

DOI:10.58240/1829006X-2025.21.12-452



ORIGINAL ARTICLE

CLINICAL EVALUATION OF THE USE OF SURGICAL TUBE TECHNIQUE VS HYALURONIC ACID GEL INJECTION IN RECONSTRUCTION OF THE INTERPROXIMAL PAPILLA IN PATIENTS WITH CLASS II PAPILLARY DEFICIENCY: A RANDOMIZED CLINICAL TRIAL

Waleed M. Sabry^{1*}, Osama Gouda², Mona Darhous³

¹ PhD researcher at the Oral Medicine and Periodontology department, Cairo University, Egypt.

Email: Waleed.sabry@dentistry.cu.edu.eg

² Professor of Oral Medicine, Periodontology, and Oral Diagnosis, Faculty of Dentistry, Badr University, and Vice Dean of Community Service Affairs, Badr University **Email:** Osama.Mohamed@buc.edu.eg

³ Professor of Oral Medicine, Periodontology and Oral Diagnosis, Faculty of Dentistry, Cairo University, Egypt.

Email: mona.darhous@dentistry.cu.edu.eg

Corresponding author: Waleed M. Sabry PhD researcher at the Oral Medicine and Periodontology department, Cairo University, Cairo, Egypt. Email: **Waleed.sabry@dentistry.cu.edu.eg**

Received: Nov 22, 2025; **Accepted:** Dec 22, 2025; **Published:** Dec. 29, 2025

Abstract

Background: Interdental papilla insufficiency is a major concern both aesthetically and functionally. Several invasive techniques have been documented for interdental papilla reconstruction. This study compares the effectiveness of a minimally invasive tube technique to hyaluronic acid gel injection for reconstructing interdental papilla in the esthetic zone, while the long-term success of invasive treatments remains uncertain.

Materials and methods: The study was designed as a randomized, controlled and double-blinded clinical trial. The trial was registered at Cairo University's Faculty of Dentistry between December 2022 and July 2024, and the registration number is (NCT05235477). A total sample size of 20 sites in 16 patients was planned to be recruited. i.e., 10 sites in each group. Patients with deficient interdental papilla class II in the esthetic zone were selected, then these sites in patients were randomized using computer-generated randomization into two equal groups Group I (intervention/surgery group): Patients received the tube technique as recommended by Group II (Control): Patients received a hyaluronic acid (HA) (0.1 mm) injection into the papilla as performed by. Blinding was performed in the selection of patient intervention. The clinical parameters were assessed at baseline, 3 months and 6 months and the radiographic parameters were assessed at baseline and 6 months, as well as the patient satisfaction between the two tested groups.

Results: The surgical group showed significant improvement in all clinical parameters at 6 months postoperatively. The findings indicate that although both methods initially decreased the buccal triangle height and surface area as 3 months postoperatively, surgical intervention yielded markedly superior and more enduring results at the six-month follow-up. Specifically, the surgery group demonstrated a consistent reduction in triangle dimensions throughout the study period. In contrast, the hyaluronic acid injection group experienced a statistically significant relapse, indicated by a gradual increase in the black triangle dimensions, between three and six months.

Conclusions: The use of the tube technique is a very effective way for papilla reconstruction when compared to HA injection over the same examination period.

Keywords: Papilla reconstruction, tube technique, hyaluronic acid gel, black triangle

INTRODUCTION

Dental esthetics are considered the most significant

determinant in personality development. A minor deviation from community norms can lead to diminished

self-esteem concerning one's appearance resulting a detrimental effect on their quality of life. To develop a professional character, self-confidence is a vital factor in an individual's existence. It also pertains to health and contributes to the experience of achievement ¹.

The interdental papilla is a gingival structure that fills the area between neighboring teeth's contact sites. It is supported by the underlying alveolar bone as well as the teeth margins. It is made up of masticatory mucosa, a dense connective tissue covered by oral epithelium and an inner layer coated with junctional and sulcular epithelium ².

There are numerous factors influencing the interdental papilla, including the vertical and horizontal dimensions of the interdental space, the distance between the contact point and the alveolar crest (CP-BC), and the horizontal inter-radicular distance (HID). Among these factors are also tooth morphology and gingival biotype, fundamental divergence, the location and extent of the contact area, gingival scalloping (gingival angle), periodontal disease, age and traumatic experiences ³.

Treatment options for black triangles encompass both non-surgical and surgical methods. Non-surgical approaches involve strategies that incorporate the correction of traumatic oral hygiene practices, as well as orthodontic and restorative interventions ⁴. Tissue engineering and the application of tissue volumizers have been explored as potential approaches for addressing interdental papilla deficiency ⁵.

Hyaluronic acid, or hyaluronan, is a naturally occurring, non-sulfated, high molecular weight glycosaminoglycan (GAG) that constitutes a vital component of the extracellular matrix (ECM) of connective tissue, synovial fluid, serum, saliva, gingival crevicular fluid, embryonic mesenchyme, vitreous humor, skin, and various other organs and tissues throughout the body ⁶. Several studies have evaluated the efficacy of HA in the reconstruction of interdental papilla within the esthetic zone ^{7,8}.

