

The Influence of the Distance from the Contact Point to the Crest of Bone on the Presence of the Interproximal Dental Papilla

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Background: Loss of the interproximal dental papilla may cause functional and, especially in the maxillary anterior region, phonetic and severe esthetic problems. The purpose of this study was to investigate whether the distance from the contact point to the bone crest on standardized periapical radiographs of the maxillary anterior teeth could be correlated with the presence of the interproximal papilla in Taiwanese patients.

Methods: In total, 200 interproximal sites of maxillary anterior teeth in 45 randomly selected patients were examined. Selected subjects were adult Taiwanese with fully erupted permanent dentition. The presence of the interproximal papilla was determined visually. If there was no visible space apical to the contact area, the papilla was recorded as being present. The distance from the contact point to the crest of bone was measured on standardized periapical radiographs using a paralleling technique with a RinnXCP[®] holder.

Results: Data revealed that when the distance from the contact point to the bone crest on standardized periapical radiographs was 5 mm or less, the papillae were almost 100% present. When the distance was 6 mm, 51% of the papillae were present, and when the distance was 7 mm or greater, only 23% of the papillae were present.

Conclusion: The distance from the contact point to the bone crest on standardized periapical radiographs of the maxillary anterior teeth is highly associated with the presence or absence of the interproximal papilla in Taiwanese patients, and is a useful guide for clinical evaluation.
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Key words: contact point, alveolar crest, interdental papilla.

The concept of biologic width proposed by Garguilo⁽¹⁾ was derived from a histologic description of the so-called dentogingival complex.⁽²⁾ The measurement was established after a study of autopsy specimens, in which the average width of

the dentogingival complex was established. 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.⁽¹⁻⁴⁾

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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.⁽⁵⁾ The loss of the interdental papilla can lead to food impaction as well as esthetic and phonetic problems. In 1959, Cohen⁽⁶⁾ 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.⁽⁷⁻⁹⁾ Kohl and Zander⁽¹⁰⁾ then studied the interproximal tissue of monkeys by stripping the site to determine if the papilla and col would reform. They found that by the 8th post-surgical week, the papilla appeared to have begun to re-form. Olsson et al.⁽¹¹⁾ also investigated the relationship between crown form and the thickness of the free gingiva of the maxillary front teeth. Their study showed that the thickness of free gingiva was associated with the width of keratinized gingiva, the buccolingual width of the crown, and the presence of keratinized gingiva. In 1996, Muller et al.⁽¹²⁾ found that individual differences appeared to exist in gingival thickness, but that the thickness was mainly associated with tooth type and the gingival width. However, no relationship between the gingival thickness and the shape and form of the tooth was found.

In 1992, Tarnow et al.⁽¹³⁾ studied whether the distance from the base of the contact area to the crest of bone was correlated with the presence or absence of the interproximal papilla in humans. Their results showed that when the distance from the contact point to the crest of bone was 5 mm or less, the papilla was present almost 100% of the time. Since the measurements were taken by surgical sounding under anesthesia and part of the measurements verified during flap surgery, however, in many instances, the need to have predicted the presence of the interdental papilla before surgical or restorative treatment using non-invasive means in clinical consultation is very important.

The purpose of this study was to examine whether the distance from the contact point to the bone crest on standardized periapical radiographs of

the maxillary anterior teeth is related to the presence or absence of the interproximal papilla in adult Taiwanese.

METHODS

Forty-five adult Taiwanese with fully erupted permanent dentition were randomly selected. Inclusion criteria for participation included (1) not being systemically compromised, i.e., having no history of medication known to increase the risk of gingival enlargement; (2) having healthy gingiva with no periodontal probing depth of greater than 3 mm and a Plaque and Gingival index (Loe & Silness⁽¹⁴⁾ 1963) of grade 0-1; (3) having no attrition or abrasion nor any artificial crown or restoration; and (4) undergoing no periodontal treatment except prophylaxis. Among the 225 interproximal sites of the maxillary anterior teeth from canine to canine of these 45 patients, 25 sites were ruled out because of such conditions as crowding or spacing; thus, only 200 sites were examined. Examinations of the presence of the papilla and radiographic measurements were performed by the same senior periodontist. In order to verify the reproducibility of measurements by the examiner, 5 periapical films were randomly selected, and the measurements for each of them were repeated 30 times. The standard deviations were all less than 0.17 mm. The presence or absence of the interproximal papilla was determined visually. If no space was visible apical to the contact area, the papilla was recorded as being present. The distance (all measurements were rounded off to the nearest millimeter) from the contact point to the crest of bone was measured on periapical radiographs (using a paralleling technique with a RinnXCP[®] film holder). The available films were of good quality and had no overlap. The distance between the contact point and the crest of bone refers to the distance of a vertical line from the point of the contact area to the crest of bone along the long axis of the distally adjacent tooth. The distance of every site was repeatedly measured 10 times, and the average was recorded. To verify the radiographic magnification, customized stents were fabricated for 25 randomly selected patients. A 5-mm wire used as an indicator of the magnification was bonded to the stent along the long axis of the right central incisor on the labial surface. If the image of the 5-mm wire was 5.5 mm on the

