Preservation of Peri-Implant Papilla: A Narrative Review

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Abstract

Beside osseointegration and restoration of function, the patient's subjective satisfaction with the esthetic result is a touchstone of the success of implant therapy. The long-term maintenance and reconstruction of papilla-like soft tissue between two adjacent implants in the esthetic zone which is esthetically satisfactory is generally regarded as a challenge. The road to success is much more complicated with implants, because of biologic and anatomical limitations of peri-implant tissues. Numerous techniques have been proposed to manage the hard and soft tissues in an attempt to achieve ideal esthetic results which includes surgical and nonsurgical techniques. The goal of reconstructive procedures is to provide peri-implant bone that supports and maintains gingival contours. An interdisciplinary approach has an obvious advantage of long-term preservation of a healthy peri-implant tissue which is of key importance in ensuring acceptable function and subjective satisfaction of esthetics of dental implants. A detailed literature search was performed in English language from 1986 to 2012, which included review articles, original research, as well as case reports. The search was performed in National Library of Medicine's PubMed database, Google Search, and Science Direct. A manual search of hard copies of available journal was also performed using interdental papilla, peri-implant papilla, esthetics, and dental implant as key words, in an attempt to gain insight into the limitations of papilla preservation, the factors which may potentially affect the maintenance and reconstruction of inter-implant papilla, and the contemporary methods to augment it.

Keywords
- dental implants
- peri-implant papilla
- interdental papilla

Introduction

In recent years, the perception and awareness of beauty and physical appearance has been on a constant rise. Today, in implant dentistry, patients not only expect a functionally sound restoration, but also demand an esthetically pleasing one. Gingival esthetics is a significant marker in the determination of success of restorations supported by implants. The loss of peri-implant papilla along with creating an esthetic obstacle also causes various problems such as food impaction and phonetics. Unesthetic spaces in the gingival embrasures or "black triangles" are considered as a failure of

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implant therapy according to the current treatment standards. Hence, the presence/absence of the implant papilla is an issue vital in decision-making process by the clinician to gain patient acceptance of the treatment.

Methodology

A thorough search was undertaken in literature which was available in the English language from 1985 to 2012, which constituted review articles, original research, as well as case reports. The search was performed in Google Scholar, Science Direct, and National Library of Medicine's PubMed database. Also, searches in hard copies of available journal were performed manually using interdental papilla, peri-implant papilla, esthetics, and dental implant as key words, in an attempt to gain insight into the limitations of papilla preservation, the factors which may potentially affect the maintenance and reconstruction of inter-implant papilla, and the contemporary methods to augment it.

Biology of Peri-Implant Mucosa

The most essential difference which separates a natural tooth and the osseointegrated implant is the absence of cementum and periodontal ligament in the latter. The peri-implant mucosa has higher proportions of collagen and lesser fibroblasts; the peri-implant mucosa may be considered akin to "scar-like tissue."[1] The absence of cementum leads to a vertical orientation of collagen fibers, which run along the length of implant surface. Additionally, in comparison to gingiva around natural tooth, peri-implant mucosa is not as well vascularized.

Biologic Width Dimensions of Teeth and Implants

The landmark study by Gargiulo et al[2] puts forth the average value for biologic width as 2.04 mm from the sulcus base to the bone crest; in which connective tissue attachment was said to be 1.07 and epithelial attachment was 0.97 mm on an average. Biologic width exhibits interindividual as well as intraindividual (tooth-to-tooth variation in the same individual) variation and is also influenced by the gingival biotype and implant concept.[3] The biologic width around an implant is approximately 3 mm with junctional epithelium consisting of 1.88 mm and connective tissue forming 1.05 mm; it varies from that around a natural tooth in dimension as well as the fact the junctional epithelium is longer when compared with that around a tooth.[4]

Anatomical Considerations in the Location of Biologic Width

Not only the dimension, but the location of biologic width is another important point of difference. Various studies on bone resorption around implants have revealed that resorption occurs only after exposure of implant to oral cavity. Bone remodeling proceeds till biologic width is established, and is usually positioned subcrestally. The subcrestally placed biologic width leads to loss of interproximal bone.