Several conventional surgical techniques employing standard periodontal plastic and augmentation procedures seek to achieve complete papilla fill to address this issue. However, flap design was found to be invasive, associated with increased patient morbidity, limited efficacy, long-term stability, and unpredictability due to confined working spaces and restricted blood supply ⁴.

Surgical approaches include the pedicle flap technique ⁹, the semilunar coronally repositioned papilla ¹⁰, the envelope flap technique¹¹, the microsurgical technique

with platelet-rich fibrin ¹², and the modified semilunar coronally repositioned papilla ¹³.

The tube technique was recently added in the track of surgical techniques to solve the shortcomings of the other techniques ¹⁴. It was claimed that the tube technique's innovative flap design does not disrupt the graft's blood supply by using apical incisions and containing the graft within a rich vascular contained bed, resulting in consistent and satisfying results.

The integrity of the soft tissue is critical to the effectiveness of this treatment. The tube grafting procedure necessitates technical precision. It is highly susceptible to surgical trauma and tension, especially when the recipient site tissue is delicate.

Based on all proposed advantages of the tube technique over other surgical techniques, as well as the demonstrated efficacy of HA for interdental papilla restoration. The purpose of this study was to compare the clinical efficacy of the surgical tube method versus hyaluronic acid gel injection in reconstructing the interproximal papilla in individuals with class II papillary deficiency.

MATERIALS AND METHODS

Study design:

The present randomized controlled clinical trial encompassed 20 sites in 16 patients exhibiting black triangles in anterior teeth. Participants were enrolled from the outpatient clinic of the Department of Oral Medicine and Periodontology at Cairo University's Faculty of Dentistry between December 2022 and July 2024. Grouping: Group I (intervention/surgery group):

Patients received the tube technique as proposed by ¹⁴. Group II (Control): Patients received a hyaluronic acid (HA) (0.1 mm) injection into the papilla³.

Ethical Approval:

The research protocol was approved by the Research Ethics Committee of the Faculty of Dentistry, Cairo University, on June 29, 2021. The enrolled patients in this clinical trial received detailed information regarding the procedures and follow-up aspects of the study. Each participant provided a written informed consent and voluntarily consented to take part in the study. The present clinical trial was registered on Clinical Trials with the identifier NCT05235477.

Power and Sample Size:

This power analysis employed interdental papilla loss at six months as the primary endpoint. Based on the findings

of ¹⁵, the mean and standard deviation (SD) for the control group were 0.71 (0.74). The minimal clinically significant difference was determined to be 1 mm² based on expert consensus. Using an alpha (α) level of 5% and a beta (β) level of 0.8 (Power = 80%), the effect size for the independent samples t-test (d) was 1.32, and the minimum estimated sample size was 10 sites per group. The sample size was expanded to 12 sites per group to account for an anticipated dropout rate of 20% after six months. Sample size determination was conducted utilizing PS Power and Sample Size Calculations Version 3.

Patient Selection:

The study was conducted on 20 sites in 16 patients recruited from the outpatient clinic of the Oral Medicine, Periodontology, and Oral Diagnosis department, Faculty of Dentistry, Cairo University. All new patients of the outpatient clinic were examined by the author and supervisors, and those who met the eligibility criteria were asked to sign a consent after explaining the details of the study and then started the randomization process. The research ethics committee has approved the study (11-6-21) and it was registered retrospectively with the clinical trial registration number (NCT05235477).

Patients were selected based on the following criteria: The patient's age ranged from 25 to 45 years old as done by ³. Highly motivated patients with papillary deficiency type II, according to the Nordland and Tarnow classification ¹⁹, were selected with at least one deficient papilla in the anterior region. Distance between the contact point and interproximal bone crest (CP-BC) was ≤ 7 mm, and probing depth is ≤ 4 mm at the deficient papillary site as done by ³. Patients with full mouth plaque index (PI) and gingival index (GI) scores between 0 and 1 as recommended by ³, systemically free of any medical condition.

According to ³: patients with a history of allergic reactions to hyaluronic acid, pregnant or breastfeeding females, smokers and alcoholic patients, and those currently or previously on medication intake that may predispose them to gingival enlargement were excluded from the study.

Patients with cardiovascular diseases patients under orthodontic treatment or who had orthodontic treatment in the past six months, carious teeth, proximal restorations, or fixed prosthesis at the site of treatment also, those with a history of traumatic oral hygiene measures or periodontal surgeries over the last six months in the area of interest or having any scar tissue were not included in the study.

