

Determining factors for formation and/or maintenance of peri-implant papilla: Literature review

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Abstract

Introduction: The interproximal papilla, among other requirements, is considered essential to achieve success in esthetic prostheses placed over implants. **Methods:** This article is based on a literature review carried out with periodicals published from 1984 to 2011 on LILACS and MEDLINE. Twenty-one articles were selected in order to highlight the determining factors for the formation and/or maintenance of peri-implant papilla, namely: the ideal distance between a tooth and an implant, the distance between implants, the above/below bone level positioning of an implant and the necessary distance from the contact point to the bone crest. **Conclusions:** We concluded that the ideal distance between a tooth and an implant is 2 mm, whereas the distance between implants is 3 mm, given that the height of the gingival papilla is supported by the formation of biological space. With regard to the positioning of the implant, above/below bone level, no differences regarding papilla formation were reported. The height from the contact point of the crown to the bone crest, which is a determining factor for papilla formation, should be up to 5 mm.

Keywords: Gingiva. Dental implants. Periapical tissue.

How to cite this article: Soares NP, Pimentel AC, Cançado RM, Manzi MR, Brozoski M, Camino Junior R, Naclério-Homem MG. Determining factors for formation and/or maintenance of peri-implant papilla: Literature review. *Dental Press Implantol.* 2013 Apr-June;7(2):73-80.

» The authors inform they have no associative, commercial, intellectual property or financial interests representing a conflict of interest in products and companies described in this article.

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Submitted: 22/07/2011

Revised and accepted: 27/02/2013

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introduction

The interdental papilla is of great interest for Implantodontics, given that its presence may lead to either esthetic success or failure in the majority of implant-supported dental prosthesis cases. Some factors should be analyzed during planning, namely: bone height and thickness, bone crest height in relation to the dental contact point, gingival tissue biotype and architecture as well as tridimensional implant positioning, all of which can determine and prevent the prognosis of treatment in Implantodontics.^{1,2}

Loss of gingival papilla will result in the formation of a relatively dark area popularly known as “black hole”. Therefore, a surgical planning implemented for implant placement should take into account the distance between the tooth and the implant, the distance between implants, above/below bone level positioning and the distances from the dental contact point to the bone crest that should be adjusted to the patient's anatomy, healing potential and remodeling of hard and soft tissues in order to avoid loss of the papilla or to prepare the patient for a potentially unfavorable prognosis.^{3,4}

Literature review

This study aims at conducting a literature review on periodicals published between 1984 and 2011 in the following databases: LILACS and MEDLINE. Additionally, it aims at analyzing the determining factors for formation and/or maintenance of peri-implant papilla, namely: the ideal distance between the tooth and the implant, the distance between implants, implant above/below bone level positioning and the necessary distance from the contact point to the bone crest.

The following are considered as determining factors for formation and/or maintenance of the papilla:

Manipulation of soft and hard tissues around implants

According to Kois,⁵ surgical techniques can affect the shape of the gingival papilla, thus, immediate implant atraumatic

protocols should be developed not only to reduce the damage caused to soft tissues, but also to preserve esthetics. In these cases, an immediate provisional implant can be placed, which is ideal to preserve the integrity of tissues as well as meet patients' expectations with regard to esthetics. Moreover, implants can also receive a healing cap with a provisional implant (fixed or movable), and that is when the technique of gingival conditioning by compression can be used in order to provide an appropriate gingival contour with papilla formation.

Should there be any bone or gingival deformities, the prognosis will be considered extremely unfavorable, even if the most modern restorative system has been selected. Additionally, even though methods for increasing the thickness of the ridge and the keratinized gingiva have been used,⁶ and given that the success rate in interproximal areas is the same that is achieved in edentulous alveolar ridge areas or tooth free surfaces, Salama et al⁶ developed a classification that takes into account the degree of alveolar bone crest height resorption in esthetic areas:

» Class I: bone crest is present, 2 mm distant from the cemento-enamel junction, which results in a optimum prognosis.

» Class II: bone crest is present, 4 mm distant from the cemento-enamel junction, with a questionable prognosis.

» Class III: bone crest is present, 5 mm (or greater) distant from the cemento-enamel junction, which results in an unfavorable esthetically prognosis.

