Reconstruction of the Lost Interproximal Papilla—Presentation of Surgical and Nonsurgical Approaches

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Modern esthetic dentistry involves not only the restoration of lost teeth and their associated hard tissues, but increasingly the management and reconstruction of the encasing gingiva with adequate surgical techniques. The loss of interproximal dental papillae may cause functional, phonetic, and devastating esthetic problems. Complete and predictable restoration of lost interdental papillae remains one of the biggest challenges in periodontal reconstructive surgery. On reviewing the literature, publications involving surgical and nonsurgical techniques for papilla reconstruction are basically case presentations. Very little scientific data concerning long-term success and predictability of specific techniques has been published so far. Starting with facts about the anatomy and morphology of the interdental tissues, this article gives an overview of surgical and nonsurgical techniques to restore lost interproximal dental papillae. (Int J Periodontics Restorative Dent 1999; 19:395-406.)

In recent years clinicians’ and dentists’ esthetic demands in dentistry have increased rapidly, driven by an enhanced awareness of beauty and esthetics. The ultimate goal in modern restorative dentistry is to achieve “white” and “pink” esthetics in the esthetically important zones. “White esthetics” are the natural dentition or the restoration of dental hard tissues with suitable materials. With today’s advances in material science and the skills of dental technicians, the imitation of the natural tooth’s function and appearance has reached a very high level. “Pink esthetics” refer to the surrounding hard and soft tissues, which can enhance or diminish the esthetic result.

Restoration and maintenance of those tissues with adequate surgical and prosthetic techniques are a real challenge in modern esthetic dentistry. Mucogingival surgery covers only a small range of daily periodontal problems: the shallow vestibule, the aberrant frenulum, and limited width of attached gingiva.

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Modern periodontal plastic surgery includes a much broader range of treatment modalities. Treatment of marginal tissue recession, excessive gingival display, deficient ridges, ridge collapse, and esthetic defects around teeth and implants are some of the problems that have to be solved today. One of the most challenging and least predictable problems is the reconstruction of the lost interproximal papilla. The loss of papillae may cause functional and especially in the maxillary anterior region, phonetic and severe esthetic problems. In the past, the reconstruction of papillae was seen as a positive side effect that occurred coincidentally following plastic periodontal surgery. The interdental papilla, as a structure with minor blood supply, was left more or less untouched by clinicians. In the past, several case presentations have been published showing different surgical and prosthetic techniques to rebuild lost papillae. But no long-term results are available to recommend any particular technique over another for correcting lost interdental tissues completely and predictably.

Knowledge of the anatomy and morphology of the interproximal tissues is mandatory to understand and develop surgical approaches and treatment patterns and to allow the recommendation of a certain augmentation technique. This article gives an overview of the anatomic and morphologic aspects of the interproximal papilla and presents several techniques to restore the lost interproximal papilla between teeth and implants and in the pontic area.

**Anatomy and morphology of the interdental gingival papilla**

The fundamental task of gingival tissues is the protection of underlying anatomic structures from mechanical and biologic influences. The fact that teeth penetrate the oral mucosa makes special constructions necessary to provide protection at the point of weakness, the dentogingival junction.

Gingiva can be defined as the tissue extending externally from the gingival margin and the tip of the interdental papilla to the mucogingival junction, which separates the alveolar mucosa from the attached gingiva (Fig 1). It also includes the internal gingival connective tissue and dental alveolar fibers. Structurally, gingiva consists of epithelia (junctional and oral) and a collagenous lamina propria containing mainly fibers, vessels, and nerves. The gingival oral epithelium is keratinized. The junctional epithelium, with its attachment to the enamel located internally, extends apically from the gingival margin and, under clinically normal conditions, forms a shallow sulcus. Collagen fiber bundles of the gingival lamina propria, the so-called supragingival fiber apparatus, have been classified according to their main orientation. The main task of dentogingival, dentoperiosteal, alveologingival, and perosteogingival fiber groups is the attachment of gingiva to the tooth and to bony structures (Fig 2). Fibers of the circular, semicircular, transgingival, intercircular, intergingival, and transseptal bundles connect teeth to one another. Interpapillary fibers fix the vestibular papilla to the oral papilla. The architecture of this apparatus provides stability and protection for the teeth, the surrounding tissues, and their very sensitive interfacial structures.