Randomization and Blinding:

The supervisor used computer-generated random numbers to assign patients to the intervention or control groups. Patients were assigned 1:1. The main supervisor, who was not involved in recruitment, conducted a computer-generated randomization list (www.randomizer.org) for concealment. Both groups were equally prepared for surgery or injection. Afterward, the randomized numbers in opaque envelopes would determine which group would receive the hyaluronic acid injection and which would undergo the tube technique. Since the surgical techniques of the two groups were fundamentally different, blinding was only used for the outcome assessor and biostatistician. The lead investigator and participants could not be blinded.

Procedures:

All patients were given stringent dental hygiene instructions, and whole-mouth supra- and subgingival debridement was performed under local anesthesia with hand instruments and ultrasonic scalers. Six to eight weeks after pre-surgical therapy, periodontal re-evaluation was undertaken to establish the suitability of the targeted sites for this study, followed by a baseline assessment of clinical and radiographic data.

Tube Technique: ¹⁴.

A semilunar incision was made on the buccal aspect at the MGJ, and a full-thickness flap was elevated using a #15 blade. The flap was 4–5 mm longer mesio-distally than needed for the graft. The buccal flap could freely enter the recession with this expansion. The zenith of another semilunar incision on the palatal aspect was near the alveolar crest. On the buccal aspect, a mucoperiosteal elevator or tunneling knife (smaller than the defect width) was used to carefully reflect the papilla away from the alveolar bone and root surfaces to access the interproximal region to prepare the graft bed. The mucoperiosteal elevator was used to do the same on the palatal aspect. Reflection was done to relax the papilla flap, allowing it to be placed in the new coronal position without stress. At this point, the recipient site resembled a "tube" with two openings: buccal at the mucogingival junction and palatal.

The connective tissue graft (CTG) was harvested by cutting parallel to the gingival margin and 2 mm it. A tiny flap of keratinized tissue was detached, and the second incision was parallel to the gingival edge but perpendicular to the alveolar bone. The graft was raised with the periosteum and freed at its anterior and posterior ends and base using a sharp elevator. Both cases required 12 to 15 mm long, 5 mm wide, and 2 mm thick harvested grafts larger than the interproximal defect side. The needle eye (swage) was passed into the tube from the palate to the buccal with a 6.0 polypropylene suture. A suture needle then engaged a graft end. Another suture was inserted on the CTG's other end. One eye-first suture wound through the tube toward the palatal side. A suture

and periosteal elevator were used to carefully slide the CTG through the buccal end of the tube into the prepared interproximal bed toward the palate. Interproximal was the thickest region of the graft. Buccal and palatal flaps were sutured over the CTG, which was then sutured under them. A 6.0 polypropylene suture with a cutting needle was used. The graft was squeezed from both ends inward for 4–5 minutes using the index finger and thumb to stabilize it.

Injection technique:

Restylane Lidocaine (Galderma S.A., Sweden) was utilized. Three injections were given at each papilla site: baseline, 3, and 6 weeks. For patient blindness, insulin plastic syringes were pre-loaded with hyaluronic acid and saline. The bevel was directed apically, and the needle was inserted 2-3 mm apically to the tip of the interdental papilla and guided coronally with a 45° angle to the tooth's long axis. With gauze, the papilla was lightly molded incisally for 1 minute.

Outcome Assessments:

A-Clinical assessment:

Digital clinical photographs: The surface area of the black triangle (SABT) mm:

The surface area of the black triangle (SABT) was measured using standardized digital clinical images and an image analysis application (Photoshop CS 5, Adobe Systems, San Jose, CA, USA). From baseline and 3- and 6-month postoperative images, the black triangle's surface area was measured and calibrated using a 10 mm William's graduated periodontal probe [3] Papilla Presence Index (PPI): according to ¹⁶

Clinical attachment level (CAL):

According to ¹⁷, CAL was measured with the periodontal probe from CEJ to the bottom of the pocket to the nearest mm

Probing depth (PD):

The distance from the gingival margin to the base of the periodontal pocket was measured using a William's graduated periodontal probe.

Gingival recession (GR):

The distance from the CEJ to the gingival margin ¹⁸

Gingival Bleeding score:

By gentle probing of the orifice of the gingival crevice using William's graduated periodontal probe. If bleeding occurred within 10 seconds, a positive finding was recorded, and the number of positive sites was recorded and then expressed as a percentage of the number of sites examined ².

Surface area of black triangle (SABT): Preoperative and postoperative photographs at baseline, 3 months and 6 months intervals were taken perpendicular to teeth of interest. Then the surface area of the black triangle (SABT) was measured. These photos were analyzed using Photoshop CS software. The program was used to measure the height of the selected papillae ³.

B-Radiographic assessment:

Standardized digital periapical radiographs were obtained preoperatively and 6 months postoperative using the long cone paralleling technique using the same equipment, film exposure, and development conditions and using the individualized bite block. The use of a correctly applied X-ray positioner provides a perpendicular alignment of the X-ray cone through the film and consequently a fixed position of the focal spot ²⁰.



