

Dimension of Keratinized Mucosa and the Interproximal Papilla Between Adjacent Implants

Dong-Won Lee,* Kwang-Ho Park,† and Ik-Sang Moon*

Background: The interproximal papilla between two adjacent implants is gaining critical interest in the implant dentistry. The aims of this study were to evaluate the effect of 1) the width of keratinized mucosa, 2) the distance from the base of the contact point to the crestal bone, and 3) the horizontal distance between two implants on the radiographic dimension from the tip of the papilla to the crestal bone between two implants.

Methods: This study involved 72 interproximal papillae between two adjacent implants (interimplant papilla) in 52 patients who had implants placed adjacent to each other and had a prosthesis in place more than 1 year. The shortest distance between the radiopaque material on the tip of the interimplant papilla and most coronal portion of the interimplant crestal bone was measured (the radiographic length of the papilla [RL]). The width of keratinized mucosa from the tip of the papilla was measured (WK). The vertical distance between the base of the contact point and the interimplant crestal bone was measured (CC). The horizontal distance between the two adjacent implants was measured at the fixture-abutment interface level (HD). Multiple regression analysis was performed between WK-RL, CC-RL, and HD-RL.

Results: RL had a significant relation with WK between two adjacent implants ($P = 0.001$). However, RL was not related with other variables, such as CC and HD (CC, $P = 0.641$; HD, $P = 0.901$).

Conclusion: The results of this study suggest that the width of keratinized mucosa between two adjacent implants might be related to the dimension of the interproximal papilla between two adjacent implants. *J Periodontol* 2005;76:1856-1860.

KEY WORDS

Dental esthetics; dental implants; dental papilla/anatomy and histology; tissue/anatomy and histology.

* Department of Periodontology, Yongdong Severance Hospital, College of Dentistry, Yonsei University, Seoul, Korea.

† Department of Oral and Maxillofacial Surgery, Yongdong Severance Hospital, College of Dentistry, Yonsei University.

In the implant dentistry, the dimensions of mucosa around implants became the subject of considerable interest not only from an epidemiologic interest but also from a therapeutic point of view.¹ Consequently, the reconstruction of the interproximal papilla between adjacent implants arose as an important topic in implant dentistry. However, generating a papilla between two implants was more intricate than between teeth or between a tooth and implants.² In a recent study, it was shown that the mean vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants was 3.4 mm.³ Some attempts have been shown in the literature to recreate the interimplant papilla.^{4,5} Although more and more sophisticated surgical techniques were developed to restore the lost interimplant papilla, the predictability and long-term stability were hardly available in the literature.⁶

It was suggested that the form of a crown may determine the position of marginal soft tissue, including the proximal papilla.⁷ Also, a study on the natural dentition reported the relationship between the interdental papilla and the contact point and concluded that the distance from the contact point to the crestal bone is significantly related to the presence of the papilla.⁸ Thus, the location of the contact point and the level of the crestal bone may play a significant role in the formation and maintenance of the interproximal papilla. A recent study⁹ evaluated the relationship between the

distance between two implants and the crestal bone level and showed that, when the interimplant distance became less than 3 mm, there was a tendency of increased crestal bone resorption. However, the effect of crestal bone resorption on the length of soft tissue between adjacent implants was not investigated.

The zone of keratinized gingiva was found to be wider in a thicker gingival biotype.^{7,10} In a thicker gingival biotype, the dimensions of peri-implant mucosa including the interproximal region can be influenced.¹¹ However, the relation between the width of keratinized gingiva at the interproximal region and the dimension of the interproximal papilla between two implants was not investigated.

The aims of this study were to evaluate the effect of 1) the width of keratinized mucosa at the interproximal region, 2) the distance from the base of contact point to the crestal bone, and 3) the distance between two implants on the dimension of the interproximal papilla between two implants.