It is an interesting fact that the junctional epithelium can, after removal, regenerate completely. Its cellular turnover rate is extraordinarily high. The junctional epithelium surrounds the erupted tooth like a collar, follows the cementoenamel junction, and is about 2 mm high and up to 100 μm thick. Under clinically healthy or slightly inflamed conditions a gingival sulcus of between 0.2 and 0.7 mm in depth develops. The base of the sulcus is formed by the free surface of the junctional epithelium. Interproximal fused junctional epithelia of adjacent teeth form the interdental col (discussed below).

The posterior and anterior superior alveolar and the major...
palatine arteries secure primary blood supply in the maxilla, and the inferior alveolar, buccal, sublingual, and mental arteries supply the mandible. The gingival vascularization derives from branches originating in the interdental septa, the periodontal ligament, and the oral mucosa.\textsuperscript{28} (Fig 2). Within the gingival lamina propria, terminal blood vessels form 2 networks: one is situated below the oral gingival epithelium and includes the gingival margin, and the other stretches along the junctional epithelium and is also termed the gingival plexus.\textsuperscript{23} The gingival plexus, rich in anastomoses, extends from the coronal to the apical termination of the junctional epithelium.\textsuperscript{19,22,23} The morphology of the interdental gingiva is determined by the adjacent teeth and underlying bone crest. If 2 adjacent teeth have contact and if the interdental papilla is defined as the gingival tissue extending from the incisal tip of the papilla to a line tangential to the gingival margins of those teeth, a healthy papilla reaches about halfway to the incisal edge.\textsuperscript{27} Normally the papillary area shows a high degree of stippling.\textsuperscript{29,30}

Until 1959 the interdental papilla was believed to have pyramidal contours with one peak. Cohen\textsuperscript{31} was the first to describe the papilla with 2 peaks, vestibulary and linguually, with a concave crest shaping the so-called col.\textsuperscript{31-34} This crest, which relates to the position and extension of the contact area of the adjacent teeth, is usually nonkeratinized or parakeratinized and covered with stratified squamous epithelium.\textsuperscript{35,36} The degree of keratinization of the col area can be modified with the use of interproximal stimulation\textsuperscript{37,38} and interproximal hygiene.\textsuperscript{39,40} Holmes\textsuperscript{35} showed in a clinical study that an excised interdental papilla does not regenerate completely to its original outline and height. This is contrary to a study published by Kohl and Zander\textsuperscript{41} on monkeys. The vestibular peak of the interdental papilla extends more coronally than the lingual one. The distance between those peaks ranges between 2 and 6 mm and the depth of the col

\textbf{Fig 1} Gingiva is the tissue extending externally from the gingival margin and the tip of the interdental papilla to the mucogingival junction.

\textbf{Fig 2} Left, dentogingival, dentoepiosteal, alveologingival, and periosteogingival fiber groups provide attachment of gingiva to the teeth and to bony structures. Right, the gingival vascularization is derived from branches originating in the interdental septa, the periodontal ligament, and the oral mucosa.
ranges between 0.3 and 1.5 mm. Both parameters increase from anterior to posterior regions. Interpapillary fibers connect both peaks. Like the vestibular and oral parts, the interproximal gingiva normally extends about 2 mm coronal to the cementoenamel junction, parallel to the crest of the alveolar bone. An interdental papilla is deemed present when it fills the interdental space up to the contact point. The contact point, which is the result of the emergence profile and the line angle form, is located between the maxillary central incisors in the incisal third of the labial aspect, between the central and lateral incisor in the middle, and between the lateral incisor and the canine in the apical third. This means that the most visible papilla—the one located between the maxillary central incisors—fills up more space than others; its absence causes more obvious esthetic problems and it is therefore the most difficult to rebuild. According to the definitions mentioned above, the interdental papilla is always deemed missing in cases of diastemata or non-contact of adjacent teeth. In those cases, the interproximal gingival tissue also shows a higher degree of keratinization.

To determine whether the distance from the base of the contact area to the crest of bone could be correlated with the presence or absence of the interproximal papilla, Tarnow et al. examined 288 interproximal sites in humans. The results of this pioneering study 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. When the distance was 6 mm, the papilla was still present in 56%, but when the distance was 7 mm or more the papilla was only present 27% of the time or less.

