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Reviving the Interdental Papilla: A Narrative Review of Various Treatment Modalities

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Abstract

The interproximal papilla is extremely important to dentists and patients, and its existence or absence is of major concern. The absence of a papilla can cause lateral food impaction, phonetic issues, and cosmetic defects ("black triangle disease"). The management of the interproximal space and the treatment of soft tissue abnormalities have been advocated using a variety of surgical and non-surgical procedures. Tissue volumizers, Orthodontic, prosthetic, and restorative non-surgical treatments alter the interproximal space, resulting in changes to soft tissue. The surgical procedure is intended to recontour, preserve, or repair the soft tissue between teeth and implants. This review categorizes numerous approaches to the literature.

Keywords: Aesthetics, Gingival Black Triangle, Interdental papilla, Periodontal Plastic Surgery.

Introduction

The interdental papilla is the portion of the gingiva that occupies the embrasure space beneath the contact point, it is an integral constituent of an aesthetic smile and its subsequent loss leads to the gingival black triangle (GBT). Preservation of the papilla in the gingival embrasures especially in the maxillary anterior esthetic zone is important. Interdental papillary deficiency or gingival black triangle is defined as the embrasures cervical to interproximal contact that is devoid of gingival tissue [1].

Morphologically, the papillae had initially been described by Cohen in 1959. Before this, the interproximal papilla was considered a gingival

characteristic with a pyramidal form that served as a deflection of interproximal food particles. It is now evident that the physiology of the papilla is more complex. It plays a crucial role in aesthetics in addition to serving as a biological barrier to preserve periodontal tissues. Nevertheless, it is crucial to preserve papillary integrity across all dental procedures and to reduce its elimination as much as feasible.[2]

Open gingival embrasures are more prevalent in the adult population, affecting 38% of adult orthodontic patients.[3] Open gingival embrasures affect 15% of the general adolescent population and 41.9% of patients treated for maxillary incisor crowding.[4] It is linked to periodontal disease, periodontal surgery, and orthognathic surgery, which may explain their increased occurrence in adulthood.[1]

If no appropriate action is taken when extracting the tooth, other neighbouring teeth will be lost, and the interproximal bony scallop will flatten. Implant-supported prostheses with poor interim plant papillae/black triangles may leave patients dissatisfied. To address this issue, modern procedures rely on reconstructing the alveolar ridge while preserving the surrounding soft tissue. Ridge preservation and socket-shield procedures are efficient in preventing ridge modification after tooth extraction, although guided tissue regeneration is the most often utilized approach for tissue restoration. Controlling and preserving the height and width of the hard tissue can assist improve the soft tissue's appearance.[5]

Papillary Anatomy and Morphology

The gingiva extends externally from the gingival margin and interdental papilla tip to the mucogingival junction.

Interdentally, the gingiva adapts to the shape, size, and position of adjacent teeth. Interdentally, the gingiva adapts to the shape, size, and position of the neighbouring teeth. Thus, the gingival interdental portion is wider between the premolars and molars and narrower between the anterior teeth in the vestibular/oral dimension. The interdental gingiva completely fills the interdental space in young persons, both orally and vestibular. The interdental gingival region forms a concave bridge, or col, between the oral papillae and vestibule, extending mid to the incisal edge.

This interdental col advances in buccolingual width from 2 to 6 mm and vertical depth from 0.3 to 1.5 mm anteroposteriorly.

The inter-dental gingiva is attached to the tooth by connective tissue and junctional epithelium (JE) (Gargiulo et al. 1961) and it is lined in a coronal position by sulcular epithelium (Schroeder & Listgarten 1997).

According to Fradeani, the distance between the roots can also impact on the presence or absence of an interdental papilla. According to the author, an inter-radicular distance of less than 0.3mm jeopardizes the presence of the proximal bone and is typically accompanied by the absence of interdental papilla.

A smile with gingival black spaces affects the aesthetic of the patient. Kokich (2005) observed that a gingival space larger than 3 mm is considered a visible aesthetically problem both for dentists and the general population.

This crest, which determines the position and extent of the contact point of the adjacent teeth, is nonkeratinized or parakeratinized and covered with stratified squamous epithelium. The most visible papilla, located on the upper central incisors, is filled with more space than the others, and its lack causes major aesthetic problems [6].

Factors Influencing Presence of Papilla

There are several parameters that influence the presence or absence of the papilla. They are as follows.