There are three situations which a clinician may be faced with:

(1) Two adjacent natural teeth: the biologic width is formed at a supracrestal location. The bone crest on an average is 1 mm away from the cementoenamel junction.[5]
(2) Implant adjacent to a natural tooth: in this scenario, on the tooth side the interdental papilla is preserved due to maintenance of levels of the bone at its initial level since it is undisturbed. The biologic width is formed supracrestally contrary to the implant site where the subcrestal sinking of implant causes formation of biologic width apical to implant-abutment junction.
(3) Two adjacent implants: this circumstance is the toughest to manage of the three possible. Loss of interproximal bone takes place due to two reasons. Primarily, the flat implant-abutment junction leads to an interproximal bone contour which is flat in comparison to from around natural teeth. This can be considered as a one-walled, making the bone augmentation procedures arduous.[6] Second, when separate implants are placed adjacent to within $\leq$ 3 mm of separation, the biologic width formed around implants is subcrestal and leads to angular defects with a vertical bone loss component of approximately 1.5 mm each. When this occurs, the interproximal bone is generally seen to resorb to the height of the interabutment junction, resulting in the elimination of inter-implant papilla.[7]

Potential Clinical Factors Affecting Peri-Implant Papilla

Crestal Bone Height

It has long been recognized that the underlying osseous morphology is the foundation of support of gingival tissue. The interdental space between the contact points of the teeth and an interdental embrasure which is occupied by the interdental papilla is a region where periodontal diseases and caries are likely to initiate. The contact point maintains stability of the dentition and prevents impaction of food into the interdental embrasure. Tarnow et al[8] landmark study on the effects of crestal bone to contact point distance on the dental papilla found that when less than or equal to 5 mm of distance between the crestal bone to contact almost always showed the presence of the papilla. According to Cho et al[9], decreases in papillary fill are inversely related to changes in interproximal distance between roots with an increase in distance between crest of bone and the contact point.

Single tooth implants are usually positioned close to the natural teeth and hence it is challenging to separate the gingiva, the peri-implant mucosa, and their combined effect on the peri-implant papilla. Choquet et al[10] performed a retrospective radiographic and clinical examination of the papillary levels adjacent to single implants and reported results similar to those observed by Tarnow et al; the regeneration of gingival papillae was found to be possible when the distance between contact point was less that of

5 mm from the crestal bone after single tooth implant placements. Above this the papilla regeneration is at least half but without predictability. Grunder studied the soft tissue stability around 10 anterior single implants in the maxilla. Papilla height was measured after 1 year of function and the results showed that all papillae around the implant regenerated after crowns were cemented if the bone crest levels on the adjacent teeth were 5 mm or less away from the contact point.[11]

The difficulty of papilla preservation seems to be more prevalent in the inter-implant region. Due to the implant biologic width being apical to implant-abutment connection, this creates difficulty as biologic width is always supracrestal in natural teeth. In a series of case reports, Elian et al[12] demonstrated that tissue heights of 5 mm between two adjacent implants are not routinely achievable. Note that 136 inter-implant papillary heights were examined in 33 patients; a 3.4-mm average (2–4 mm) height of soft tissue was found to cover the inter-implant bone crest on average. Tarnow et al[13] agreed with these findings.