Biology of the periimplant mucosa

Most surgical papilla reconstruction techniques developed to treat interdental gingiva can be modified to handle the soft tissues surrounding implants, although significant differences between those tissues must be considered. At first sight, gingiva and periimplant mucosa show strong similarities clinically and histologically. Because of the lack of cement-like structures on the implant surface, connective collagenous fibers of the mucosa around implants are oriented differently than those of the gingival fiber apparatus. In fact, they stretch parallel to the implant surface, originating in the crestal bone (Fig 3). Also, the junctional...
epithelium is longer—about double the size of that in healthy gingiva. Another important difference, which concerns the blood supply, is caused by the absence of the periodontal ligament and branches originating there (Fig 3). Because of its high amount of collagen and low number of fibroblasts, the periimplant mucosa can also be defined as a scar-like tissue.

Reconstruction of the lost interdental papilla

Most of the reconstructive techniques to rebuild lost interdental papillae focus on the maxillary anterior region, where esthetic defects appear interproximally as "black triangles." These are unacceptable for both the patient and the clinician. Phonetic problems and food impaction are other disadvantages. Causes for interdental tissue loss are, for example, common periodontal diseases, tooth extraction, excessive surgical periodontal treatment, and localized progressive gingival and periodontal diseases.

To avoid interproximal defects in the esthetically important zone, care should be taken when periodontal therapy is performed to eliminate inflammatory processes. This is also valid for nonsurgical procedures such as scaling and root planing. If surgical treatment is necessary, adequate flap designs are required to prevent extreme tissue loss and maintain natural gingival contours. Numerous techniques have been published using flap designs that leave interdental papillae connected to both the palatal and the labial flap or retained on one of the flaps, or that totally preserve the facial tissue.

Takei and coworkers recommended the papilla preservation flap technique that preserves the papilla completely but allows good access for root planing or bone-graft augmentation of osseous defects. A modified version of this surgical approach was described by Cortellini et al.

Nonsurgical papilla creation

If an interdental papilla is absent because of a diastema, orthodontic closure is the treatment of choice. "Creeping" papilla formation has been described by closing the interdental space and creating a contact area. In certain cases this formation can also be achieved with appropriate restorative techniques and alteration of the mesial contours of the adjacent teeth.

Distally angulated roots of central incisors in contact may be another indication for orthodontic treatment. By repositioning these roots and reshaping the mesial contours of the teeth, the contact point can be located more apically and the embrasure reduced, changing the interdental papilla in a positive way.

In various case reports Ingber and coworkers showed tremendous achievements in the management of gingival deformities by using forced eruption. Ingber described forced eruption as an orthodontic process: a tooth is moved coronally through application of a gentle and continuous force using orthodontic appliances. The effects are alterations within the supporting structures, causing changes in the bone level and the soft tissue contours and thereby creating new papillae, ideally.

A noninvasive treatment to recreate papillae destroyed after acute necrotizing ulcerative gingivitis was presented by Shapiro. Periodically repeated scaling, root planing, and curettage during 3 months induced proliferation of gingival tissue caused by inflammatory hyperplasia. About 9 months after initial treatment, regeneration of the interdental papilla was observed. Some papillae showed complete regeneration, while others did not respond to the periodic curettage, making more invasive techniques unavoidable.

Recently, Jemt observed tissue reaction similar to Shapiro's findings around implants. In a pilot study of retrospective material, the size of interproximal dental papillae adjacent to single-implant restorations was followed for 1 to 3 years. The results indicated that papillae regenerate to some extent without any clinical manipulation. At the time of
follow-up, 58% of the tested papillae had recovered completely. Jemt explains this spontaneous recovery as maturation and reorganization of previously inflamed hyperplastic tissue caused by plaque accumulation. This interesting finding raises the question of whether the fundamental demand of a certain distance from the bone crest to the interproximal contact point to affirm the presence of a papilla—shown by Tarnow et al—^is also valid for the periimplant soft tissue that resembles scar tissue more than healthy gingiva.

Another attempt to regain lost papillae securely but noninvasively is the local engorgement of the interdental soft tissue. This might be possible by injection or implantation of materials used in modern plastic surgery.

Surgical papilla reconstruction

As explained above, the interdental papilla is a small area with minor blood supply. This seems to be the major limiting factor in all surgical reconstructive and augmentation techniques. Most surgical methods published involve gingival grafting; however, only limited success because of insufficient blood supply.