radiograph, then we knew that there was a 10% magnification factor for the radiograph. After evaluating all the data, we found that the average magnification of the method was 1.05 times. Pearson correlation was used to analyze relationship between the percentage of papilla presence and the distance between bone crest and contact point. Due to the clustered data structure in this study, a special statistical software, *MLwiN**, which can take the dependence of sites on the subjects into account, was used to performed two-level (site-level and subject-level) logistic regression using the presence of interdental papilla as the outcome variable. Pearson correlation was performed using SPSS 10.0.

RESULTS

Results in Table 1 show that when the distance from the contact point to the bone crest on periapical radiographs was 5 mm or less, the papilla was present almost 100% of the time. When the measurement was 6 mm, the papilla was present 51% of the time, and when the distance was 7 mm or greater, the papilla was present 23% of the time. The relationship between the percentage of the presence of the papilla and the distance was also highly significant ($r = -0.954, p < 0.001$). The results of multilevel logistic regression analysis showed that the variance (0.791, standard error 0.468) on the subject level is not significant showing there was no significant variation across the subjects, but the coefficient of the distance between contact point and bone crest was highly significant (-1.723, standard error 0.264, $p < 0.001$).

DISCUSSION

Finding a way to successfully restore the interdental papilla is the most challenging task in peri-

odontal reconstructive surgery. An interproximal black hole greatly affects the esthetic appearance and can cause problems with phonetics and food impaction in the maxillary anterior region.⁽¹⁵⁾ Reconstruction of the lost interdental papilla is generally achieved in 3 ways. (1) Non-surgical methods: An orthodontic force is used to create an environment conducive to the reconstruction of the interdental papilla and closing of the diastema. Subsequently, the interdental papilla creeps toward the incisal direction due to closing of the interdental space.⁽¹⁶⁾ By changing the distally angulating roots of adjacent teeth and reshaping and stripping the contact area of adjacent teeth, the contact point can be moved apically.⁽¹⁷⁾ Forced eruption is also used to reposition the interdental alveolar bone crest to improve the supporting tissue of the interdental papilla so that the objective of reconstruction of the interdental papilla can be achieved.⁽¹⁸⁻²²⁾ (2) Surgical methods: Many surgical methods are used in the reconstruction of the interdental papilla.⁽²³⁻²⁷⁾ However, they fail to achieve long-term stability and predictability mainly because of the minor blood supply in the interdental papilla.⁽¹⁵⁾ Thus, flap pedicles have been shown to have better results than free gingival grafts.⁽²⁸⁾ Tarnow et al.⁽¹³⁾ also showed that the interdental papilla is dependent on the distance between the contact point and the crest of bone. If guided bone regeneration can be used to raise the height of the alveolar bone crest to 5 mm below the contact point, sound reconstruction of the interdental papilla can be achieved.⁽¹⁵⁾ However in reality, guided bone regeneration has encountered certain difficulties in the papilla region.⁽¹⁵⁾ The deficiency of tissue for primary closure in this region is common, so barrier technology is difficult to use. The fragility of the tissue plus the minor blood supply lead to the need for using #7-0 or 8-0 sutures.⁽²⁹⁾ Otherwise, necrosis of the papilla will occur. Future research