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Availability of underlying osseous support: Ochsenbein (1986) coined the term "positive architecture" to describe osseous crests that follow the contours of cementoenamel junctions and interproximal bones that are more coronal in position than radicular bones.[7]

In the study by Tarnow et al. (1992), When the alveolar bone was less than or equal to 5 mm from the contact site, the papilla was present 98% of the time, 56% of the time at 6 mm, and 27% of the time at 7 mm. [8]

Salama & Salama (1998) emphasized the idea that, in comparison to a flatter gingival scallop (4.1 mm vs. 2.1 mm), a more prominent gingival scallop had a greater level of the interdental bone. [9]

Cho et al (2006) discovered that the number of papillae filling the interproximal space increased with the distances between the contact point and the alveolar crest and the roots' interproximal distance. [10]

Periodontal biotype

Interdental papilla and osseous architecture morphologies can be divided into thin and thick periodontal biotypes. The friable nature of the thin periodontal biotype increases the likelihood of recession after periodontal or implant surgery and crown preparation. Due to thin tissue's fragility, meticulous handling is necessary to prevent recession and, as a result, the visibility of subgingivally positioned crown margins at the restoration/tooth interface. [9,11]

Periodontal bioforms

Periodontal bioforms are divided into high, regular, and flat gingival scallop morphologies. The interproximal bone is thin, and the interproximal gingival contour is approximately parallel to the underlying bone contour in a shallow scallop. The latter is preferable for implant therapy because The bone exhibits greater resilience against recession following surgery and maintains a consistent connection with the free gingival margin.[9]

When the scallop is prominent or high, the interproximal bone is broader; nonetheless, it is challenging to obtain aesthetically attractive outcomes following implant placement or restorative operations due to the disparity between the bone shape and the free gingival margin. (because of the possibility of a recession and the development of "black triangles"). Flat is preferable over pronounced and high-scallop. [9,11]

Contact points

The maxillary teeth's contact sites are crucial for achieving the optimum "pink aesthetics" in patients with a high smile line. The "5 mm rule", which was introduced by a study by Tarnow et al. claims that when the gingival embrasures are entirely filled by an interdental papilla, the contact point is no more than 5 mm from the interproximal osseous crest. For every 1 mm above 5 mm, the probability of being completely filled gradually drops to 50%. Teeth with square shapes and large contact points were less likely to produce "black triangles" than teeth with triangular shapes and narrow, more incisally located contact points. [12]

Tooth morphology

The form of the crown determines how the interdental papilla develops and takes shape. The three primary tooth shapes—circular, square, and triangular define the degree of the gingival scallop. The triangular teeth form a distinct scallop and are particularly susceptible to the so-called "black triangles", particularly in thin phenotype. In addition, triangular teeth have divergent roots and thicker interproximal bone than square teeth, which results in less vertical bone loss. Yet, due to a shorter interproximal distance from the osseous crest to the contact point, teeth that are more squarely shaped produce better interproximal papilla maintenance.[13]

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Factors which influence presence/absence of the inter-dental/inter-implant papilla [14]

Aspect	Measurement Range/Preference
Crestal Alveolar Bone Height	
Vertical	1.0–3.0 mm (Gargiulo et al. 1961)
	2.1–4.1 mm (Becker et al. 1997)
Horizontal	3.0 mm (Tal 1984)
Dimension of Interproximal Space	
	Natural Tooth: <5 mm (Tarnow et al. 1992)
	Single Implant: <5 mm (Choquet & Hermans 2001)
	Two Implants: <3.5 mm (Tarnow et al. 2003)
Soft Tissue Appearance	
	Flat is better than pronounced and high scallop (Salama et al. 1995, Kois 2001)
	Thick phenotype is better than thin phenotype (Kois 2001)
Minimal Buccal Plate Thickness	
	41.8 mm in anterior implant (Spray et al. 2000)
Contact Areas	
	Square is better than triangular (Kois 2001)

Etiological Factors for Papilla Absence

Studies are well-documented that the etiology of the gingival black triangle is multifaceted and diverse. Papillae dimension can be changed due to various reasons: [4,9,10.15,16]

1) Plaque-associated lesions
2) Traumatic dental hygiene practices
3) Unusual tooth morphology
4) Distance between teeth
5) Missing teeth
6) Absolute causes - Osseous surgery, Periodontal disease, Traumatic tooth extraction.
7) Relative causes - Increase in gingival embrasure caused by root divergence, Gingival phenotype (e.g. thin versus thick).
8) Incorrect restoration contours

Classification System for Loss of Papillary Height.