Figure 1. showing a 5.5mm distance between the contact point and interproximal bone crest (CP-BC)

C- Patient Satisfaction:

It consists of 3 questions: How satisfied are you with your smile? How satisfied are you with the black space showing between your teeth? Having had this overall experience, would you choose to have the procedure again? ¹⁵.

...

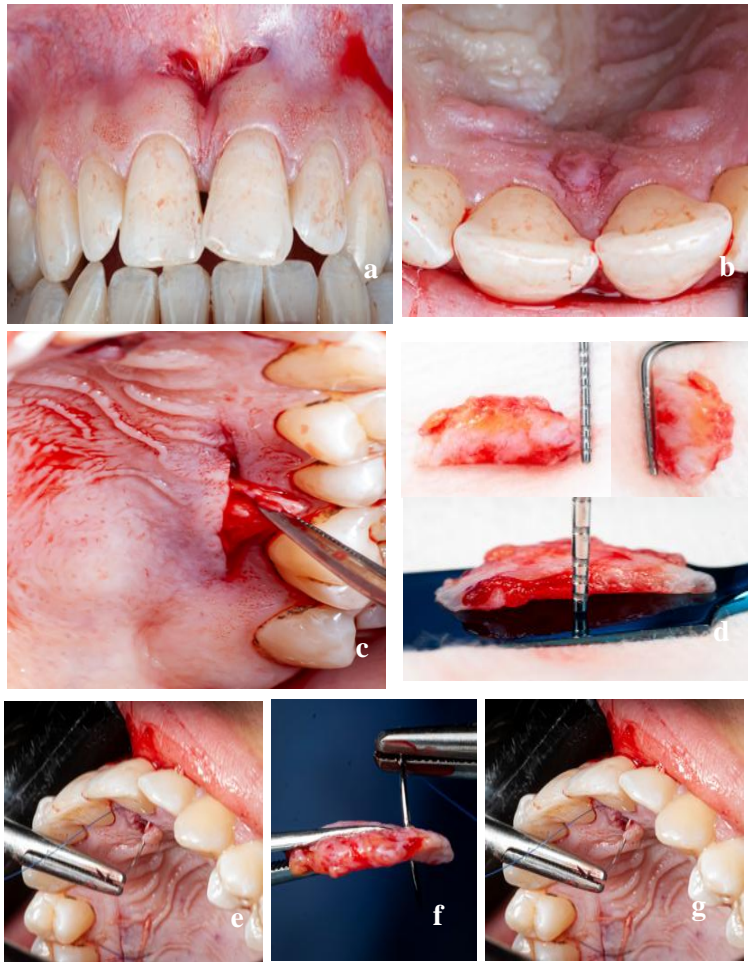


Figure 2. (Intervention): (a) Semilunar flap buccally, (b) Semilunar flap palatally, (c) Single incision technique for CT graft, (d) Showing the length (9 mm), width (4 mm) of the graft, and the thickness of the graft (2 mm), (e) inserting the swaged area of the needle palatally in the tube area created, (f) inserting the needle in the graft from one side, and (g) adjust the Graft to get into the tube area to raise the papilla to fill the black triangle

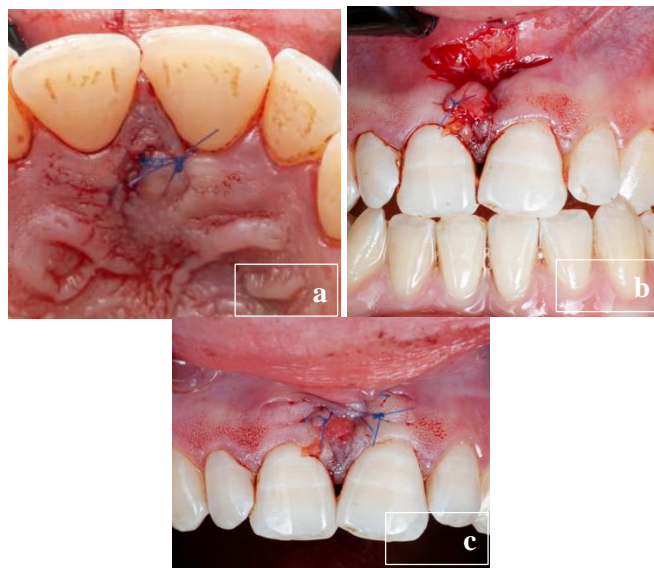


Figure 3. (a) suturing the graft into the tissues and suturing the palatal flap, (b) suturing the graft in the buccal tissues, and (c) suturing the buccal flap over the graft



Figure 4. (a) Baseline (b) 3-month follow-up and (c) 6-month follow-up showing absence of black triangle



Figure 5. Control group



Figure 6. (a) Baseline (b) 3-month follow-up and (c) 6-month follow-up showing relapse

Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). All data showed non-normal (non-parametric) distribution except for distance data that showed normal (parametric) distribution. Data were presented as median, range, mean and standard deviation (SD) values. For non-parametric data, Mann-Whitney U test was used to compare between the two groups. Friedman’s test was used to study the changes by time within each group. Dunn’s test was used for pair-wise comparisons when Friedman’s test is significant. For parametric data, the repeated measures ANOVA test was used to compare between the two groups as well as to study the changes by time within each group. Bonferroni’s post-hoc test was used for pairwise comparisons when the ANOVA test is significant. Qualitative data were presented as frequencies and percentages. Fisher’s exact test was used to compare patient satisfaction results in the two groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

Patients’ demographic data

Descriptive statistics for gender and age are presented in Table (1).