MATERIALS AND METHODS

The present study was based on 52 patients (30 males and 22 females), recruited from January 2003 to December 2003, aged 40 to 62 years (mean age 52.4 years) who had an implant-supported, fixed prosthesis in posterior sites more than 12 months. The patients had implant surgery and prosthetic treatment at the Department of Periodontology of the Yongdong Severance Hospital from January 1999 to December 2001. Patients had various implant types, designs, and surfaces (turned, titanium dioxide-blasted, and acid-etched). All of the patients had undergone specific oral hygiene instruction for the individual implant prosthesis right after delivery using interproximal brushes of various sizes. Thus, patients included in this study were devoid of plaque accumulation, and patients who had inflamed mucosa around implants with bleeding tendency and plaque accumulation were excluded. They were then reinstructed on proper oral hygiene and reexamined during another session.¹² Subjects who were taking any medication known to affect periodontal soft tissues and who had any kind of soft tissue graft during implant surgery were excluded. The study protocol was approved by the Yonsei University Ethics Committee. Informed consent was obtained from all subjects. In total, 72 interproximal papillae between two adjacent implants were investigated in this study.

The measuring of the radiographic length of the papilla (RL) using a radiopaque material is described elsewhere.¹³ In brief, radiopaque material, consisting of a 2:1 mixture of an endodontic sealer, and barium sulfate were placed with a probe on the tip of the papilla. A periapical radiograph was taken using a parallel technique with an XCP device. The films were

digitized using a digital scanner. To calculate the length between the crestal bone and the tip of the papilla, a line was drawn connecting the abutment-fixture junction between two implants, and two parallel lines were drawn passing 1) the tip of the papilla and 2) the tip of the crestal bone. The shortest distance between the two lines, that is, the length between the most coronal portion of the interimplant crestal bone to the radiopaque material, was measured with a computer-aided device.[†] Along with measuring the papilla, the distance between two adjacent implants (the horizontal distance [HD]) was measured at the same periapical radiograph at the fixture-abutment level. Calibration was done with a known thread pitch distance for vertical measurement and a fixture diameter for horizontal measurement.

Probes[§] calibrated at 1, 2, 3, 5, 7, and 10 mm were used to measure the width of keratinized mucosa from the mucogingival junction (MGJ) to the tip of the interproximal papilla between adjacent implants to the nearest 0.5 mm (WK). The mucogingival border was identified by inspecting mucosal surface characteristics and, if in doubt, functionally by applying a periodontal probe to the alveolar mucosa parallel to the border, thereby demarcating the mucogingival junction.¹⁰ Using the same probes, the distance from the base of the contact point to the tip of the papilla was measured. To calculate the distance between the base of the contact point to the interimplant crestal bone, this value was added to RL (the contact point to the crestal bone [CC]).

A schematic illustration of the measured distance is depicted in Figure 1, and the actual radiograph used for measuring RL and HD is presented in Figure 2.

All measurements were done twice by the same investigator to the nearest 0.5 mm with an interval of 1 minute. Intraexaminer agreement was high (Spearman correlation coefficient = 0.996; $P < 0.001$).

The influence of various parameters (WK, CC, and HD) on RL was examined by means of a multiple regression analysis, including data from the whole sample. Linear models were constructed with RL as the dependent variable and WK, CC, and HD as explanatory variables. All calculations were performed on a personal computer with a statistical program.^{||}

RESULTS

The mean value of RL was 3.3 ± 0.5 mm. The mean WK was 4.5 ± 1.7 mm. The mean CC was 4.7 ± 1.2 mm. The mean HD was 3.1 ± 0.5 mm (Table 1).

The results from the multiple regression model are presented in Table 2. RL was significantly related

† UTHSCSA ImageTool, University of Texas Health Science Center at San Antonio, Dental Diagnostic Science, San Antonio, TX.

§ Williams PW, Hu-Friedy, Chicago, IL.

|| SPSS for Windows release 10.0.1, SPSS, Chicago, IL.