Interproximal Distance

The effect of interproximal distance of soft and hard tissue appearance in the embrasure space has been studied. Heins and Wieder[14] in their study showed that very thin lamina dura was found to exist when the distance between adjacent roots was less than 0.5 mm. If this distance drops below 0.3 mm, thee crestal bone is lost, and the adjacent roots are leading to fusion of periodontal ligament spaces. Hence, teeth with closer roots develop crestal bone loss more often, which could eventually cause loss of papilla. Additionally, in a study by Tal vertical defects were found to occur only when there is a minimum of 1.5 mm interdental distance. Otherwise, recession of dental papilla occurs due to horizontal crestal bone loss.[15]

Gastaldo et al[16] investigated how interproximal papilla incidence was inter-implant and tooth to implant distances in horizontal and vertical directions. According to their findings, the ideal distance from the crestal bone to the base of the contact point between adjacent implants is 3 mm and between an implant and tooth was 3 to 5 mm. The ideal lateral spacing between two implants and tooth and an implant was found to be 3 to 4 mm. Further, they also proposed that when the lateral spacing is greater than 3 mm there is a correlation between horizontal and vertical distances.

In Tarnow et al's[7] study on 36 subjects with adjacent implants, they investigated the effect of distance between two implants on the height of crestal bone. Results revealed that lateral bone loss between adjacent implants between the mesial and distal implant shoulders was 1.34 and 1.40 mm, respectively. Furthermore, crestal bone loss was 0.45 mm for implant spacing greater than 3 mm, but 1.04 mm for implants with a spacing of less than 3 mm. They concluded that in addition to the vertical component of bone loss around implants, there also exists a horizontal component once the biologic width is formed. What is of clinical significance, is that when crestal bone loss is increased, the distance between the contact point of the adjacent crowns increases and this could determine the presence or absence of papilla between adjacent implants.

Tooth Form and Shape

Teeth can be categorized into triangular, square, and ovoid based on their shape. Tooth form has been distinguished as short, wide, long, or narrow. In natural dentition, tooth shape and form has been found to influence the gingival morphology.[17,18]

Note that 192 individuals with varying forms of upper central incisors were studied by Olsson and Lindhe[19] for their periodontal characteristics. Participants with narrow, long maxillary central incisors had increased buccal gingival recession than those with a wide, short incisors and probing attachment was significantly influenced by the crown width/crown length ratio and gingival recession on the buccal surfaces. Based on these observations, it appears that persons with narrow, long teeth have a thinner periodontal biotype and more prone to gingival recession than those with a thick biotype. In another study by Olsson et al,[20] it was reported that a long and narrow tooth forms had a narrow band of keratinized gingiva with thin free gingiva, prominent scalloping of the marginal gingiva, and a shallow probing depth.

Compared with triangular or ovoid-shaped teeth, square teeth have a potentially better esthetic outcome due to their longer interproximal contact and the lesser requirement of papilla to fill the space. Tapered/triangular shapes have a more coronally placed interproximal contact region, increasing the risk of recession in the inert proximal area, which results in a more pronounced interproximal black triangle.

For a predictable amount of gingival recession, the midbuccal margin should be at least 2 mm above the implant superstructure to prevent 0.6 mm of gingival recession annually.[21]

Gingival Biotype

Individual differences in width and thickness of gingiva in particular and thickness of masticatory mucosa in general are largely genetically determined and appear to be strongly associated with tooth form. Because of this mutual interdependence, careful consideration must be given to the surrounding soft tissue if and when tooth size or form has to be altered. Subjects with a narrow band of thin gingiva are more vulnerable to traumatic injury and tend to suffer from more gingival recession than subjects with thicker keratinized tissue.[22]

The two basic gingival architectures that exist are "scalloped thin" and "flat thick." In summary, plenty of empirical evidence supports the hypothesis that thick gingival tissue not only resists injury and subsequent gingival recession, but also improves papilla fill by supporting creeping attachment and decreases clinical inflammation, as well as resulting in predictable surgical outcomes.[23–27]

It has also been stated by Kan et al[28] that reestablishment of the implant papilla can be performed predictably to

normal levels when thick biotype is present but it is seldom achievable in thin periodontal biotypes.

Other Potential Factors

Other factors affecting the establishment of the papillary level around implants include—the amount of keratinized gingiva, type of gingival scallop, and relative tooth position.