In another study, Phillips et al⁷ describe the need for appropriate bone support in order to preserve soft tissues. The authors report that, in cases with insufficient bone, bone graft or orthodontic manipulation must be included in the planning. Additionally, they advocate the use of surgical guide based on the waxing of the future crown in order to appropriately locate the implant on the three planes that must be considered (mesio-distal, buccolingual and apico-coronal). Moreover, they suggest that the implant platform in the vertical aspect (apico-coronal) be placed 3 mm apical to the marginal gingiva line or 2 mm from the cemento-enamel junction of adjacent teeth, so as to compensate the expected gingival retraction around the implant.

Distance between dental implants and between implants

Some researchers radiographically assessed marginal bone loss around Brånemark System implants and adjacent teeth.⁸ Fifty-eight adults with 71 prosthesis (47 of which had restorations with single implants, while 9 received two implants and 2 received three implants) were monitored for a period not greater than three years, after the crowns had been placed. The following aspects were considered: age, reason for bone loss, vertical relationship between the prosthesis and the teeth, distance between adjacent teeth, distance between the prosthesis and natural teeth, and the region in the mandible or the maxilla where implants were placed. The distances, the level of marginal bone around the implants as well as the dental surfaces were measured through enlarged and standardized intraoral radiographs. Before implant surgery was carried out, initial radiographs were taken in order to observe bone tissue height in relation to adjacent teeth. All 71 implants were monitored for a week after the prosthesis had been placed. Forty-one of them were observed for a year, while 30 of them were observed for three years. The results showed bone loss around the implants, with a mean value of 0.97 mm at the moment when the prostheses were being placed. After a year, such loss increased in 0.08 mm; and after three years, it increased in 0.32 mm. The highest rates of bone loss were observed for upper lateral incisors, whereas the lowest rates were observed for the molars. Furthermore, the results showed that there was marginal bone loss of teeth adjacent to implants during the interval between the pre-operative and crown placement phases. Such loss exceeded the loss occurring over the following years. A strong correlation between bone loss of adjacent teeth and the horizontal distance from the implants to the teeth was found. As distance decreased, bone loss increased, especially in the region of the upper incisors. It seems rather difficult to predict which individual conditions may have a greater risk of bone loss due to intra and inter individuals' variations.

A longitudinal study was conducted on 36 patients with adjacent implants and whose periapical radiographs were taken by means of the paralleling technique, using special positioners with the purpose of standardizing and making the study reproducible within at least one and not longer than three years after implant exposition. The radiographs were scanned and enlarged so that the measures from the bone crest to the implant surface as well as from the bone crest to a line drawn between the adjacent implant platforms could be taken. The samples were divided into two groups according to the distance between implant shoulders. The results showed that lateral bone loss was 1.34 mm on the mesial of the implant, and 1.40 mm on the distal of adjacent implants. Moreover, loss of bone crest at a distance of 3 mm was 0.45 mm, whereas at distances shorter than 3 mm, loss of bone crest was 1.04 mm. Thus, there should be enough space for the bone crest and, as a consequence, for the preservation of the best interproximal space. Therefore, it is suggested that implants with smaller diameters be used in esthetic areas,⁹ and that it is harder to maintain or create papillae between two adjacent implants than between an implant and a tooth.

Another study conducted by Gastaldo et al¹⁰ assessed the effects of vertical and horizontal distances between adjacent implants (group 1) and between an implant and a tooth (group 2) on the incidence of interproximal papilla. Forty-eight patients were included, of which 96 interproximal areas between implants and 80 implant-tooth areas were assessed, totalizing 176 interproximal areas. The areas presented fixed prostheses that had been installed for at least 18 months and for a period not greater than 6 years. Measurements were taken by means of a periodontal probe, with the implant shoulders and the root surface of adjacent teeth as reference. The papilla was visually assessed, and the distance from the contact point base to the bone crest (D1), the tooth-implant distance or the distance between implants (D2) and the distance from the contact point base to the end of the papilla (D3) were measured. The

authors concluded that, in both groups, the papilla was often present when D2 was 3, 3.5 or 4 mm ($P < 0.05$); whereas it was always absent when D2 was 2 or 2.5 mm ($P < 0.05$). Additionally, in group 2, the papilla was often present when D1 was between 3 and 5 mm ($P < 0.05$). However, in group 1, the papilla was often present only when D1 was 3.0 mm ($P < 0.05$). For both groups, the analysis demonstrated that there was interaction between D1 and D2 (D2 < 2.5 mm papilla was absent, and with D2 > 3.0 mm there was interaction between D1 and D2). The ideal distance, from the base of the contact point with the bone crest, between adjacent implants was 3 mm, whereas between an implant and a tooth it ranged from 3 to 5 mm. Lateral spacing between implants and between a tooth and an implant ranged from 3 to 4 mm.