Nordland and Tarnow (1998) [17]

Normal: The interdental papilla fills embrasures space apical to the interdental contact point/area.

Class I: The tip of the interdental papilla lies between the interdental contact point and the most coronal extent of the interproximal CEJ (space present but inter proximal CEJ is not visible).

Class II: The tip of the interdental papilla lies at or apical to interproximal CEJ but coronal to the apical extent of facial CEJ (interproximal CEJ visible).

Class III: The tip of the interdental papilla lies level with or apical to the facial CEJ.

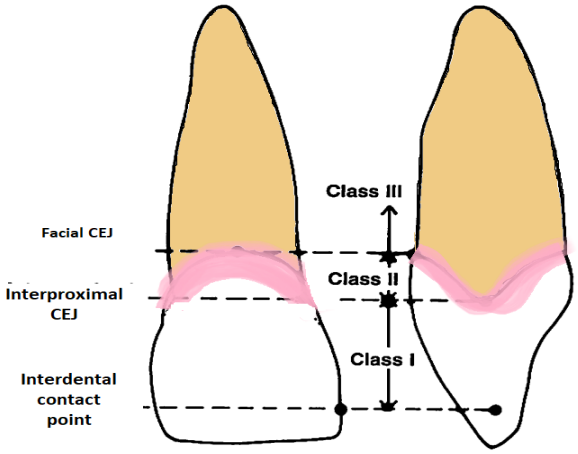

Figure 1

Nemcovsky (2001) [18]

Introduced classification system as a papillae index score (PIS) based on a comparison with adjacent teeth:

PIS 0: Papilla not present and no curvature of the soft tissue contour.

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PIS 1: Present papillae height less than half the height of the papilla in the proximal teeth and a convex curvature of the soft tissue contour.

PIS 2: Presence of at least half the height of the papilla in the proximal teeth, but not in complete harmony with the interdental papilla of the proximal teeth.

PIS 3: Papillae able to fill the interproximal embrasure to the same level as in the proximal teeth and in complete harmony with the adjacent papillae.

Papilla Presence Index (PPI)- Cardaropoli et al (2004) [19]

A classification scheme is proposed on the basis of the Positional relationship among the papilla, CEJ, and neighboring teeth.

PPI Score 1 - Papilla is completely present and completely filling embrasure and at the same level as adjacent papilla.

PPI Score 2 – Papilla is not completely filled embrasure, the level below adjacent papilla but interproximal CEJ is not visible.

PPI Score 3 – Papilla moved more apically and interproximal CEJ visible.

PPI Score 4 – Papilla lies more apical to both interproximal CEJ and buccal CEJ.

Treatment

Various efforts have been made to repair and restore the lost interproximal papilla. If the loss of papilla is solely due to soft tissue damage, reconstructive techniques can entirely restore it. Complete reconstruction is typically not possible if interdental papilla loss is brought on by severe periodontal disease with interproximal bone resorption. In periodontal literature, many surgical and non-surgical methods are suggested to achieve adequate interdental reconstruction.

Non-Surgical Techniques

A. Traumatic Oral Hygiene Procedure Correction

Brush abrasion damages supporting gingival tissues wear down the cement and enamel and can result in papilla loss and recession. According to a study by Addy and Hunter (2003) [20], excessive or abusive brushing or force can seriously injure the gingival tissues whether it is done manually or with a power toothbrush.

To enable re-epithelialization and the repair of papilla, these stressful oral hygiene practices should be quickly detected and stopped. To lessen gingival abrasion, flat trim toothbrush bristles, filaments with rounded ends, and interdental cleaners with rubber bristles are advised.

The interdental papilla can be damaged if dental floss is used incorrectly. Traumatic interproximal hygiene measures should be stopped first and then gradually changed. The papilla can be fully restored by re-epithelializing the traumatic lesion.[20]

B. Repeated Curettage of the papilla

A proliferative hyperplastic inflammatory response of the papilla is brought on by repeated curettage performed every 15 days for three months to replace papillae lost by necrotizing gingivitis. Interdental papillae regeneration was seen about nine months following the original course of therapy. While some papillae completely regenerated, others did not, even after repeated curettage. .[21]

C. Restorative and Prosthetic Approach

The vertical aspect of the defect, which includes both the papilla and gingival margin levels, it is a crucial factor in alveolar ridge recession. Pink composite resin This was indicated to restore gingival architecture and guide the shape of the interdental papilla, and it was a faster and less expensive alternative to surgery. The maxillary teeth were splinted after gingival restoration to limit movement and enhance prognosis, as advised (Strassler,

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2009) [22].