In a case report, Beagle described a technique using a pedicle flap between the 2 central incisors without any graft. Basically, he combined the roll technique reported by Abrams with Evian et al.'s papilla preservation technique. First, a partial-thickness flap was dissected and labially elevated. Then, the thus-elongated papilla was folded on itself, resembling the roll technique for ridge augmentation. Adequate sutures were used to bind this "papilla" together and position it between the 2 incisors. A periodontal dressing for further support was applied from the palatal aspect only.

Techniques using pedicle flaps show clearly better results than techniques with free gingival grafts because sufficient blood supply is provided from the base of the pedicle. Further treatment developments include subepithelial connective tissue grafts to provide greater support of displaced gingival tissue flaps.

In 1996, Han and Take described a newly developed technique whereby the interdental papilla was displaced coronally and a subepithelial connective tissue graft packed underneath. Their technique is based on a flap design reported previously by Tarnow; the semilunar coronally repositioned flap. A crescent-shaped incision was made parallel to the free gingival margin of the facial tissue and the dissected flap was positioned coronally to cover a denuded root that was caused by gingival recession. In their modification for gingival papilla reconstruction, they recommended placing the semilunar incision in the interdental region to allow restoration of a lost interproximal papilla by placing a graft below the deficient area. According to the authors, this procedure might have to be repeated a second or third time after 2 to 3 months of healing, depending on the extent of papillary loss. This technique was applied in a patient who presented with an endosseous implant in the region of the maxillary right central incisor (Fig 4a). Both the mesial and the distal papillae were absent. After insertion of a provisional restoration, a slight improvement of the interdental situation was recognizable (Fig 4b). The proposed semilunar and intrasulcular incisions were performed to free the connective tissues from the root surfaces. This gingival-papillary unit could be displaced coronally. A subepithelial connective tissue graft of appropriate size was removed from the palate (Fig 4c) and packed into the dead space created by the displacement. The gain in interdental tissue was obvious directly after wound closure (Fig 4d) and also after healing periods of 3 (Fig 4e) and 4 months (Fig 4f).

Tarnow et al showed that the presence of the papilla is dependent on the distance between the bone crest and the contact point of 2 adjacent teeth and should ideally be about 5 mm. This leads to the conclusion that guided regeneration of the underlying bone results in complete reconstruction of a lost
Fig 4a  Patient presents with an endosseous implant in the region of the maxillary right central incisor. Both the mesial and the distal papillae are absent.

Fig 4b  Slight improvement of the interdental situation is achieved by the insertion of a provisional restoration.

Fig 4c  Subepithelial connective tissue graft of appropriate size is removed from the palate.

Fig 4d  Semilunar and intrasulcular incisions are performed, the gingival-papillary unit is displaced coronally, and the graft is stuffed into the space created underneath. Frontal view of the situation directly after wound closure.

Fig 4e  Close-up view of the clinical situation after a healing period of 3 months after removing the temporary restoration.

Fig 4f  Frontal view of the final situation 4 months postoperative. The right central incisor has been restored with an implant-supported PFM crown.

interproximal papilla. In fact, guided bone regeneration in interdental areas is a major problem. One reason may be the fact that with bone regenerative techniques and materials primary and secure wound closure is necessary, but is hampered by the deficiency of tissue in the papilla region. Reduced blood supply and fragility of this tissue add to the difficulties. New methods and advanced flap designs have been proposed to solve this problem.

The combination of a new flap design on the facial aspect of the defect, described by Hürzeler and Weng,25 and the coronally positioned palatal sliding flap on the lingual aspect, published by Tinti and Parma-Benfenati,26 might be an answer to handle the delicate interdental tissue and cover augmentation materials completely and securely. If indicated, an infracrestal and supracrestal bone defect might be filled with bone grafting material and covered with a bioresorbable barrier membrane fixed with bioresorbable pins. The use of bioresorbable devices eliminates the need for a second surgical procedure for removal of the barrier membrane. Afterward the flaps should be readapted coronally without any tension. The 2 flap designs mentioned above allow...
suturing of the interproximal area in 3 different layers.⁷⁵ The deepest layer needs to be sutured with a biodegradable suture material. The other layers should be sutured with a nonresorbable material to avoid additional inflammatory reaction of the tissue. When suturing in 3 or 4 layers it is mandatory to use microsurgical suturing techniques. The use of # 4-0 or 5-0 sutures would add too much suture material to the interproximal area and could cause necrosis of the papillae. Therefore, # 7-0 or 8-0 sutures should be used to re-adapt the buccal and lingual flaps in a more coronal position. With the combination of advanced techniques, the problem in reconstructing the interproximal area seems to be more related to the barrier technology than to soft tissue management. New flap designs, surgical approaches, and suture materials allow interproximal tissues to be kept closely adapted in the interproximal areas postoperatively.

