

Reconstruction of Lost Interdental Papilla: A Review of Nonsurgical Approaches

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Abstract Modern dentistry involves both functional and esthetic role. Interdental papilla loss results in Gingival Black Triangle (GBT), which is considered esthetically unacceptable. It is strongly associated with aging, periodontal disease and post orthodontic treatment. Reconstruction of the lost interdental papilla is difficult and challenging objective to be achieved, as it is strongly associated with the patient smile. Apart from its esthetic function, absence of interdental papilla raises concern over phonetic problems, food and plaque accumulation, which further deteriorate the present condition. Treatment for papilla loss involves correcting oral hygiene procedure, prosthetic restorations and tissue volumizing. Therefore, the present review discusses the different types of papilla loss classifications, etiology associated with open gingival embrasures and all currently available nonsurgical treatment modalities recommended for papilla preservation and reconstruction. It can be inferred that though a golden standard is not yet set to treat papilla loss, the usage of minimally invasive technique has a promising clinical potential in aesthetic reconstruction of lost interdental papilla.

Keywords- Open gingival embrasures, Gingival black triangle, Interdental papilla, Papilla reconstruction, Hyaluronic acid

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I. Introduction

Interdental papilla represents small visible area presents in-between a hard (teeth) and soft tissue (gingiva) of the oral cavity. Though anatomically small, it plays a huge role in face esthetics due to its strong association with the patient smile as a result of its anterior positioning. Gingival black triangles (GBTs) are cosmetic deformities which refer to an absence of papilla resulting in black spaces or open embrasures which impair esthetic features, phonetics problems and food accumulation [1-3]. In the absence of contact point or when papilla migrates apically due to inflammation, the col disappears leading to black, pyramidal shape formation [4]. GBT is highly prevalent among adult population and frequently encountered among adult (38% of 119 cases) [5] and adolescents patients (41.9% of 129 cases) [6]. According to a survey conducted by Kokich *et al.* [7], it was reported that orthodontists considered a 2 mm open gingival embrasure as less attractive and a similar study reported that both patients and dentist consider GBT about 3 mm to be less esthetic [1]. Irrespective of its functional role, growing public demands for esthetics, place huge pressure on modern clinical dentistry to restore any lost 'white' and 'pink' esthetics. White esthetics denotes natural teeth arrangement or restoration of lost dental tissues and pink refers to gingival tissues surrounding the teeth [2]. Harmony association of these soft tissues adjacent to teeth with minimal or no tissue deficiencies is key for stable dentition and to eliminate issues like dental caries [8].

Therefore, the main objective of periodontal therapy is to prevent progression of periodontal disease and associated trauma by regeneration of the lost periodontal tissues [8,9]. Though several surgical techniques have been constantly proposed and experimented, they are mostly invasive and unpredictable [10]. Moreover, the success rate of surgical augmentation of papilla relies on the thickness of gingiva biotype [11]. Hence, a number of nonsurgical, minimally invasive techniques has been developed to preserve and restore interdental papilla. Though many solutions have been proposed to correct lost interdental tissues, no golden standard technique is followed so far due to the absence of long-term clinical results and predictability. The present review discusses the various classification of papilla loss, etiology associated with GBT and currently available nonsurgical treatment modalities recommended for papilla preservation and reconstruction [2].

II. Etiology of Interdental Papilla Loss

From several studies it is well documented that etiology of interdental papilla is multifactorial [1,13]. Patients may present with one or more etiologic factor; thus, managing each patient requires an individual assessment and treatment plan. The major causes of interdental papilla loss are explained below;