Table 1. Presence of Papilla Versus Distance from Contact Point to Crest of Bone

	Distance in mm from contact point to crest of bone							
	3	4	5	6	7	8	9	10
Number of papilla present	1	8	49	40	10	2	0	0
Number of papilla not present	0	0	1	38	34	13	3	1
Total number of papilla	1	8	50	78	44	15	3	1
% present	100	100	98	51	23	13	0	0
% not present	0	0	2	49	77	87	100	100

should investigate advanced flap designs, surgical methods, and suture materials in order to solve these problems. (3) Prosthetic methods: The distance between the contact point and the crest of bone determines the existence of the interdental papilla. If prosthetic or operative dentistry is adopted to recontour the morphology or relocate the contact point apically, then interproximal spaces can be closed. Therefore, clinically we can make use of a provisional prosthesis to induce the interdental papilla to undergo creeping papilla formation.⁽¹⁵⁾ When periodontal defects are too extensive or the region of missing teeth too large, physiological reconstruction is not viable. Pink-colored porcelain⁽³⁰⁾ or a removable gingival mask⁽¹⁵⁾ can be considered for hiding severe tissue defects and improving appearance. Prosthetic solutions should be used only when other alternatives have been exhausted.

Olsson and Lindhe⁽³¹⁾ suggested that variations in the morphology of the human periodontium may be related to the shape and form of the teeth. Their results showed that subjects with long, narrow upper central incisors have a comparatively thin periodontium and may be more susceptible to gingival recession than subjects with a short and wide tooth form.

Tarnow et al.⁽¹³⁾ showed that when the measurement from the contact point to the crest of bone was 5 mm or less, the papilla was present almost 100% of the time, which correlated highly with the results of our study. However, at 6 mm, the papilla was present 56% of the time, and at 7 mm only present 27% of the time. Their study included both anterior and posterior teeth, and did not exclude those teeth with proximal restorations nor define patients who had had previous surgery. In our study, the 1.05 magnification effect of the periapical radiographs should be considered. However, since we measured the distance to the nearest mm, a magnification effect of 1.05 most likely did not alter the final result and it is not surprising that we obtained similar results to the study by Tarnow et al.⁽¹³⁾ Therefore, our results may be modified such that when the distance from the contact point to the bone crest on periapical radiographs was 4.7 mm (rounded to 5 mm) or less, the papilla was present almost 100% of the time. When the measurement was 5.7 mm (rounded to 6 mm), the papilla was present 51% of the time, and when it was 6.7 mm (rounded to 7 mm) or greater, the papilla was present 23% of the time. Our results are com-

paratively lower only for the 5.7- and 6.7-mm sites than for the 6- and 7-mm sites of Tarnow's study. This may be explained by the fact that we limited our study to anterior teeth only, while excluding areas with previous surgery or proximal restorations. The sensitivity of the papilla recession of the anterior teeth is higher because of its longer and thinner shape. In healthy periodontium with normal tooth alignment, the distance between CEJ (cemento-enamel junction) to alveolar bone crest is approximately 1 to 2 mm and the distance between CEJ to contact point is approximately 2 to 3 mm.⁽³²⁻³⁴⁾ Therefore, the distance between contact point to alveolar bone crest is about 4 to 5 mm. This may explain the usual presence of papilla in normally aligned teeth. Also, the concept of biologic width, which was first described by Garguilo et al.,⁽¹⁾ shows that the combined dimensions of the connective tissue attachment above the alveolar crest plus the length of the junctional epithelium, averages 2.04 mm. It must be emphasized that sulcus depth varies, while the combined width of the connective tissue and the epithelial attachment mentioned above is more consistent. A maximum depth of 3 mm of sulcus is clinically observed to maintain the health of periodontal status. Therefore, the biologic width of 2.04 mm plus the sulcus depth of 3 mm approximately equals 5 mm. If the sulcus depth presents more than 3 mm, the rate of inflammation of periodontium due to compromised environment to carry out plaque control may increase. The possibility of resultant gingival recession may also increase. In Tarnow's study, scaling and root planing 2-8 weeks before measurement eliminate the presence of inflammation. Therefore, a distance of 5 mm is more compatible to biological health and stability. In this study, only healthy periodontium with probing depths less than or equal to 3 mm are included.