Table1. Descriptive statistics for baseline characteristics in the two groups

Patients’ data	Surgery (n = 10)	Injection (n = 10)
Gender [n, (%)]		
Female	5 (50%)	4 (40%)
Male	5 (50%)	6 (60%)
Age [Mean, SD]	30.4 (3)	32.7 (3.5)

A-Clinical assessment:

Gingival recession (GR in mm)

At baseline, after three as well as after six months, there was no statistically significant difference between the two groups (P -value = 1, Effect size = 0), (P -value = 0.527, Effect size = 0.238), and (P -value = 0.245, Effect size = 0.051), respectively.

Pocket Depth (PD in mm)

At baseline, after three as well as after six months, there was no statistically significant difference between the two groups (P -value = 0.662, Effect size = 0.187), (P -value = 0.631, Effect size = 0.204), and (P -value = 0.071, Effect size = 0.804), respectively.

Clinical Attachment Level (CAL in mm)

At baseline, after three as well as after six months, there was no statistically significant difference between the two groups (P -value = 1, Effect size = 0), (P -value = 0.542, Effect size = 0.17) and (P -value = 0.276, Effect size = 0.343), respectively.

Plaque Index (PI)

At baseline, after three as well as after six months, there was no statistically significant difference between the two groups (P -value = 0.317, effect size = 0.17) for each time, respectively.

Gingival Index (GI)

At baseline, after three as well as after six months, there was no statistically significant difference between the two groups (P -value = 0.648, Effect size = 0.17), (P -value = 0.689, Effect size = 0.136) and (P -value = 0.752, Effect size = 0.119), respectively.

Buccal triangle height (mm)

At baseline as well as after three months, there was no statistically significant difference between the two groups (P -value = 0.821, Effect size = 0.102) and (P -value = 0.384, Effect size = 0.396), respectively. After six months, surgery group showed statistically significantly lower buccal triangle height than injection group (P -value = 0.013, Effect size = 1.344).

Table 2. Descriptive statistics and results of Mann-Whitney U test for comparison between buccal triangle height (mm) in the two groups and Friedman’s test for the changes within each group

Time	Surgery (n = 10)		Injection (n = 10)		P-value	Effect size (d)
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Base line	2.8 (1.37, 4.54) ^A	2.75 (0.88)	2.81 (1.95, 3.98) ^A	2.89 (0.67)	0.821	0.102
3 months	1.35 (0.44, 2.5) ^B	1.47 (0.72)	1.63 (0, 3.26) ^C	1.76 (0.58)	0.384	0.396
6 months	0.94 (0, 2.34) ^C	1.09 (0.78)	1.99 (1.44, 3.5) ^B	2.13 (0.68)	0.013*	1.344
P-value	<0.001*		<0.001*			
Effect size (w)	1		0.833			

*: Significant at $P \leq 0.05$, Different superscripts in the same column indicate statistically significant change within group