Challenges: Carefully assessed to prevent undue thickness which could cause plaque retention. Inflammation leads to subsequent aesthetic problems (Burke et al 1994; Tanaka et al 2008), The incorrect resin composition may result in wear, fracture, and limited success rate.[23]

Composite Veneer

The use of composite veneers can be a cost- and time-saving alternative to porcelain when indicated (Fahl, 2007; Dietschi and Devigus, 2011). Long-term (5-year) satisfaction with composite veneers has been reported (Zorba et al., 2010). In addition, both pink and white composite materials have been shown to have similar bond strength (An et al., 2011) [23].

D. Orthodontic Approaches

An orthodontic force is employed to establish an environment conducive to interdental papilla restoration and diastema closure. As a result of the interdental gap narrowing, the interdental papilla crawls toward the incisal direction.

By changing the distally angulating roots of adjacent teeth and reshaping and stripping the contact area of adjacent teeth, the contact point can be moved apically. Orthodontic closure of the interdental gap is achieved by bodily movement of the two neighboring teeth, reducing the diastema and creating a contact point between them. Proper diastema closure results in some coronal "creeping" of the interproximal gingival tissue. [16]

E. Hemolaser therapy

Photobiomodulation treatment (PBMT) was utilized to increase blood microcirculation, promote metabolic improvement, and stimulate fibroblastic activity in order to achieve healthy and stable gingival development in the long run.

Numerous studies have demonstrated how PBMT influences cells' capacity to proliferate, migrate, differentiate, and produce proteins and growth factors, all of which are required for tissue regeneration. These cell types include fibroblast, osteoblast, muscle, and endothelial cell cultures, among others.

PBMT bleeding in the gingival papilla area with loss or anatomical deformity of the papilla. To test this hypothesis, the authors gently provoked bleeding on the gingival margin of patients having black spaces in anterior teeth and applied PBMT with adequate parameters. The authors are interested in investigating the clinical cases presented, the effect of laser therapy on gingival papilla growth, and how the stem cells respond to such therapy.

Figure 2: Schematic drawing of laser application points in the three black triangles.

This treatment did not require local anaesthesia. Entailed using orthodontic drills to smooth the tooth-porcelain contact and remove surface debris between the gingiva and the tooth surface on Day 1. These drills encourage bleeding of the marginal gingiva but cannot harm the porcelain or the tooth.

PBMT is administered with a diode laser in two steps: right before (first PBMT) to stimulate local microcirculation and provide analgesia, and right after (second PBMT). Energy = 14 J before and 14 J after bleeding; 14 points per daily session, 2 J per point, 7 points dispersed in the center of the three defective

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papillae and in the cervical gingiva of each of the four upper incisors. Two sessions in total, with a one-week break in between. In order to maintain the health of the gingival and dental tissues, the dosage for each application site was selected based on the size of the incisors.

In the second session, the same technique is used, but instead of a clinical probe, gingival bleeding is created in the inner portion of the gingival sulcus, where the papilla should still be growing. Patients were instructed not to use tooth floss for a period of 24 hours following each session in order to protect the stimulated area.

Patients were instructed not to use tooth floss for a period of 24 hours following each session in order to protect the stimulated area.[24]

E. Tissue Volumizer

Hyaluronic acid (HA)

By scavenging reactive oxygen species, Hyaluronic Acid functions as an antioxidant and contributes to its anti-inflammatory properties. Following local anaesthesia, 0.1–0.2 mL of Hyaluronic Acid was injected as a single dosage; this may be done up to five times, or until the black triangles disappeared. Using an injectable hyaluronic gel, it is possible to improve papillae that do not completely cover the interdental space.

The injection of HA for the reconstruction of deficient papillae in the region of the upper and lower maxilla was a possible option treatment strategy in mild black triangles.[25]

Injectable-Platelet Rich Fibrin (i-PRF)

To obtain the i-PRF, 10 ml of blood from the antecubital area is taken into a plastic tube and centrifuged at 700 rpm for 3 minutes. The top yellow-orange liquid is collected, and roughly 1 cc of liquid is procured. The i-PRF was loaded into insulin syringes and ready for usage at the determined position. It stays in a liquid condition for 10-15 minutes before creating a gel-like membrane, thus it is vital to inject it promptly.