3.1 Interproximal Space between Teeth

Interproximal space between teeth represents the distance between the proximal surfaces of the adjacent teeth. Horizontal dimensions of interdental space can affect the shape and maintenance of the interdental soft tissue [13]. While a greater width may enable improved blood supply to papillae tip, which may be helpful to maintain full papilla, a very wide interdental width increases the risk of the presence of a GBT possibly due to stretching the papilla [14]. Teeth with root proximity (less than 0.5 mm interdental distance) possess very thin bone [15]. In return, thin cancellous bone has a greater risk for resorption, decreasing the interproximal bone height and implicitly the papillary disappearance [16]. Martegani *et al.* [17] found that the radicular distance and the distance between the contact point and the alveolar crest have independent and combined effects on the presence or absence of the interdental papilla. In particular, when the interradicular distance was >2.4 mm, the distance of the bone crest from the contact point lost its influence on the presence or absence of the papilla. Cho *et al.* [4] measured the interdental space at the osseous crest during flap surgery. It was concluded that the number of papillae that filled the interproximal space decreased with the increasing interproximal distance of the roots. Also, when interdental distance at the bone crest surpasses 4mm, complete papillae fill should not be expected.

3.2 The Distance between Proximal Contact Point to Crest of Alveolar Bone

The most crucial factor for the loss of interdental papillae is the distance between interproximal contact point and alveolar bone crest. Study by Tarnow *et al.* [18] which determined the presence or absence of GBT by estimating the vertical distance, reported that papilla was present 98% when the vertical distance between contact point and crest of bone was ≤ 5 mm, when the distance was estimated to be more than 7 mm, the papilla was mostly missing (73%) and GBT noted. The study inferred that a 1mm increase in distance between interproximal contact position and crest of alveolar bone (6-7 mm), the chance of GBT occurrence increased by 78% to 97% respectively. Cho *et al.* [4] measured the distance between contact height to bone crest during a gingival flap procedure. It was found that the interproximal distance between roots and the distance between the contact point and the alveolar crest have an independent and combined effect on the existence of interproximal papilla.

3.3 Diverging Roots and Root Angulation

Root divergence of adjacent teeth is highly associated with open gingival embrasures. This either occurs naturally or is caused by improper bracket placement during orthodontic treatment. Bracket placements results in relaxation of stretched transeptal fibers which aids in filling the gap [12]. Prior bracket fixation it is important to radiographically review the positioning of the bracket which should be placed perpendicular to the tooth long axis and not parallel to the incisal edges of tooth. According to Kurth and Kokich [5] the mean root divergence in normal cases is assembled at 3.65° . However a 1° increase in angulation may increase the chance of GBT by 14% to 21%. Therefore, the severity of occurrence of open gingival embrasures in case of root angulation can be reduced by connecting the brackets in such a way it lies perpendicular to the tooth long axis which allowing root convergence without causing open embrasures. Burke *et al* [19] found that movement of crowded anterior teeth can separate the roots and stretch the interdental papilla, increasing the presence of GBTs between incisors after orthodontic treatment.

3.4 Traumatic Interproximal Oral Hygiene Procedures

There is sufficient evidence from literatures to prove that brushing is an efficient way of removing plaque and prevention of gingivitis and periodontitis [20,21]. However, its efficacy depends upon the physique and mental attitude of an individual, type of toothbrush, condition of the bristles [22]. Study by Rosema *et al.* [23] reported that a minimum of ≥ 1 mm of gingival recession was observed in 97.8% of the study population using both manual and power toothbrushes. It was found that gingival recession has been related to increased brushing frequency with a hard toothbrush [23]. Traumatic flossing may also contribute to open embrasures, in this case interproximal cleaning should be discontinued to allow tissue recovery [12].

3.5 Abnormal Crown Forms and Tooth Morphology

The basic tooth forms: circular, square or triangular, determine the degree of gingival scallop. Circular or square teeth produce a shallower gingival scallop, while triangular teeth form have a pronounced scallop. The latter predisposes to GBTs especially with a thin biotype which has a propensity for recession. Furthermore, triangular teeth have divergent roots with thicker interproximal bone, resulting in reduced vertical bone loss compared with square teeth. However, squarer teeth yield better interproximal papilla maintenance due to a smaller interproximal distance from the osseous crest to the contact point [24].