Gingival scallop can be classified as flat, normal, and high. The flat architecture creates an osseous scallop such that there is less discrepancy interproximally than facially of the tissue coronal to the bone. As a result, there is increased predictability in the maintenance of the papilla due to reduced risk of interproximal tissue loss postextraction.[29]

The existing tooth position has an impact on the configuration of gingival architecture.[30] Thus, it is essential to evaluate the position of a hopeless tooth prior to its removal. For instance, teeth with diastemas have a thicker interproximal bone which reduces the chances of bone resorption postextraction. On the contrary, in teeth with root proximity, the interproximal bone is very thin; it is more prone to resorption after removal of tooth consequently leading to interproximal soft tissue loss. Hence, the preservation and regeneration of papilla around an implant is less likely.[29]

Much debate exists about the role of attached/keratinized gingiva around natural teeth. Lang and Löe[31] have suggested that to maintain gingival health, 2 mm of keratinized tissue with a minimum of 1 mm attached tissue is required. There are other authors, however, who maintain that it is patient's oral hygiene that is vital to optimize tissue health and not the amount of attached/keratinized gingiva.[32–34] There is a similar controversy with regard to keratinized/attached gingiva around implants. Block and Kent[35] did a prospective analysis to identify the factors associated with compromise of soft and hard tissues in endosseous implants. Of 239 mandibular implants, 141 implants with 1 to 2 mm of keratinized gingiva adjacent to the implant did not develop any significant bone loss. In 15 of these implants 2 mm or more of crestal bone loss was observed and had an increased correlation with soft tissue pockets $>$ 3 mm, bleeding on probing, and a lack of keratinized gingiva. They concluded that the presence of attached gingiva was strongly related to favorable gingival health and maintenance of bone in mandibular anterior region. In the anterior mandible, however, the absence of keratinized gingiva did not correlate with the bone loss.

The general consensus is that with adequate plaque control, the absence of sufficient width of attached/keratinized gingiva will not magnify the probability of recession or attachment loss. However, in case inflammation is present, the site with inadequate attached tissue is highly vulnerable to loss of attachment and progressive recession.[29] Current evidence also states the likelihood of plaque accumulation and gingival inflammation around dental implants is promoted in the absence of sufficient keratinized and attached tissue.[36]

Approaches toward Peri-Implant Preservation and Reconstruction

Maintaining an acceptable level of esthetics and function for dental implants requires long-term preservation of peri-implant tissue. Numerous techniques have been proposed over the past two decades to manage the hard and soft tissues in an attempt to achieve ideal esthetics results.

Presurgical Planning

Since the peri-implant papilla reconstruction is one of the most exacting aspects of implantology, the role of presurgical planning cannot be overemphasized. A few factors which should be considered during planning of implant therapy are quality and quantity of soft tissue and bone, periodontal biotype, biologic width, implant design and size, implant position, and emergence profile.[37,38]

Surgical management

Hard Tissue Management

Management of hard tissue is an important aspect of dental implant therapy. Bone resorption is the inevitable sequelae of tooth extraction; compromises optimal placement of implant and leads to undesirable esthetic outcome. According to Misch,[6] dense hydroxyapatite should be used in the crestal and interproximal area of the implant placement to increase the soft tissue height to the desired inter-implant/interdental papilla height. Autogenous ridge augmentation, distraction osteogenesis, and guided bone regeneration are some of the techniques by which ridge deficiencies can be managed.[39–41]

Bone resorption in the first 6 months after extraction progresses at a very rapid rate and may lead to loss of almost 3 to 4 mm of bone height leading to loss of papilla.[42] Prevention of loss of papilla altogether by preventing loss of underlying bone after tooth removal is the most effective way to recreate papilla. Atraumatic extraction should be performed by using periotomes and forceps rotations and then maintaining socket space with bone substitutes. In case of multiple anterior teeth which are indicated for extraction, extraction of all teeth concurrently leads to collapse of buccal bone followed by recession. In such a scenario, atraumatic extraction of every other tooth can be practiced followed by immediate provisionalization. This helps maintain the height and contour of the bone on the tooth side while the other side is going through healing phase. The adjacent tooth also serves as a guide for placement of implant.[43,44]