Under topical anesthesia, the insulin syringe needle was inserted 2-3 mm apical to the papillary tip and directed coronally at a 45° angle. Following the injection, the papilla was gently massaged for one minute. Patients were recommended to use a soft toothbrush coronal to the gingival margin and avoid interdental aids. [26]

Surgical Techniques

Surgical approaches included following three treatment modalities.

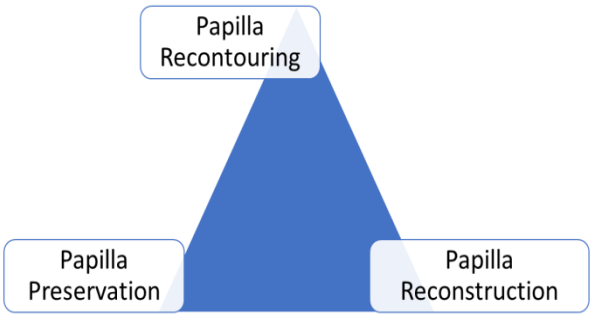

Figure 3

A. Conventional Papilla Preservation flap

Takei et al. (1985) [27] introduced the conventional papilla preservation technique. In order to ensure that the flap margin is away from the region to be grafted, the semilunar incision must be at least 3 mm apical to the margin of the interproximal bone defect. The semilunar incision is made with the scalpel perpendicular to the gingiva's outer surface and continues through the periosteum to the alveolar process. This avoids limiting the blood supply to the interdental papillae while also ensuring the maximal quantity of tissue interdentally.

The interdental flaps are reflected using a curette and/or an interproximal knife to separate the interdental papilla from the underlying hard tissues. The full-thickness flap is reflected. Small back-action chisels scrape the flap's margin, including the interdental tissue, until

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firm connective tissue appears. Excess granulation tissue is removed from the underside of the interdental tissue with fine tissue scissors.

A cross mattress suture is inserted prior to graft insertion to prevent the graft from becoming dislodged during the suture technique. The defect is filled with graft material, and a flap is placed over the graft.

B. Modified Papilla Preservation Technique

Cortellini et al. (1995) [28] developed a new modification on the conventional papilla preservation flap. It became known as the Minimally Invasive Surgical Technique.

A modified papilla preservation approach was employed throughout the surgical procedure to enable coronal positioning of the interdental tissue. A buccal and interproximal intrasulcular primary incision was made into the alveolar crest, followed by a horizontal incision in the buccal gingiva of the interdental region at the base of the papilla. A full-thickness buccal flap was elevated to the level of the buccal alveolar crest, followed by a buccal horizontal incision in the interproximal supracrestal connective tissue for splitting the papilla.

The papilla was elevated towards the palatal aspect, and a full-thickness palatal flap was then raised to display the interproximal defect. Vertical releasing incisions were carried out in the interproximal areas mesial and distal to the teeth next to the defect to allow the buccal flap to be positioned coronally. The buccal flap was subsequently released by a split-thickness incision. An interproximal titanium-reinforced Teflon membrane was modified and placed supracrestally as close to the CEJ as feasible.

Teflon sling sutures were used to anchor the membrane to the surrounding teeth, and the flaps were sutured to seal the interdental space and coronalize the buccal flap. A horizontal internal mattress suture was put between the base of the palatal papilla and the buccal flap, followed by a vertical internal mattress suture between the buccal aspect of the interproximal papilla and the buccal flap. Patients were encouraged to rinse twice daily with 0.2% chlorhexidine, practice modified oral hygiene, take tetracycline HCl four times per day, and have their teeth professionally cleaned once a week. The membranes were removed six weeks after surgery.

In 93% of patients, the modified papilla preservation approach resulted in full Teflon membrane covering and primary closure of the mucoperiosteal flap. This was achieved in sites where the barrier membranes were coronally positioned 4.5±1.6 mm above the alveolar crest. The rationale for developing this procedure was twofold: to protect the regenerating tissue, and to increase the amount of regeneration.

Primary closure in single-rooted teeth and lower molars without neighbouring teeth can be achieved using the modified papilla preservation approach. It is more difficult at sites with limited interproximal spacing and is not recommended in cases of insufficient vestibular depth.