The presence of the interdental papilla is also influenced by many factors such as tooth alignment, crown shape and distance of contact point to CEJ. Kurth and Kokich⁽³⁵⁾ recently conducted a study on the occurrence rate and causes of an interdental black triangle in adults who received orthodontic therapy on the upper central incisor. The study showed that the occurrence rate was 38%, and no causal relationship with pre-therapy rotation or overlap was found. The related factors were crown shape, the distance between the contact point and the crest of bone, the

root angulation of the adjacent teeth, and the volume of the embrasure space. Thus root angulation and tooth malposition are factors that affect the distance and teeth with crowding or spacing are therefore excluded in this study.

In Tarnow's study the distance between the contact point and the crest of bone which affects the existence of the interdental papilla was measured by surgical sounding. This distance is shown to be an important index for predicting the presence of the interdental papilla. Even though Tarnow et al. (1992) have suggested using periodontal probe to demonstrate the accuracy of measurement, several lines of clinical observations made us think otherwise. For example, in situations where overlapping of the adjacent teeth, tilting of tooth, and the inflamed interdental papilla was not uncommon, the measurements by clinical probing may be hindered and masked. Hence, the readout by probing technique to predict the presence or the absence of the interproximal dental papilla may be inaccurate. This point can be further emphasized by the results obtained from present study and Tarnow et al. (1992). Both studies showed that the measured distances of 5 and 6 mm depth from contact point to crest bone had resulted in clinical significant impact on the presence of papilla from 100% down to 51%, respectively. It is the critical measurement between 5 or 6 mm that predict the outcome of presence or absence of the interproximal dental papilla at the end of dental treatment. Thus, we suggested that the utilization of the standardized periapical radiograph provide a better and direct accurate measurement from contact point to crest bone. Since periapical radiographs were commonly taken for certain dental procedure, they may be served as an additional diagnostic tool to determine the presence or absence of the interproximal dental papilla at the end of treatment.

The intriguing point that the measurements of 5 and 6 mm depth distinguished drastically the presence and absence of the interdental papilla, respectively remained unsolved and awaited further investigation.

The objective of this study was to create a Taiwanese database collected from standardized periapical radiographs, which are readily available in clinical examinations. In spite of the magnification of standardized periapical radiographs, and regard-

less of being during phase I therapy or at the outset and aftermath of periodontal surgery, results in this study show that dentists can still rely on standardized periapical radiographs as a useful guide and an alternative to surgical sounding to predict the chance for the presence of the interdental papilla. Clinically, only standardized periapical radiographs using a paralleling technique are needed, and they are usually necessary for consultation and discussion with patients. Considering the growing attention paid to anterior esthetics by both patients and dentists, this study only focused on the maxillary anterior teeth, which is the most important esthetic zone. The results can be applied not only to before periodontal therapy but also prior to restorative treatments such as provisional prosthesis, crown and bridge or composite resin restoration in the interproximal area. In addition, the results can also be applied in orthodontic therapy, by reshaping and stripping teeth, and changing the morphology and the position of the interproximal contact point to remodel the shape of the interdental papilla to reduce the interdental black triangle. Nevertheless, there are other factors determining the existence of the interdental papilla, including the morphology and alignment of teeth, the mesiodistal distance between the adjacent teeth, and the volume of the embrasure space. Further investigations exploring this area are indicated.

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鄰間接觸點至骨脊之距離對齒間乳頭存在之影響

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背景： 齒間乳頭的喪失會導致美觀、發音及食物嵌塞等問題。本研究的目的是探討在台灣人上顎前牙區根尖周X光片中，鄰間接觸點至骨脊之距離對齒間乳頭存在與否之影響。

方法： 隨機選取45位病人的上顎前牙區，總共200個鄰間接觸點作檢查。病人均為成年人，且恆牙已完全萌出。齒間乳頭之存在與否以視診作鑑別，而鄰間接觸點至骨脊的距離由根尖周X光片上測得。

結果： 測量的資料顯示於根尖周X光片中，當鄰間接觸點至骨脊之距離小於或等於5mm時，齒間乳頭幾乎100%存在。當距離是6mm時，齒間乳頭有51%存在。而當距離大於或等於7mm時，齒間乳頭有23%或更少的機會存在。

結論： 在台灣人的上顎前牙區，根尖周X光片鄰間接觸點至骨脊之距離與齒間乳頭的存在與否有密切相關，因此使用根尖周X光片作臨床評估有重要參考價值。
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關鍵字： 鄰間接觸點，齒槽骨脊，齒間乳頭。