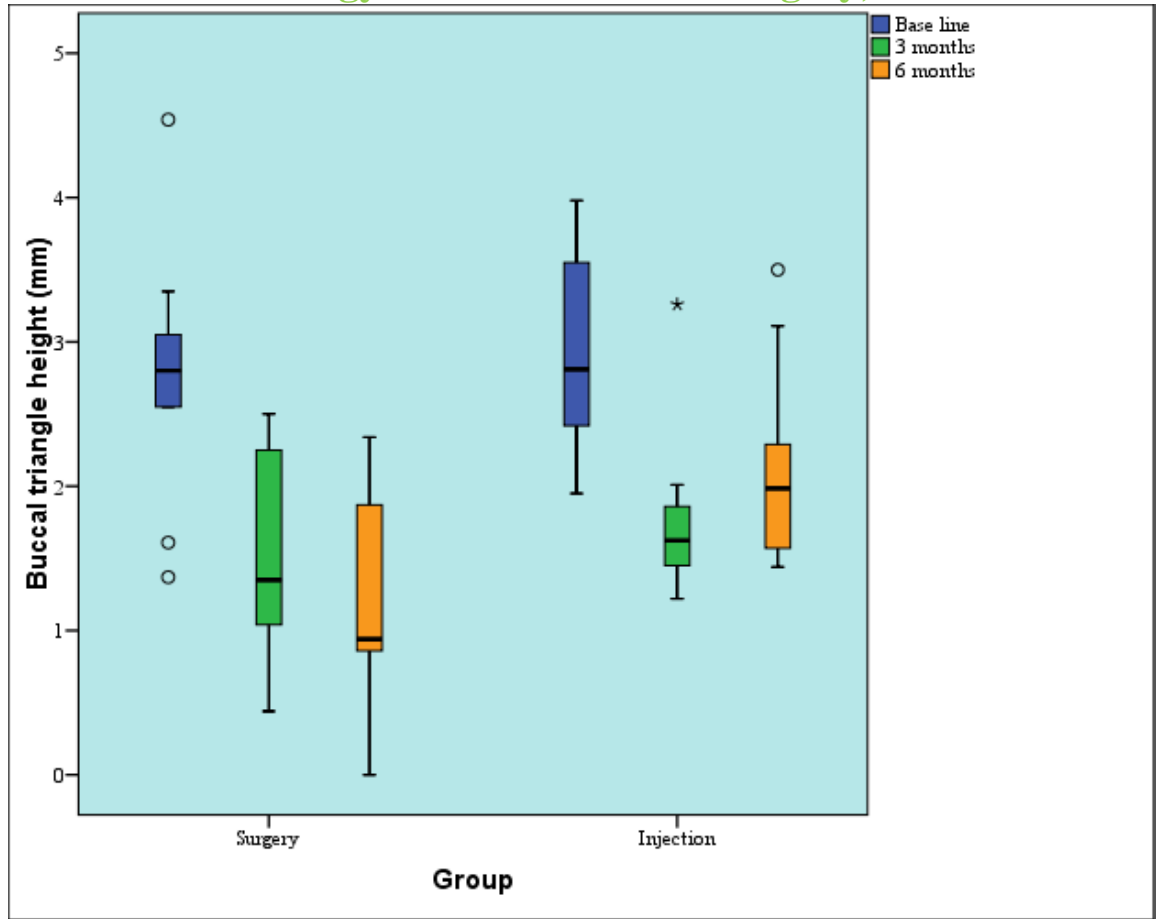


Figure 6. Box plot representing median and range values for buccal triangle height in the two groups (Star and circles representing outliers)

a. Comparison between amounts of reduction in buccal triangle heights in the two groups

The amount of reduction is calculated as the difference between three, six months measurement and base line measurement.

After three months, there was no statistically significant difference between the two groups (*P*-value = 0.820, Effect size = 0.102).

After six months, the tube surgical group showed statistically significantly higher amount of reduction in buccal triangle height than injection group (*P*-value = 0.019, Effect size = 1.23).

Table 3. Descriptive statistics and results of Mann-Whitney U test for comparison between amounts of reduction in buccal triangle height (mm) in the two groups

Time	Surgery (n = 10)		Injection (n = 10)		<i>P</i> -value	<i>Effect size (d)</i>
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
3 months	1.1 (0.27, 3.33)	1.28 (0.89)	1.11 (0.28, 2)	1.13 (0.54)	0.820	0.102
6 months	1.63 (0.43, 3.68)	1.66 (0.88)	0.56 (0.28, 1.91)	0.76 (0.51)	0.019*	1.23