3.6 Gingiva Biotype

The periodontal biotype has been classified as scalloped-thin and flat-thick biotype [25,26]. Scalloped-thin tissue is more prone to develop recession following trauma or inflammation, while flat-thick tissue is more likely to develop deeper periodontal pockets [25]. Chow *et al.* [27] examined papillae fullness in 672 sites in 96 adult patients, they found that there was a positive correlation between gingival thickness and papilla fill. Limited blood supply is believed to be one of the major reasons of unpredictable regeneration of interdental papilla. Thick tissues respond more favorably due their increased vascularity and extracellular matrix volume [27]. Therefore, flat-thick biotype has been considered more favorable for achieving optimal esthetics.

3.7 Patient's Age

Aging results in thinning of oral epithelium, decreased keratinization, reduced papilla height and bone loss which are risk factors of open embrasures [36]. It was found that papillary tissue height decreased by 0.012 mm/year of age [27]. Vandana & Savitha [28] attributed the thinning periodontium to the accumulating effects of periodontal disease, traumatic habits, and natural diminishing of keratinization of the tissue during aging. [28]. However, Van der Velden [29] presented the changes in the periodontal tissue due to aging and concluded there is insufficient evidence for physiological gingival or papillae apical migration during aging.

3.8 Periodontal Disease and Loss of Attachment

Periodontitis is defined as an inflammatory disease of the supporting tissues of teeth and it is caused by the microorganisms which have the ability to invade and colonize the periodontal tissues. Periodontal disease has been associated with loss of interdental papilla due to the loss of alveolar bone [27]. The foundation for the gingival support is the underlying contour of the osseous crest. If the distance from the alveolar crest to interdental contact point exceeds 5 mm, it is more likely that the papilla is insufficient to fill the embrasure [18].

III. Classification Of The Interdental Papilla Loss

A classification system to identify and describe the severity of papillae loss is useful during the patient examination and facilitates monitoring of papillary augmentation techniques. A traditional classification system by Nordland and Tarnow [30] was based on the vertical relationship among the interdental contact point, the facial apical extent of the cemento-enamel junction (CEJ) and the interproximal coronal extent of the CEJ. They classified it into four categories:

- Normal: Interdental papilla fills embrasure space to the apical extent of 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.
- Class II: The tip of the interdental papilla lies at or apical to the interproximal CEJ but coronal to the apical extent of the facial CEJ.
- Class III: The tip of the interdental papilla lies level with or apical to the facial CEJ.

Nemcovsky [31] introduced a classification system as a papillae index score (PIS) based on a comparison with adjacent teeth, four different index scores were used to measure papillae:

- PIS 0: Presence of no papilla and no curvature of the soft tissue contour.
- 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.

Cardarpoliet *al.* [32] proposed a scoring system as papillae presence index (PPI) positional relationship among the papilla, CEJ, and adjacent teeth to assess interproximal papillary level:

- PPI 1: The papilla is completely present and at the same height of the adjacent tooth.
- PPI 2: The papilla is not completely present but interproximal CEJ is not visible.
- PPI 3: The papilla is not completely present and interproximal CEJ is visible.
- PPI 4: The Papilla lies apical to both interproximal and buccal CEJ.

IV. Nonsurgical Approaches

Patients may present with one or more etiological factor; thus, managing each patient requires an individual assessment and treatment plan. If the loss of papilla is related to only soft tissue loss, reconstruction techniques are capable of restoring it completely. If the loss of papilla is caused by periodontal disease with interproximal bone resorption, usually a complete reconstruction is not achieved. Though several surgical and nonsurgical treatment options are available, there is no golden standard set due to lack of large scale clinical trials nor long terms clinical outcomes. When compared to surgical techniques which are less predictable and painful [11,12], nonsurgical techniques are preferred due to their cost effectiveness, less stressful and achieve immediate results with high satisfaction rate. Nonsurgical approaches include correction of traumatic oral hygiene procedure, restorative techniques, orthodontic movement, repeated scrapping of the papilla and tissue volumizers.