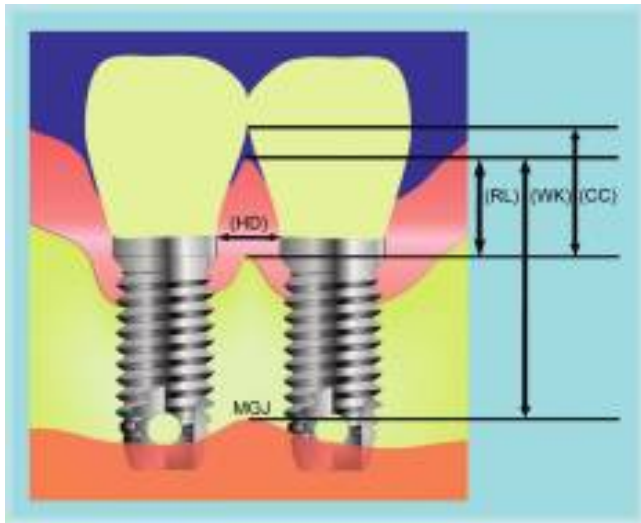


Figure 1.
Schematic illustration of measured distance.

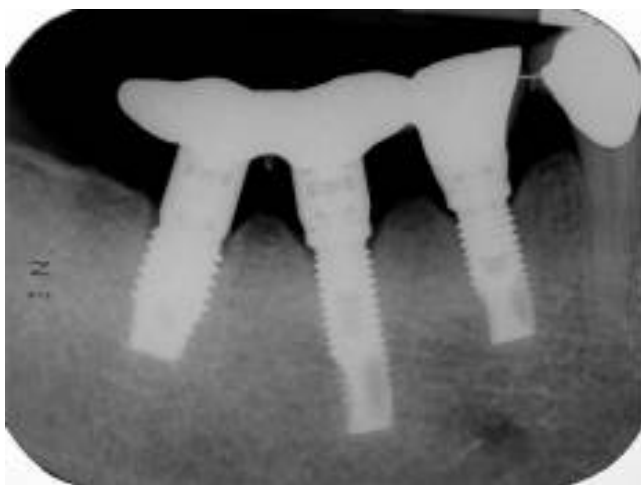


Figure 2.
Radiograph showing the radiopaque material at the tip of the interproximal papilla between adjacent implants.

to WK between two adjacent implants ($P = 0.001$). However, RL was not related to other variables, such as CC and HD (CC, $P = 0.641$; HD, $P = 0.901$).

DISCUSSION

The main purposes of this study were to find out the effect of 1) the width of keratinized mucosa, 2) the distance from the base of the contact point to the crestal bone, and 3) the distance between two implants on the radiographic length of the interproximal papilla between two implants.

The mean length of RL was similar to the result of a recent study, which showed that the mean height of soft tissue of the papilla between two adjacent im-

Table 1.
Mean Values and Standard Deviation for RL, CC, WK, and HD (mm)

RL	CC	WK	HD
3.3 ± 0.5	4.7 ± 1.2	4.5 ± 1.7	3.1 ± 0.5

Table 2.
Multiple Regression Analysis

Parameter	Estimate	SE of Estimate	P Value
CC	0.02	0.05	0.641
WK	0.127	0.39	0.001*
HD	-0.07	0.15	0.901

* Statistically significant ($P < 0.01$).

plants was 3.4 mm.³ In the present study, the mean length of RL was 3.3 mm. The radiopaque material used for measuring RL was introduced elsewhere,¹³ which verified its usage in measuring soft tissue length and showed a high correlation with actual soft tissue measuring and bone probing. Its usage ensured a less invasive method, which gave patients less trauma and discomfort.

In the natural dentition, when the distance from the base of the contact point to the crestal bone was less than 5 mm, the papilla filled the interdental area most of the time.⁸ This indicated that, when the distance from the base of the contact point to the crestal bone was less than 5 mm, the position of the contact point would be the determining factor for demarcating the length of the interproximal papilla from the tip to the crestal bone, since it is intuitively easy to analogize that the length of the interproximal papilla would be limited by the position of the contact point. However, this relationship was not confirmed in the present study. The results here showed that the distance from the base of the contact point to the crestal bone did not significantly influence the length of the interproximal papilla between two implants. This might be due to the arbitrariness of making the contact point by the clinician in the making of the implant prosthesis, thus having little meaning in the biologic dimension of peri-implant mucosa. However, in the single implant therapy, the level of papillae seemed to be significantly related with the level of the contact point.¹² In the case of single implant therapy, the level of the papilla is determined by the crestal bone level on the tooth side, not the implant side.^{11,14} Also, according to a study that compared implant-supported single-tooth replacements to contralateral natural teeth, no