*: Significant at *P* ≤ 0.05

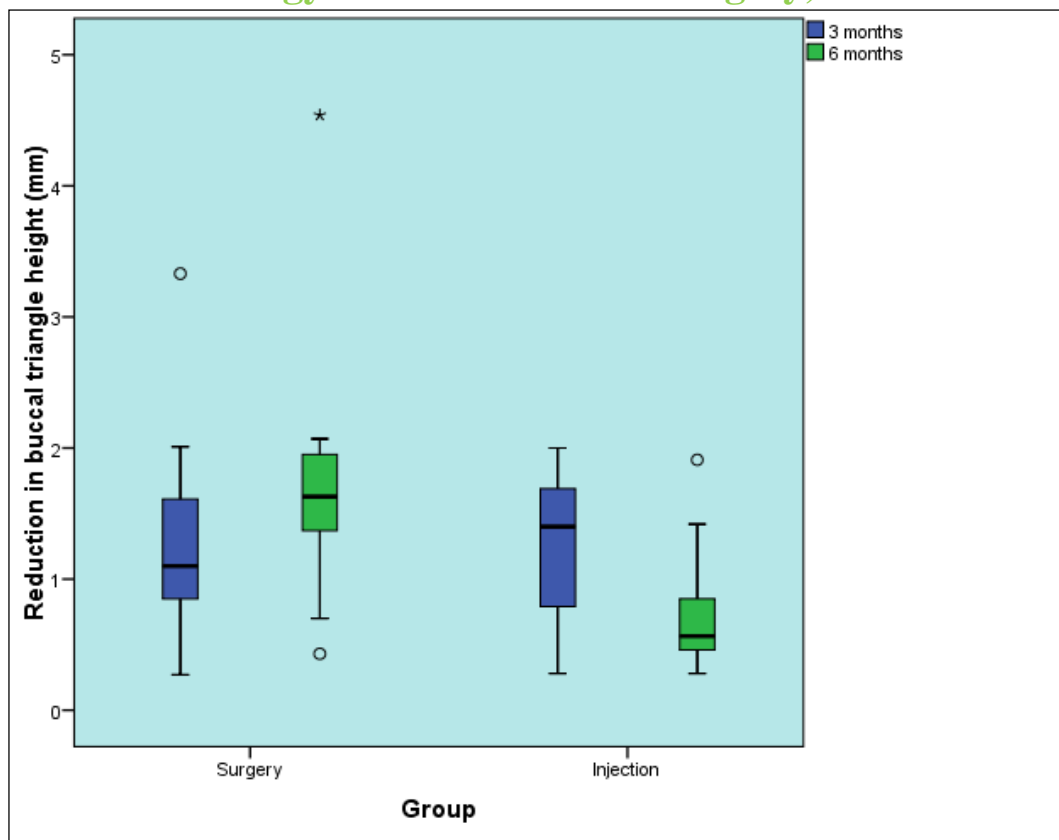


Figure 7. Box plot representing median and range values for reduction in buccal triangle height in the two groups (Stars and circle representing outliers)

Buccal triangle surface area (mm²)

At baseline as well as after three months, there was no statistically significant difference between the two groups (*P*-value = 0.821, Effect size = 0.102) and (*P*-value = 0.199, Effect size = 0.6), respectively.

After six months, surgery group showed statistically significantly lower buccal triangle surface area than injection group (*P*-value = 0.002, Effect size = 1.835).

Table 4. Descriptive statistics and results of Mann-Whitney U test for comparison between buccal triangle surface area (mm²) in the two groups and Friedman’s test for the changes within each group

Time	Surgery (n = 10)		Injection (n = 10)		<i>P</i> -value	<i>Effect size</i> (<i>d</i>)
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Base line	1.77 (0.69, 2.04) ^A	1.58 (0.53)	1.59 (0.55, 4.07) ^A	1.96 (1.14)	0.821	0.102
3 months	0.58 (0.09, 1.13) ^B	0.62 (0.37)	0.93 (0, 1.62) ^C	0.89 (0.53)	0.199	0.6
6 months	0.22 (0, 1.45) ^C	0.41 (0.51)	1.32 (0.65, 2.86) ^B	1.47 (0.71)	0.002*	1.835
<i>P</i> -value	<0.001*		0.002*			
<i>Effect size</i> (<i>w</i>)	0.84		0.63			

*: Significant at *P* ≤ 0.05, Different superscripts in the same column indicate statistically significant change within group

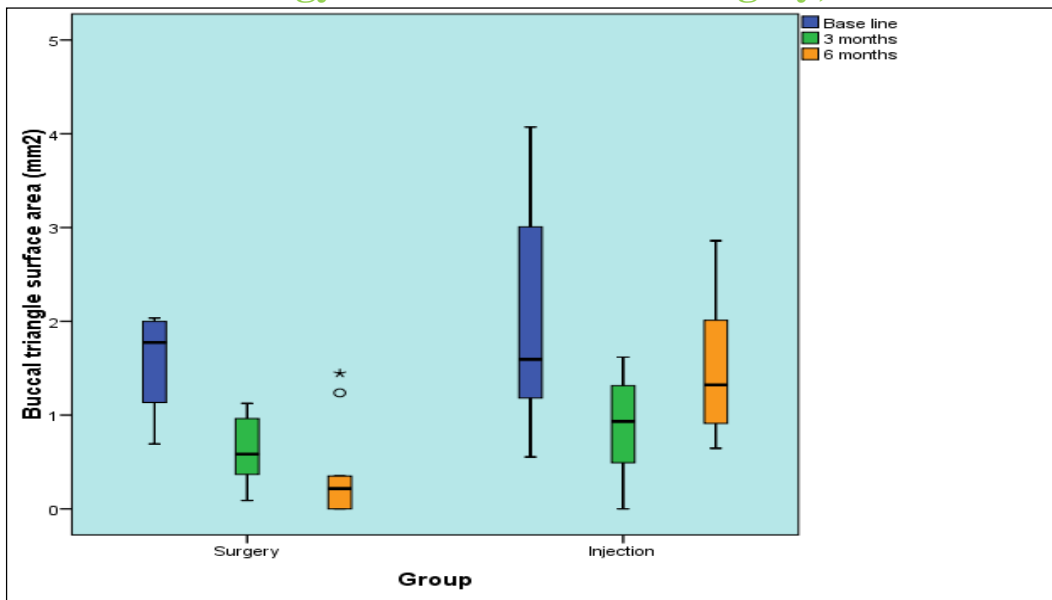


Figure 8. Box plot representing median and range values for buccal triangle surface area in the two groups (Star and circle representing outliers)

a. Comparison between amounts of reduction in buccal triangle surface areas in the two groups

The amount of reduction is calculated as the difference between three, six months measurement and base line measurement.