4.1 Correction of Traumatic Oral Hygiene Procedure

Toothbrush abrasion leads to cement-enamel wear and damage of supporting gingival tissues leading to recession and papilla loss [33]. A study by Addy and Hunter [34] reported that irrespective of manual or power tooth brushing, over or abusive brushing or force applied significantly harm the gingival tissues. Therefore, such traumatic oral hygiene procedures should be identified early and discontinued to allow re-epithelialization and restoration of papilla [2,12]. Usage of flat trim toothbrush bristle, end-rounded filaments [35], rubber bristles interdental cleaner [36] are recommended to reduce gingival abrasion. Improper use of dental floss may damage the interdental papilla. Traumatic interproximal hygiene procedures must be initially discontinued and successively modified. Reepithelialization of the traumatic lesion can restore the papilla completely [37].

4.2 Restorative and Prosthetic Approaches

Prosthetic approaches for reproduction of gingival tissue include porcelain, acrylics, silicone-based soft materials, or co-polyamide and composite resin [38]. Composite resin is available in pink shades for gingival reproduction. It can be used on restorations to replace missing soft tissue and considered to be more realistic than pink porcelain in similar situations. Although pink porcelain can mask the loss of interdental papilla, porcelain shades and optical properties are limited [16].

Removable acrylic or silicone can be used as a gingival veneer to camouflage lost gingival tissues. It is indicated when interdental defects with >5 mm gap between contact point and alveolar crest. The removable prosthesis can facilitate a larger volume of tissue replacement without disturbing other dental units while allowing proper cleaning. While for fixed restoration of soft tissue in the esthetic zone, gingiva-colored (pink) porcelain can help in recreating natural tooth proportions and provide a realistic alternative to surgery [38]. Hygiene training is strongly recommended by dentist to patients who seek restoration therapy to improve the performance of prosthesis. Kimand Cho [39] used modified Mylar strip technique to close diastemaby using direct composite resin. Though the techniques adapted were less stressful and economic, incorrect resin composition may results in wear, fracture and limited success rate. Abnormal tooth shape contributing to missing papilla and associated GBT can be corrected by following appropriate restorative techniques to prevent further interdental papilla loss. By using restorative or prosthetic techniques, the contact point can be lengthen apically, reducing open embrasure and creeping of interdental gingiva [2,40].

4.3 Orthodontic Approach

Orthodontic movement has several applications in reducing the GBTs. Closing the interdental contacts by conventional orthodontic movement of adjacent teeth creates a new contact point thereby reducing diastema and subsequent creeping of gingival tissues towards interdental space [41]. In conjunction with orthodontic treatment, interproximal reduction (IPR) of enamel is one of orthodontic approach to achieve contact point between two adjacent teeth. IPR of enamel on triangular crown will convert contact point to a broader contact area thereby reducing GBT. Normally 0.5-0.75 mm enamel is removed with IPR method to prevent occurrence of open embrasures. A study by Livas [42] mentioned that a maximum of 50% of interproximal enamel can be removed without causing dental risk.

Coronal movement of tooth by application of gentle, continuous pressure results in closure of interdental space. The effects are alterations within the supporting structures, causing changes in bone level and the soft tissue contours and thereby creating new papillae. Cardaropoli *et al.* [32] presented a study evaluating a combined approach of orthodontic-periodontal treatment to reconstruct the interdental papillae between upper central incisors, demonstrating that the soft tissues adapted to the new emergence profiles during intrusion of the teeth as the interproximal spaces were reduced.