By carrying out an extensive literature review, Grunder et al¹¹ wrote an article that discusses the 3D bone-implant relationship and its influence over the esthetics of soft tissues around implants. The limiting factor for esthetic results of treatments performed with implants is the level of bone on the implant site. Clinicians should focus on the bone-implant 3D relationship in order to establish the basis for an ideal and harmonious situation in which the soft tissue will remain stable during a long period of time. With regard to papilla preservation, the following measures should be adopted: 2 mm between the implant and the tooth, 3 mm between implants, and distance greater than 3 mm between implants in the anterior region. Wide-platform implants are not recommended for the region of central incisors as they can cause esthetic problems in the prosthesis due to difficulties of keeping a minimum space of 2 mm between the implant and the buccal cortical, which leads to potential retraction of the peri-implant mucosal margin.

Distance from the contact point of the crown to the bone crest

The distance from the contact point of the crown to the bone crest determines the height and geometry of the space that will be filled by the soft tissue forming the gingival papilla.

Tarnow et al¹² observed the vertical relationship between the level of bone crest with natural teeth through probing and demonstrated the importance of such relationship for proper maintenance of soft tissues. They assessed the presence or absence of papilla in the interproximal region of 288 interdental areas of 30 patients. Should the space be visualized apically in relation to the contact point, the papilla was considered absent; should the space be completely filled, the papilla was considered present. When the distance between the contact point and the bone crest was 5 mm, papilla formation occurred in 100% of the cases; when the distance was 6 mm, it appeared in 56% of the cases; and when the distance was 7 mm, the papilla was present in 27% of the cases, or even absent. The authors concluded that the vertical distance from the base of the contact point to the bone crest is one of the factors responsible for the presence or absence of papilla.

Choquet et al¹³ conducted a clinical, photographic and radiographic retrospective that focused on the papilla around the implant-supported dental prostheses and their adjacent teeth. The authors assessed 26 patients who had received 27 implants in the anterior region of the maxilla. Six months after the implants had been placed, 17 of them were exposed to the oral environment by means of a standard technique, while 10 of them were exposed to the oral environment by means of a modified technique so as to favor papilla formation around the implants. The presence and/or absence of papillae was determined and the effects of the following variables were analyzed: the influence of the two surgical techniques employed in the second implant surgical phase; the vertical relationship between the height of the papilla and the bone crest present between the implant and the adjacent tooth; the vertical relationship between the level of papilla and the contact point between the crown over the implant and the adjacent tooth; and the distance from the contact point to the bone crest. The results demonstrated that when the distance from the contact point to the bone crest was 5 mm or less, the papilla was present in 100% of the cases; however, when the

distance was 6 mm, the papilla was present in 50% or less. The interproximal soft tissue height (distance between the bone crest and the papilla peak) was 3.85 mm. Additionally, a comparison between conventional and modified techniques revealed that the relationship changed from 3.77 mm to 4.01 mm, respectively. Based on the results obtained, the authors concluded that the bone crest influences the presence or absence of papilla between the implant and the tooth. Moreover, it also positively influences the modified surgical technique that aimed at reconstructing the papilla at the moment of implant reopening.

Tarnow et al¹ conducted a study in which the distance from the bone crest to the contact point between teeth was related to the presence or absence of papilla in the interproximal space. The authors assessed the height of the papilla in 136 areas between implants with prostheses that had been fixed for at least two months in 33 patients. Measurements were taken by means of a millimeter periodontal probe that was vertically positioned from the bone crest to the papilla height. When the distance from the contact point to the bone crest was 5 mm or less, the papilla filled the interdental space in nearly 100% of the cases; when the distance was 6 mm, the interdental space was filled in nearly 55% of the cases; whereas when it was 7 mm, the space was filled in 25% of the cases. Therefore, when planning to place two adjacent implants in an esthetic area, one should be aware that the height of soft tissues ranges from 2, 3 to 4 mm (with a mean value of 3.4 mm) and it is formed over the crest and between implants.