Immediate placement of dental implant is a feasible treatment option for selected cases of anterior maxillary tooth replacement. Kan et al[45] evaluated 35 patients for esthetic outcomes and success of maxillary anterior single implants which were immediately placed and provisionalized. This method helped minimize average marginal bone loss and thus improve success rate of the implant and provide desirable esthetic outcome.[5,45,46]

One suggested treatment option for enhancement of implant esthetics is flapless implant surgery. This approach has some significant advantages over the conventional approach; reduced time for surgery, decreased bleeding intraoperatively, and reduced postoperative discomfort, minimal soft tissue inflammation crestal bone level changes and probing depth around implants.[47]

Oh et al[48] performed a randomized control trial to assess flapless surgery and its effect on soft tissue profile where an endosseous implant via flapless surgery was placed each in of the 24 subjects. Stability of the soft tissue profile was noted up to 6 months in both groups (immediate and delayed loading) without any significant differences. After immediate loading, creeping attachment was observed to occur within 2 months. Study results indicate that flapless implant placement results in esthetic outcomes of the soft tissues for single dental implants which are loaded either immediately or delayed.

Froum and Khouly in their study to assess the survival rate and with two implant placement methods, soft tissue and bone levels change around one-piece dental implants, flap and flapless, found no difference in success and survival rates at a follow-up period of 8.5 years between the two groups. Neither the probing pocket depths nor the bleeding on probing were statistically significantly different between both the groups.[49]

Another method to reduce the crestal bone loss and subsequent papilla loss is the use of Morse taper connection with platform-switching as it has been found to be impervious to bacterial colonization.[50]

Soft Tissue Management

Soft tissue contour, form, and color around implants should be in harmony with the adjacent tissues to achieve a pleasing esthetic result. Literature presents with two basic approaches to manage soft tissue around implants. The first approach involves use of specific surgical techniques or flap designs to preserve the papilla postsurgical procedures.[51] The second approach makes use of different techniques of grafting to ensure papilla fill. The inadequacy of blood supply, however, coupled with the complexity of handling the papillary soft tissues, limits the efficiency of these techniques.

The papilla preservation technique was introduced by Takei et al[51] for use in cases of multiple teeth to enhance the interproximal papilla. Over the years modifications of this technique have been proposed to achieve the best possible results.[47,52–54]

Other flap designs involve manipulating tissue thereby ensuring that blood supply is preserved to the peri-implant papilla and that minimal recession is observed in the esthetic zone. Gomez-Roman[55] compared a widely mobilized flap with a limited flap that protected the papilla. In a 1-year follow-up, a limited flap design caused a less pronounced bone loss (0.29 mm) than a widely mobilized flap that included the papilla (1.12 mm). Flanagan[56] advocated a flap design in which the gingiva could be lifted off without disruption of the periosteum to preserve blood supply and improve formation of inter-implant papilla.

Various techniques for the surgical reconstruction when a soft tissue deficit is present have been described. These are based on the traditional approaches used during plastic surgery such as subepithelial connective tissue graft (sCTG). A unique technique was described by Palacci[57] by creating a semilunar beveled incision, a pedicle is then rotated 90 degrees to form a new implant papilla.[47] Misch et al[58] suggested use of "split-finger" design of surgical incision to enhance papilla formation. Other techniques which have been promising are vascularized interposition periosteal connective tissue grafts, inlay and onlay soft tissue grafting to enhance the soft tissues.[59,60]