4.4 Repeated Scrapping of the Papilla

Repeated curettage every 15 days for 3 months recreate papillae which were previously destroyed by necrotizing gingivitis. This instrumentation induce a proliferative hyperplastic inflammatory reaction of the

papilla. About 9 months after initial treatment, regeneration of interdental papillae was observed. Some papillae showed complete regeneration, while others did not respond to the periodic curettage [43]. Yanagishita *et al.*[44], observed improvement of interdental papillae in a patient undergoing supportive periodontal therapy. The patient received initial periodontal therapy for periodontitis, included oral hygiene instruction, scaling and root planing. Use of an interdental brush was then suspended to allow the interdental papillae to recover. A gradual improvement was observed in recession of the interdental papillae over a period of several years together with coronal regrowth of the gingival margin.

4.5 Tissue Volumizing

Among several minimally invasive techniques proposed, the injection of various fillers and biological preparations has been studied for papilla reconstruction [11,45-47]. Hyaluronic acid (HA) is a large molecule, non-sulphated glycosaminoglycan present in connective tissues like skin and cartilage. Under physiological conditions, it contributes to tissue hydrodynamics, by binding to water to provide elasticity and stability resulting in tissue regeneration and healing. Its non-immunogenic, biocompatibility and bacteriostatic properties enhance its clinical significance. Long used as dermal fillers, recent findings have suggested its use to treat interdental papilla loss.

HA in tissues is digested by macrophages in blood or lymphatic system and broken HA reaches bloodstream to get disintegrated in liver for excretion. HA is usually eliminated through urine at a very minute quantity. HA acts as an antioxidant by scavenging reactive oxygen species, which helps in the regulation of immune response implying its anti-inflammatory properties [9]. HA's anti-inflammatory response and rheology properties make it ideal for biomedical usage.

Chemical modified hyaluronic acid preparations degrade more slowly than biological HA (due to cross-linkage and decreased water solubility) extending its clinical efficacy by 6-12 months. Such preparations are used as fillers which are usually manufactured from animal sources and more recently *Streptococcus* species of bacteria was used to extract gel form of hyaluronic acid which was chemically cross-linked with butanediol diglycidyl ether, stabilized and suspended in neutral phosphate buffered saline.

A study by Becker *et al* [45], aimed to evaluate the efficacy of commercially available hyaluronic acid gel to eliminate deficient papillae. A total of 14 GBTs were treated by injecting HA gel 2-3 mm apical to the tip of the papilla up to three times at 3 weeks intervals. They concluded that it is possible to enhance papillae that do not entirely fill the interdental space with an injectable hyaluronic gel. The results of this study were promising, even after 25 months and no relapse was apparent. A series by Lee *et al.*[46] evaluated the clinical efficacy of using hyaluronic acid gel on enhancing interdental papilla deficiency using radiographic assessment. The study reported that when HA was repeated up to 5 times every 3 weeks and post follow up period of 6 months, there was a significant improvement in interdental papilla reconstruction with contact point and bone crest reaching 6 mm. Mansouri *et al.* [11] assessed the efficacy of using HA gel for reconstruction of interdental papilla. It was reported that application of HA gel successfully treated interdental papilla deficiencies in a 6 month period. A clinical trial by Awartani and Tatakis [47] examined effects of using injectable, non-animal based, HA gel in reconstruction of interdental papilla loss. The study concluded that there was a significant improvement in treating interdental papilla loss at 6 months post HA gel injection. Also, it was reported that patients were satisfied with the obtained results and raised concerns regarding associated procedural discomforts. However, according to Tanwar and Hungund [9], though, HA is biocompatible and safe to use, with no evidence of cytotoxicity, HA is associated with allergic reactions and patients should be warned of this possible treatment side effect.

V. Conclusion

Rebuilding the pink gingival esthetic is an important issue in esthetic dentistry. An increased cosmetic demand from the profession and patients has resulted in more emphasis on the gingival esthetic. Though several surgical techniques are proposed its results were usually short-term, unpredictable and rarely achieved the required esthetics. From the review, we can conclude that nonsurgical, minimally invasive technique like usage of hyaluronic acid gel has a promising clinical outcome in esthetic reconstruction of papilla which can be further recommended for a large clinical study.

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