Above/below bone level positioning of implants

Hammerle et al¹⁴ clinically and radiographically observed the effect of implant placement below the bone crest in peri-implant hard and soft tissues in 11 patients who had received two implants in the same quadrant (test and control). Implant placement was carried out as follows: one implant was placed in compliance with the manufacturer's instructions (control), whereas the other one was placed so as the most

apical portion of the implant was approximately 1 mm below the alveolar bone crest. After 12 months, the authors concluded that bone crest resorption also occurred in the implants placed below the bone crest. Additionally, they also found that the bone underlying the polished surface of implants that were most deeply placed was lost over time (from a biological standpoint, the authors claim that it is not advisable to place implants below the bone crest, since this practice does not favor the formation of biological space).

Discussion

Dental implants are considered a highly predictable treatment option that is performed to replace lost teeth. They should offer function, esthetics and phonetics. For this purpose, the interproximal area must be intact due to the fact that the gingival papilla performs an important physiological function related to mastication and phonetics: for instance, the fact that it restrains the accumulation of food in the interproximal area and prevents air from escaping while some sounds are being pronounced.^{8,12,13}

Some authors even claim that the presence of an esthetically appropriate gingival papilla is determined more by a combination of previous anatomic factors than by the operator's skills and techniques.⁸ However, several studies demonstrate the influence of manipulation of soft tissue and implant placement techniques over papilla formation.^{6,15}

With regard to anatomic factors, Phillips et al⁷ and Tarnow et al¹⁶ describe the need for quantity and quality of soft and bone tissue, while Henriksson et al¹⁷ claims that the contour of soft tissues is not necessarily determined by the adjacent bone tissue. As for gingival biotype, Kan et al⁴ and Kois¹⁸ report that thick gingival tissues present a better prognosis when compared to thin gingival tissues.

Surgical techniques can affect the shape of the gingival papilla,⁴ thus, immediate implant atraumatic protocols should be developed not only to reduce the damage caused to soft

tissues, but also to preserve esthetics. Becker and Becker¹⁹ take the manipulation of soft tissues into account, and describe new methods for gingival flap that, according to the authors, minimize gingival recession. Other studies conducted by Choquet et al¹³ and Oliveira et al²⁰ describe a modified reopening technique that influences papilla maintenance, in which placing an appropriate provisional implant is essential to avoid the formation of "black holes". In these cases, the use of provisional implants may lead to gingival conditioning by means of three different techniques: gradual pressure, scarification or electrosurgery.

Three dimensions should be considered with regard to the techniques and procedures concerning implant bone status: mesiodistal, buccolingual and apico-coronal.^{7,11,16} It is on the basis of these dimensions that one should consider the adaptation of bone and soft tissues before surgery is performed. Some studies⁴ report, for instance, that the simultaneous removal of adjacent teeth causes the bone crest to collapse, which, as a result, leads to bone plate remodeling. According to Kois,⁵ bone plate remodeling is an important diagnostic factor for papilla formation.

As for the buccal palatal dimension, Grunder et al¹¹ claims that, according to the amount of bone available, the implant must be 2 mm from the vestibular cortical, whereas for Priest²¹ this distance must be 1 mm. This minimal thickness is required to avoid loss of bone height, since in cases in which bone height is not available, the vestibular bone plate will be lost during remodeling and, as a result, cause a high risk of soft tissue recession.

Several authors^{1,5,6,8,9,10,13} agree that the distance from the bone crest to the interdental contact point with or without interproximal gingival papilla effectively exerts a major influence over the dimensions of the gingival papilla, not only for natural dentition, but also for areas with implant restorations. The dimensions that have been suggested for the aforementioned height diverge: for some authors,¹² this

height must be equal or less than 5 mm between natural teeth as well as implants. Conversely, other authors^{9,13,22} claim that this dimension is also appropriate for rehabilitation with implants, since the soft tissue varies an average of 3.4 mm of tissue that is formed over the bone crest.

Many studies^{10,23,24} advocate that the contact point height must not exceed 6 mm. On the contrary, Henriksson and Jemt¹⁷ do not establish any relation between the papilla and the contact point. Their study yielded satisfactory esthetic results when the contact point was 6 mm from the bone crest.