C. Simple Papilla Preservation Technique

Simplified papilla preservation technique is suitable for narrow interdental spaces (≤2 mm) aspect. An oblique incision is made from the gingival margin at the buccal line angle of the affected tooth to the mid-interproximal area of the adjacent tooth's papilla along the defect-related papilla. The oblique incision is carried further intrasulcularly in the buccal side of the teeth close to the defect and expanded to partially divide the papillae of the adjoining interdental spaces, allowing for the elevation of a buccal flap with 2-3mm alveolar bone exposure.[29]

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Figure 4

D. Platelet Rich fibrin (PRF)

Platelet rich fibrin (PRF) is an autologous fibrin matrix that facilitates haemostasis, wound closure, and wound healing. As the fibrin matrix is resorbed, it releases its cytokines, PDGF, TGF-ß, and IGF-1, which promote healing. It has been shown to improve bone density and may be utilised as a membrane or in combination with a bone graft. It's not been utilised for interdental papilla; it's only been used for hard and soft tissue augmentation.

PRF was prepared using the guidelines established by Choukron et al. Using sterile 10 ml tubes and no anticoagulant, intravenous blood (from antecubital site) was collected and centrifuged for 10 minutes at 3000 revolutions per minute (about 400 × g). PRF settles between the platelet poor plasma (PPP) on top and the red blood cells (RBC) on the bottom of the tube.

Using sterile tweezers, the prepared PRF was obtained, trimmed with scissors, and placed onto sterile gauze. The serum in the PRF clot was extracted, yielding a thick fibrin membrane.

In the interdental area of 11, 12, 21, and 22, a split thickness semilunar incision was made approximately 1 mm coronal to the mucogingival junction. The split thickness flap extended to form a pouch in the interdental region by the semilunar incision towards the interdental papillae. To facilitate the gingiva-papillary unit's coronal displacement, a curette was employed around the necks of 11, 12, and 21 to release the tissue connection from the root surface.

The majority of the interdental papillae incisions were filled by gently pushing the PRF membrane into the pouch and coronally positioning it. Absorbable sutures were used to close the incisions, and a periodontal dressing covered the surgical site. There was little discomfort during the uncomplicated postoperative recovery. When the patient was reviewed on the tenth day, it was found that the interdental area had partially filled. The papilla fills the interproximal embrasure to the same level as the proximal teeth and is perfectly in harmony with the adjacent papillae.[30]

E. Autogenous osseous and connective tissue grafts

In periodontally involved patients, it is this loss of bone interdentally that lengthens this distance, creating the unpredictable status for papillary reconstruction. It is the interdental space between the maxillary central incisors that presents the most visible esthetic problem. This technique presents reducing the distance from the crest of bone to the contact by using an autogenous bone graft and subperiosteal connective tissue graft between the maxillary central incisors.

Preparation of patients includes PMPR and 30 sec 0.2% Chlorohexidine Gluconate preprocedural rinses. Exposed roots are planed under copious saline to remove bacterial accretions and root convexity.

The intrasulcular incision on the buccal and palatal aspects is made around the necks of the lateral and central incisors, preserving as much gingiva as feasible. A horizontal incision is created at the mucogingival junction, continuing into the alveolar mucosa and ascending to the labial vestibular fold. A mucoperiosteal flap is released at the apical portion of the split-thickness flap, allowing a more coronal positioning of the flap with minimal tension. The design of this incision is to maximize the blood supply to the flap from its lateral portions. The initial intrasulcular incision on the buccal

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and palatal aspects allows the detachment of the connective tissue from the root surface, while the papillae are kept intact and gently undermined. The entire gingivo-papillary unit is displaced coronally.

The mucogingival flap is elevated coronally and secured with a horizontal mattress suture anchored to the interdental contact point of the central incisors, exposing the interdental bone.

Several holes are drilled into the cortical bone to achieve a bleeding surface. The osseous graft is molded to create a saddle that fits over the interdental crest. The recipient site is perforated in the center portion with a small, 1-mm pilot drill to allow stable fixation of the bone graft with a titanium screw. The bone graft is placed on the recipient site, with the cancellous section in contact with the host bone's perforated cortical layer; it is secured with a titanium fixation screw. Crushed cancellous bone is placed around the grafted bone to form the reconstructed interdental bone.

A substantial amount of connective tissue graft from the palate is placed to the top of the bone graft to cover the entire augmented region. A vertical mattress suture is placed to secure the graft in the proper position at the crest. The contact between the central incisors is splinted at the incisal area using a composite. The mucosal portion of the flap is approximated to the gingiva-papillary edge of the flap and sutured using 4.0 silk sutures. Complete closure is obtained and healing is by primary intention. Primary soft tissue healing is essential during the entire healing period. The surgical site is not covered with a periodontal dressing. The patient is directed to rinse twice a day with 0.12% chlorhexidine gluconate, and antibiotics (2 gm per day) are given for 8 days.

