistic regression.

Table 5. Odds of central papilla recession among the four study groups after adjustment by age

	Exp (B)	95% CI	<i>p</i> -value
Adjustment by A	Age		
Narrow-long	1.00		
Narrow-short	0.47	0.21-1.03	0.058
Wide-long	2.67	0.97-7.33	0.057
Wide-short	1.47	0.41-5.25	0.556

Dependent Variable: central papilla recession. Statistical method: multi-logistic Regression.

commonly studied of these, but there are many others (Tarnow et al. 1992, Choquet et al. 2001, Kurth & Kokich 2001, Gastaldo et al. 2004). There is an important need in aesthetic dentistry to find the risk factors for recession of the central papilla including the association between embrasure morphology and the central papilla recession.

In an attempt to further understand the influences on central papilla recession, herein the author divided the embrasure morphology of the study subjects into four groups according to pCEJ–CP distance and pCEJ width, respectively: narrow-long, narrow-short, wide-long, and wide-short. There were many more subjects in the narrow-short group than in any of the other groups. This may reflect the greater natural prevalence of the narrowshort embrasure morphology. However, the random sampling design of the study negated any bias related to group size.

Presently, a positive relationship between age and the papilla recession was apparent, even after controlling for the BC-CP distance. The relationship between age and the recession height was more statistically significant in the widelong group than in the other groups. This may have been caused by greater bone loss at the same height of BC resorption, resulting in a larger recession for the wide groups (wide-long and wide-short) than for the narrow groups (narrow-long and narrow-short). The wide-long group also had narrower widths than the wideshort group, so the height of the recession was longer in the wide-long group. (The recession area is almost equal to PT width \times PT–CP height $\times 0.5$.)

Further statistical analysis showed a negative relationship between age and papilla height, both with and without controlling for BC-CP distance. Vandana & Savitha (2005) observed that the gingivae of younger individuals are significantly thicker than those of older individuals. This is because a dense connective tissue covered by oral epithelium constitutes the papilla, and ageing changes the oral epithelium by thinning the epithelium and diminishing keratinization. Traumatic oral hygiene and racial or genetic factors may also contribute to the inverse relationship between age and papillary height (Wara-aswapati et al. 2001, Litonjua et al. 2003, Prato et al. 2004, Vandana & Savitha 2005).

Presently, the papilla recession equaled the discrepancy between the BC-CP distance and the papilla height. Thus, the strongest negative relation between age and papilla height exists in the wide-long group (both with and without controlling for BC-CP distance). Furthermore, the results of this study reveal that the groups can be ranked as follows according to their odds of central papilla recession (in ascending order): narrowshort, narrow-long, wide-short, and widelong after adjustment by age. The mean age of the wide-short group was older than those of other groups, which may explain why the wide-short group presents the highest odds of central papilla recession before adjustment by age.

In previous studies, papillary height was measured by sounding, with the patient under local anaesthesia (Tarnow et al. 1992, Grunder et al. 2000); however, this method is invasive. The thickness of masticatory mucosa and gingivae can be determined ultrasonically, but this measurement does not include interdental papillary height (Muller et al. 1999, 2000). Therefore, the author developed a noninvasive method of measurement that was simple, accurate, and easily accepted by subjects. And, the use of radiopaque material and periapical radiographs may permit measurement of the length of the inter-dental papilla in relation to the crestal bone, which would enable more accurate prognoses for a regenerated papilla (Lee et al. 2005).

Conclusions

The occurrence of central papilla recession is significantly related to age, especially for those with a wide inter-dental width and long pCEJ–CP distance ("wide-long"). However, other factors also determine whether the inter-dental papilla is present or not. At present, the interactions among these factors are unclear and in need of exploration.

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Clinical Relevance

Scientific rationale for the study: The distance from BC to contact point is the most frequently studied of the many factors that influence whether inter-dental papilla are present. There is an important need in aesthetic dentistry to understand the

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other risk factors for central papilla recession.

Principal findings: This study confirms a significant association between the occurrence of central papilla recession and increased age, and demonstrates that it is especially relevant for those with a wide inter-

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dental width and long pCEJ–CP distance ("wide-long"). *Practical implications*: In clinical practice, the "wide-long" embrasure morphology may be a risk factor for central papilla recession.

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