Similarly, many authors tried to relate the distance between adjacent roots and implants, as well as between the implant platform and the axial wall of the adjacent tooth, with interproximal gingival papilla formation.^{8-1,17,21,23,24} Thus, given that the height of gingival papilla is basically supported by the formation of biological distances, it is expected that the gingival papilla have a more esthetically appropriate topography in teeth than it does in implants.¹ Thus, it is interesting that we search for studies that investigate the potential bone loss around implants.⁸ In cases of implants adjacent to natural teeth, nearly all authors consulted for the present research agree that the bone crest adjacent to the tooth is more determinant in gingival papilla formation in the proximal area than bone loss in the implant platform, which causes this papilla to be similar in height and topography to a gingival papilla between teeth.²²

Esposito et al⁸ report that when the distance between implants decreases, bone loss increases. Tarnow et al⁹ and Priest²¹ state that the minimal distance between implants should be 3 mm, while the implant-tooth minimal distance should be 2 mm. Conversely, Gastaldo et al¹⁰ claim that the distance between adjacent implants should be 3 mm, while the implant-tooth distance should range from 3 to 5 mm. On the other hand, for Degidi et al²³ distances greater than 4 mm causes more loss of vertical bone crest, while distances shorter than 2 mm causes more loss of lateral bone crest

and distances greater than 4 mm present lower frequency of papillae. Therefore, the authors recommend a distance that ranges from 2 to 4 mm. Tarnow et al¹ and Grunder et al¹¹ also found values of 2 mm for implant-tooth distances and 3 mm or greater for the distance between implants. However, on a study conducted with experimental implant geometry, Choi et al²⁵ did not find any significant differences in bone loss with distances of 2 and 5 mm. Nevertheless, the authors justify such fact by the use of experimental implants that could have been used in larger numbers on critical sites, given that this geometry would reduce marginal bone loss.

According to Scarano et al,²⁴ the clinical meaning resides in the fact that an increase in the loss of bone crest results in increase in the distance between the base of the contact points of adjacent implants and the bone crest, which can determine whether the papilla will be present between two implants. The findings by Gastaldo et al¹⁰ corroborate the aforementioned data. The authors claim that should the distance between implants be greater than 3 mm, the height of the contact point will exert greater influence over papilla formation. Furthermore, they report that when the interimplant distance is shorter than 3 mm, this interaction between factors does not occur. Similarly, Buser et al²⁶ claim that if the distance between teeth is too narrow and the contact point is high, the papilla does not fill the entire space. However, if the distance between teeth is large and/or the contact point is short, the papilla will fill the entire space; which corroborates the aforementioned interaction.

Studies^{14,26} conducted with non-submerged implants undergoing different surface treatments did not present any complications of bone loss or migration of soft tissue. Additionally, no differences between the above/bellow bone level positioning of implants were found. Nonetheless, Yi et al²⁷ and Hartman et al²⁸ found a higher rate of bone loss for below bone level implants.

In addition, the depth of attachment regarding soft tissues should be mentioned as well. Kan et al⁴ claim that the gingiva is what guides the depth of attachment (apico-coronal dimension). As for single implants, they should be apically placed 3 mm in relation to the most apical point of the cervical-buccal margin that is planned for restoration. Similarly, the studies conducted by Priest²¹ agree with the aforementioned assertion, having the gingiva as a guide to attain satisfactory esthetic results.

Based on this literature review, we reassert that implant placement should consider not only the highest bone height due to osseointegration, but also the appropriate space in order to yield satisfactory esthetic results. As for above/bellow bone level positioning, it did not prove to exert any influence over papilla formation. Furthermore, prosthetic rehabilitation should also be considered, particularly with regard to the contact point, given that this factor also proved to exert considerable influence over the occurrence of "black holes".

Conclusion

Based on the results of this literature review it is reasonable to conclude that:

- 1) The ideal tooth-implant distance is 2 mm, whereas the ideal distance between implants is 3 mm, due to the fact that the height of the gingival papilla is basically supported by the formation of biological space.
- 2) The above/bellow bone level positioning of implants did not present any differences with regard to papilla formation.
- 3) The distance from the contact point of the crown to the bone crest should have a mean value of 3.4 mm. Such height determines the space where the papilla will be, and the soft tissue will rarely fill dimensions with height greater than 5 mm.

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