statistically significant differences were observed in the position of the contact points between the single implants and the contralateral natural teeth.¹⁵ Thus the determining factor for leveling the papilla was more or less like mimicking the natural dentition in the case of a single implant next to a natural dentition.

A recent study described the effect of the horizontal and vertical distance between adjacent implants on the incidence of the interproximal papilla.¹⁶ In this study, the papilla fill was closely related with the horizontal distance between two implants. When the distance was less than 2.5 mm, there was an absence of papilla fill between two adjacent implants. However, in our study, there was a lack of a relationship between the horizontal distance and length of the interproximal papilla between two implants. This different result might be due to the fact that we measured the radiographic dimension of interimplant papilla, not the papilla fill between two adjacent implants. Thus, even though the interimplant crestal bone might resorb due to the decreased horizontal distance,⁹ that might not guarantee a decreased soft tissue length per se between implants. However, considering the decreased crestal bone level and consistent soft tissue thickness simultaneously, it is possible to predict less papilla fill in closely implanted sites. Also, the study pool was obtained from successfully treated patients with well-aligned implants, so that subjects with HD less than 3 mm might not be sufficiently included. Moreover, the implant system was arbitrary selected so that the influence of HD on a specific design was eliminated. Further study on the influence of different implant systems on the length of soft tissue between implants is presently underway.

Wennström et al.^{17,18} analyzed the dimension of the gingiva in beagle dogs and made an observation that gingival units with a wide zone of keratinized gingiva were more voluminous than units with a narrow zone. This finding was confirmed in a human study by Olsson et al.⁷ There was a strong relationship ($P = 0.001$) between the two variables, the width of keratinized gingiva and the thickness of the gingiva, in the stepwise multiple regression model in central incisors. Also, in orthodontic treatment, an increased bucco-lingual thickness of the tissue at the facial aspect of teeth would result in coronal migration of the soft tissue margin.¹⁹ A recent study¹¹ on the dimension of mucosa around single implants found that the dimensions of peri-implant mucosa can be influenced by the gingival thickness, so that greater peri-implant mucosal dimensions were noted in the presence of a thick peri-implant biotype as compared to a thin biotype. An analogical interpretation for the high correlation with WK and RL found in this study ($P = 0.001$) would be established. Thus, wider WK indicates that mucosa around implants was more volumi-

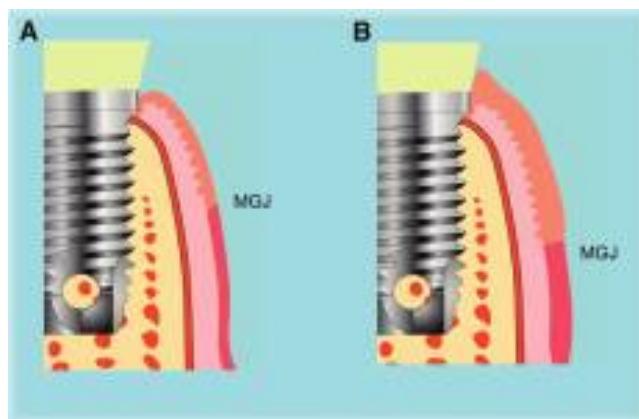


Figure 3.

Schematic illustration of the possible relationship between WK and RL. **A)** Narrower WK, thus indicating thinner mucosa, resulting in a smaller dimension of the interimplant papilla. **B)** Wider WK, thus indicating thicker mucosa, resulting in a greater dimension of interimplant papilla.

nous and had a thicker peri-implant biotype, leading to the thicker RL (Fig. 3).