In cases of severe periodontal breakdown with great tissue loss and gingival margins at the same level interdentally as orally and vestibularly, the apically repositioned flap⁷⁷,⁷⁸ may be a possibility to create an esthetically acceptable gingival contour. The crestal bone has to be recontoured through osteoplasty, following its natural morphology. Because of the thinning of the clinical crown that accompanies this technique, it might be necessary to shorten the incisal edges of the affected teeth. Papillae will not regenerate, but the esthetic appearance might be clearly enhanced.

**Prosthetic solutions**

The presence of an interdental papilla depends on the distance between the crest of bone and the interproximal contact point, allowing it to fill interdental spaces with soft tissue by altering the mesial contours of the adjacent teeth and positioning the contact point more apically. In a clinical case where a mesial diastema and short clinical crowns were compromising the patient’s esthetic appearance, this treatment pattern was followed (Fig 5a). The maxillary canines and incisors were prosthetically restored using porcelain-fused-to-metal (PFM) crowns. By recontouring the shape and outlines of the prosthetic restorations, the interproximal spaces were closed and a natural gingival contour, including interdental papillae, was achieved (Fig 5b).

The interdental tissue can also be conditioned with the use of provisional crowns prior to the definitive restoration, refined successively to induce creeping papilla formation. If all other procedures are contraindicated or fail, prosthetic solutions have to be considered as the last possibility to rebuild lost interdental papillae. Interdental spaces can be filled using pink-colored resin or porcelain.³³

Figure 6 demonstrates a case in which a patient was provided with a PFM fixed partial denture from the maxillary right lateral...
incisor to the left canine. The missing papillae in the pontic area were imitated with pink-colored porcelain. Dental technicians’ skills and knowledge are challenged in cases like this. Different shades of pink ceramic materials are mandatory to achieve esthetically satisfying results. Very often, however, esthetics and oral hygiene are compromised by these prosthetic solutions. In severe cases, the use of a removable gingival mask might be the last opportunity to hide severe tissue defects.

A 26-year-old female patient who lost all maxillary incisors and their associated hard and soft tissues in a car accident received 3 implants in the edentulous area and was referred to the authors’ department for further treatment. The disadvantages in this case were the unfavorable implant position—too far palatal—and the fact that the alveolar defect had not been augmented previously with bone or soft tissue grafts. An implant-supported PFM fixed partial denture was manufactured. The missing hard and soft tissues were restored by a removable, precision attachment-retained acrylic gingival veneer. A metal framework of high-noble gold alloy was used to support the individually colored pink resin. Figure 7a shows the clinical situation after insertion of the final PFM prosthesis. The severe alveolar defect is obvious. The situation after insertion of the gingival epistle is shown in Fig 7b. The integrated precision attachment offers good retention, yet allows easy removal of the gingival veneer for oral hygiene.
Conclusion

Rebuilding of pink esthetics, the frame-like gingival and peri-implant tissues, becomes more of an issue in modern esthetic dentistry, parallel to patients’ and clinicians’ enhanced esthetic awareness and dental technicians’ skills. The absence of the interproximal papillae may cause devastating esthetic, functional, and phonetic problems.

Anatomic and morphologic characteristics of the interproximal gingival and periimplant tissues are very well known and scientifically documented. The interdental papilla could be defined as a very small and fragile tissue with minor blood supply that demands sensitive handling. Clinicians from different disciplines including periodontics, orthodontics, and periodontal plastic surgery have described various treatment plans and techniques to restore the deficient papilla, but none of them seems to be sufficient to regain the lost interproximal tissue completely and predictably. Most of the articles published to date are case presentations containing no scientific data about long-term results with specific techniques. A lot more scientific research and reliable data are needed to recommend certain techniques for use in private practice on a regular basis.

It seems that future surgical methods have to involve modern bone augmentation techniques to be more successful, based on the fact that the gingival contour follows the crestal bone and that the presence of the interproximal papilla is dependent on the distance between the bone crest and the interdental contact point. However, it has not yet been proven how valid these facts are for the scar-like soft tissue surrounding implant-supported restorations. At this point, the predictable restoration of the lost interdental papilla remains an unsolved problem.

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