Though it is the gold standard for soft tissue augmentation, autologous sCTG is accompanied by certain limitations such as an additional surgical site and preoperative preparation before harvesting. Additionally, regardless of the surgical technique employed and the expertise of the operator, it requires a prolonged surgical duration and increased morbidity. Acellular dermal matrix has been demonstrated to be as effective as autologous soft tissue grafts in treating mucogingival defects in several studies.[61]

A meta-analysis by Thoma et al to assess the influence of soft tissue augmentation procedures in partially and fully edentulous patients on peri-implant health and disease, found that these procedures with autogenous grafts improved the health of the peri-implant tissues and allow for increased mucosal thickness with significantly less marginal bone loss and for increased amounts of keratinized mucosa with higher marginal bone levels and improvement of bleeding indices.[62]

In spite of all the colossal efforts made to preserve or regenerate the inter-implant papilla, the papilla loss may be seen, especially in thin, scalloped periodontium. None of these techniques offer predictability and only a handful guarantee long-term stability.

Nonsurgical Management

When all augmentation procedures for the hard and soft tissues prove to be unsuccessful and when the patient declines surgical interventions, the clinician needs to opt for other nonsurgical treatment modalities, which include hyaluronic acid injections, micronized acellular dermal grafts, repeated curettage, and orthodontic or restorative procedures. Multiple factors affect the treatment of papilla loss using filler materials, but clinical trials on humans have shown more promising results in the interdental rather than inter-implant papilla.[63]

Restorative/Prosthetic Treatment

Prosthetic/restorative reshaping, lengthening of the interproximal contact, or a more apical location of the contact are some of the ways to create an illusion of papilla fill in the interproximal region.

A proper emergence profile is vital not just for pleasing appearance but also for maintaining oral hygiene and gingival health. For replacement of single tooth, the use of ovate pontic aids in contouring the gingival embrasure and papillary height.[64] For edentulous ridges, the concept of cervical contouring can be followed. The contouring is done on a model and provisional prosthesis is fabricated using acrylic resin, which when cemented helps to create emergence profile which is desired by pressing on the tissues and allowing them to form according to the contour.[65]

Similarly, in cases of anterior immediate implant placement with immediate loading, where there is insufficient torque, customized abutment use improved the emergence profile by ensuring healthy peri-implant soft and hard tissues.[21,66]

Orthodontic Approach[67]

Orthodontic therapy has a significant role to play in developing the ideal implant site and offers the best esthetic outcome in various situations. The repositioning of teeth by orthodontic movement in cases of mesial drifting of adjacent teeth or to remedy the absence of papilla in presence of diastemas can be done effectively. Forced orthodontic extrusion should be considered when teeth are planned for extraction, to augment both soft and hard tissue profile. It increases the peri-implant papilla height providing better esthetics, also allows for more deposition of bone beneath the roots for future placement of implant and minimizes the need for bone grafting in future.

To promote bone formed at the apical and interproximal areas of the tooth, maintaining tooth position for a period of 3 to 6 months is highly crucial after orthodontic extrusion is completed at a rate not more than 1 to 2 mm per month.[62] The occlusal contacts must be gradually adjusted during this period of extrusion to avoid trauma.[21] Following this a crown-lengthening using flapless procedure may be required to overcome the recession of the facial soft tissue, to improve the esthetic outcome.[63,68]

Conclusion

Restoration of esthetics is as integral a part of implant therapy as is restoration of function. Despite the advances in field of implantology, preservation of peri-implant papilla is one of the most challenging aspects of implant dentistry.

Among all the contributing factors to the presence of peri-implant papilla, crestal bone levels play a major role. Various surgical techniques as well as modification of implant design such as the "platform-switching" concept have been put forward to preserve crestal bone. Despite various studies and case reports available in the literature, predictable maintenance of peri-implant papilla continues to remain a challenge. An interdisciplinary approach in treatment planning and execution can help overcome this situation. To substantiate the findings of the existing literature, further clinical trials and long-term studies are needed.

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Concepts	✓	✓	✓
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