The reason for failure may have been because of the type of bone used in the bone graft by the use of pure cortical bone removed from an exostosis Reasons for success can be attributed to the following principles to maximize blood supply to the graft site. The most predictable soft tissue grafting is achieved by the use of pedicle grafts because the blood supply is derived directly from the base of the mobilized flap. This principle, as well as submerging the grafted tissue (both bone and connective tissue) beneath the flap and the primary closure of the graft site, provides an environment of maximum blood supply to the grafted tissues.[31]

F. Whale's Tail Technique

Bianchi and Basseti first presented the Whale's Tail technique in 2009. This is a surgical approach that uses directed tissue regeneration to maintain interdental tissue. It is used to treat wide intrabony defects in the aesthetic zone by elevating a large flap from the buccal to the palatal side, allowing access and visibility of the intrabony defect and performing GTR while maintaining interdental tissue over the grafting material. The reflected flap resembles a whale's tail, thus the name Whales Tail method.[32]

G. Non-incised Papillae Surgical Approach

In 2018, the nonincised papillae surgical method NIPSA was proposed by Moreno Rodriguez & Caffesse. The basic principle of the technique was to place only buccal horizontal incisions at the mucosa, as apically as possible from periodontal defects and marginal tissues. The coronal elevation of a mucoperiosteal flap allowed apical access to the defect while preserving the marginal tissues intact. Meanwhile, the lingual soft tissues remained intact. The marginal soft tissues served as a roof, protecting the underlying interproximal deficiencies and preventing papilla collapse. It should be remembered that the intrabony flaws should be appropriately mapped and the horizontal incision should always be placed on the cortical bone.

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To accomplish wound closure while conserving blood clots, the flap may be readily stabilised on the associated marginal tissues. Better preservation of the blood flow in the interdental region was finally achieved by preserving a large volume of undamaged supracrestal soft tissue. This method reduced postoperative shrinking. Despite the fact that the supraperiosteal gingival vessels at the mucogingival junction were dissected, the nonincised gingival vessels revealed continuity with the periodontal ligament and a substantial lingual blood supply.[33]

H. Papilla regeneration by injectable stem cell therapy with regenerative medicine

Regenerative medicine (RM) is an emerging field that creates new tissue for repair or replacement, with the potential to overcome the limitations of conventional treatment. Mesenchymal stem cells (MSCs) have been used to regenerate tissues because they are easily separated from bone marrow or other anatomical areas using minimally invasive techniques, and they are self-replicating, and capable of replenishing tissue-forming cell supplies.

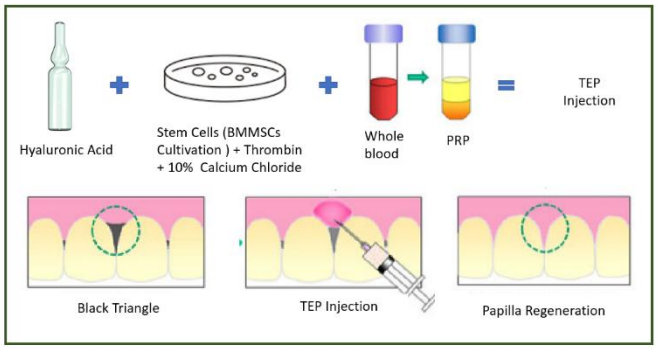

Figure 5

Preparation of platelet-rich plasma: The obtained blood was initially centrifuged at 1500 rpm for 10 minutes before the yellow plasma (containing the buffy coat) was removed. The second centrifugation was done at 3500 rpm for 5 minutes to unite the platelets with a single pellet. The resultant platelet pellet, buffy coat/plasma fraction (PRP), was resuspended in the residual plasma before to use in the platelet gel.

Preparation of bone marrow-derived mesenchymal stem cells (BMMSCs): BMMSCs were extracted from the patient's bone marrow aspirate using the published procedure (Yamada et al., 2008) [34]. Briefly, the control medium contains the following. Basal medium, low-glucose medium, 10% serum, L-glutamine, and penicillin-streptomycin combination Each patient could choose whether to use patient serum or fetal bovine serum (FBS) for BMMSC culture. Bone marrow aspirates in control media were collected, the medium was altered to eliminate non-adherent cells, and the adherent, spindle-shaped BMMSC population was employed. The cells were incubated at 37°C in a humid environment (95% air, 5% CO2).