The results of the present study imply that the biologic dimension of soft tissue covering of the interimplant crestal bone (RL) might neither decrease nor increase regardless of the horizontal distance between adjacent implants and the position of the contact point. However, the dimension of soft tissue tends to increase where wider keratinized mucosa exists, thus indicating thicker mucosa beneath the interimplant papilla. It is possible that the dimension of interimplant papilla might be related to the gingival biotype of preexisting or contralateral natural dentition. Further study focusing on the gingival phenotype and soft tissue around dental implants is necessary.

REFERENCES

1. Muller HP, Eger T. Masticatory mucosa and periodontal phenotype: A review. *Int J Periodontics Restorative Dent* 2002;22:172-183.
2. Garber DA, Salama MA, Salama H. Immediate total tooth replacement. *Compend Contin Educ Dent* 2001;22:210-218.
3. Tarnow DP, Elian N, Fletcher P, et al. Vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants. *J Periodontol* 2003;74:1785-1788.
4. Tinti C, Benfenati SP. The ramp mattress suture: A new suturing technique combined with a surgical procedure to obtain papillae between implants in the buccal area. *Int J Periodontics Restorative Dent* 2002;22:63-69.
5. Grossberg DE. Interimplant papilla construction: Assessment of soft tissue changes and results of 12 consecutive cases. *J Periodontol* 2001;72:958-962.
6. Prato GPP, Rotundo R, Cortellini P, Tinti C, Azzi R. Interdental papilla management: A review and classification of the therapeutic approaches. *Int J Periodontics Restorative Dent* 2004;24:246-255.

7. Olsson M, Lindhe J, Marinello CP. On the relationship between crown form and clinical features of the gingiva in adolescents. *J Clin Periodontol* 1993;20:570-577.
8. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *J Periodontol* 1992;63:995-996.
9. Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. *J Periodontol* 2000;71:546-549.
10. Muller HP, Heinecke A, Schaller N, Eger T. Masticatory mucosa in subjects with different periodontal phenotypes. *J Clin Periodontol* 2000;27:621-626.
11. Kan JYK, Rungcharassaeng K, Umezaki K, Kois JC. Dimensions of peri-implant mucosa: An evaluation of maxillary anterior single implants in humans. *J Periodontol* 2003;74:557-562.
12. Choquet V, Hermans M, Adriaenssens P, Daelemans P, Tarnow DP, Malevez C. Clinical and radiographic evaluation of the papilla level adjacent to single-tooth dental implants. A retrospective study in the maxillary anterior region. *J Periodontol* 2001;72:1364-1371.
13. Lee DW, Kim CK, Park KH, Cho KS, Moon IS. Non-invasive method to measure the length of soft tissue from the top of the papilla to the crestal bone. *J Periodontol* 2005;76:1311-1314.
14. Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1-year results. *Int J Periodontics Restorative Dent* 2000;20:11-17.
15. Chang M, Wennström JL, Ödman P, Andersson B. Implant supported single-tooth replacements compared to contralateral natural teeth. *Clin Oral Implants Res* 1999;10:185-194.
16. Gastaldo JF, Cury PR, Sendyk WR. Effect of the vertical and horizontal distances between adjacent implants and between a tooth and an implant on the incidence of interproximal papilla. *J Periodontol* 2004;75:1242-1246.
17. Wennström JL, Lindhe J, Nyman S. The role of keratinized gingiva for gingival health. Clinical and histological study of normal and regenerated gingival tissue in dogs. *J Clin Periodontol* 1981;8:311-328.
18. Wennström JL, Lindhe J, Nyman S. The role of keratinized gingiva in plaque-associated gingivitis in dogs. *J Clin Periodontol* 1982;9:75-85.
19. Wennström JL. Mucogingival considerations in orthodontic treatment. *Semin Orthod* 1996;2:46-54.

Correspondence: Dr. Ik-Sang Moon, Zip 135-720, Department of Periodontology, Yongdong Severance Hospital, 146-92 Dokok dong, Kangnamku, Seoul, Korea. E-mail: ismoon@yumc.yonsei.ac.kr.

Accepted for publication March 18, 2005.