Preparation and injection of injectable tissue-engineered papilla (TEP): Two syringes are filled with powdered human thrombin. BMMSCs were combined with PRP and hyaluronic acid in one syringe while the thrombin/calcium chloride combination was made in another. The two syringes were linked with a T connection and pushed and pulled alternately. Because thrombin influenced fibrin polymerization, the contents became gel-like within a few seconds, resulting in an intractable gel. The injection site was cleansed before being anaesthetized with 2% xylocaine adrenaline, and the TEP was injected into the aspect adjacent to the papilla using a needle with no incision.[34]

Interimplant papilla reconstruction at second-stage surgery Technique

A variety of surgical procedures have been proposed to generate the interimplant papilla structure, with the majority focusing on coronally modified flaps and subepithelial connective tissue grafts during implant placement. In contrast, this procedure proposes a

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strategy for interimplant papilla reconstruction at the second-stage surgery implementing modified pedicle flaps.

After 6 months of recovery, remove the interim restoration and polish the surrounding teeth. Use a diamond rotary instrument to remove the cuticular epithelium from the ridge above the implants. Make two semicircular incisions in the region where the cuticular epithelium was removed (Fig a). To form the new papilla, elevate the flaps and connect them together with an absorbable suture. (Fig b, c). Remove the cover screw. Make two interim restorations to accommodate the papilla after placing the abutments. Hold the papilla coronally to the interim repair with a nylon suture. After one month of healing, replace the teeth with permanent restorations.

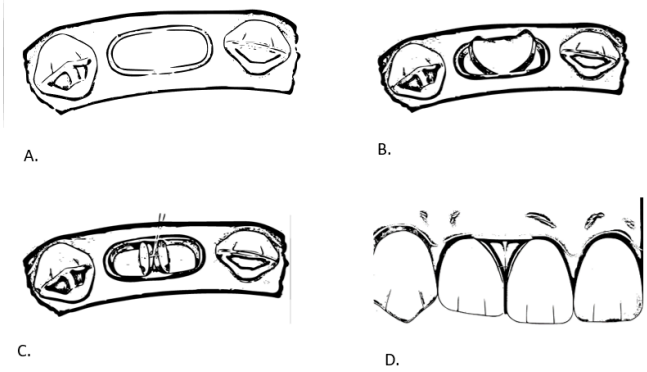

Figure 6: (a) Semicircular incision on ridge (b) Full-thickness flap elevated (c) Flaps tied together with absorbable suture (d) Newly formed papilla held to interim restoration

At the second stage of surgery, the suggested approach aids in the reconstruction of the interimplant papilla. Some important considerations for using this method include having adequate keratinized tissue since the cuticular epithelium within the flap region is completely eliminated during the second stage of surgery, allowing the two elevated flaps to heal together and form a new papilla. Second, the thin soft tissue phenotype may provide poor functional and aesthetic outcomes. Furthermore, the soft tissue between the two flaps should be maintained intact to ensure enough blood flow to the new papilla. 3 mm or greater mesial-distal space between the two implants allows for periosteum attachment during surgery and bone support for the papilla after healing.

The proximal profile of interim restorations should be sufficiently wide to accommodate the papilla, and a vertical suture is recommended to support the newly formed papilla. For patients with a resorbed alveolar ridge, bone-splitting and guided bone regeneration should be undertaken; however, this procedure does not treat vertical alveolar bone resorption.

The area was refilled with papilla, as seen at the 1-year follow-up. This result agrees with the statement reported by Tarnow et al that Bone level is the determinant for soft tissue thickness between 2 implants, and the vertical space from the alveolar crest to the apical part of the contact surface should be 5 mm or less to achieve long-term intact papilla.[5]

Conclusion

Surgical interventions, such as SPPT, MPPT, Whale's techniques have shown promising results, offering the advantage of precise manipulation and control over tissue regeneration. However, these procedures are not without drawbacks, often involving increased invasiveness, patient discomfort, and extended healing periods.

However, this exploration also highlights the need for further research and clinical studies to comprehensively assess the long-term efficacy and predictability of these techniques. Comparative studies evaluating different interventions across diverse patient populations and clinical scenarios would enhance our understanding of their relative strengths and limitations.

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In conclusion, interdental papilla regeneration presents an evolving landscape where Inter-disciplinary and Intra-disciplinary approaches such as surgical, non-surgical, orthodontic, restorative, Laser therapy yield better clinical outcomes. As our understanding deepens and technology advances, the synergy between these methods could potentially lead to breakthroughs in achieving consistent, predictable, and aesthetically pleasing outcomes for patients seeking interdental papilla restoration.

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