After three months, there was no statistically significant difference between the two groups (*P*-value = 0.940, Effect size = 0.034).

After six months, the tube surgical group showed statistically significantly higher amount of reduction in buccal triangle surface area than injection group (*P*-value = 0.041, Effect size = 1.026).

Table 5. Descriptive statistics and results of Mann-Whitney U test for comparison between amounts of reduction in buccal triangle surface area (mm²) in the two groups

Time	Surgery (n = 10)		Injection (n = 10)		<i>P</i> -value	Effect size (<i>d</i>)
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
3 months	0.96 (0.17, 1.86)	0.97 (0.53)	0.82 (0.06, 2.87)	1.06 (0.89)	0.940	0.034
6 months	1.1 (0.52, 2.04)	1.18 (0.63)	0.39 (-0.09, 2.06)	0.49 (0.66)	0.041*	1.026

*: Significant at *P* ≤ 0.05

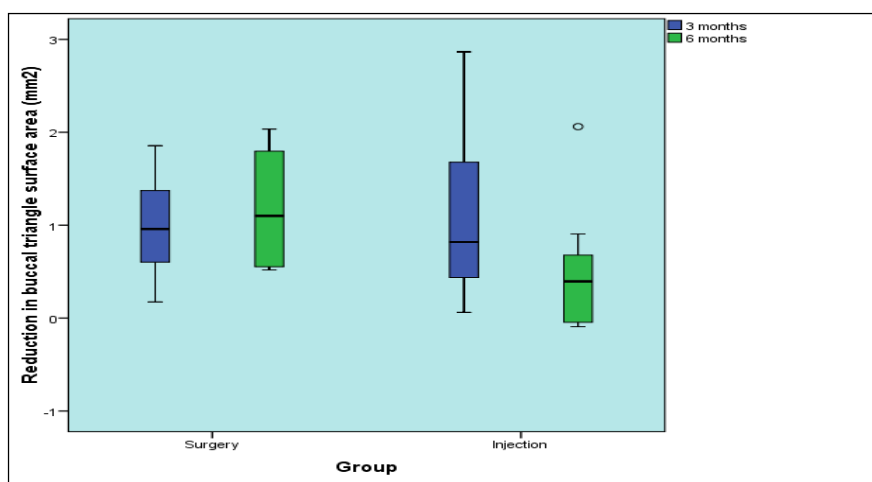


Figure 9. Box plot representing median and range values for reduction in buccal triangle surface area in the two groups (Circle representing outlier)

Radiographic evaluation - Distance (mm)

a. Comparison between the two groups

At base line as well as after six months, there was no statistically significant difference between the two groups (P -value = 0.793, Effect size = 0.004) and (P -value = 0.593, Effect size = 0.016), respectively.

C- Patient Satisfaction:

At base line, all cases in the two groups were not satisfied at all, so no statistical comparison could be done. After six months regarding Question one as well as Question two, there was a statistically significant difference between groups (P -value <0.001, Effect size = 0.872) and (P -value <0.001, Effect size = 0.922), respectively. Surgery group showed higher prevalence of extremely satisfied and very satisfied patients than injection group. As regards recommendation of the technique, there was a statistically significant difference between both groups (P -value = 0.003, Effect size = 0.745). Injection group showed higher prevalence of definite and probable recommendation of the technique.

DISCUSSION

In modern esthetic dentistry, the interdental papilla constitutes a vital element of an esthetically pleasing smile, and has an impact on patient satisfaction, speech, and long-term periodontal health². The black triangle occurs when the papilla is absent or recedes, creating interproximal gaps that affect pink esthetics and can allow food impaction and space for air or saliva, affecting both appearance and function²¹.

The preservation of papillary integrity and flexibility to site-specific anatomy render it especially beneficial for anterior aesthetic restorations, improving patient satisfaction and phonetic function⁵.

This randomized clinical trial compared the clinical efficacy of the surgical tube technique versus hyaluronic acid gel injection for the reconstruction of interproximal papilla in patients with class II papillary deficiencies. The tube technique used in this study was chosen as it is considered a minimally invasive surgical method for addressing black triangle abnormalities resulting from the regression of interdental papillae in the gingival aesthetic zone¹⁴.

The tube technique relies on the integrity of soft tissues and that scar tissue should not be present at the recipient site before this procedure. Success also depends on donor tissue thickness. The size of the graft and soft tissue defect can affect the success of this treatment. Dual blood supply improves the success of subepithelial connective tissue grafts¹⁴. All this was taken into consideration during the choice of the cases in this study.

On the other hand, non-surgical soft tissue augmentation involves injections of various materials. Since hyaluronic acid is the most commonly used soft-tissue augmentation substance, this study used a non-crosslinked form. Biodegradability, biocompatibility, non-immunogenicity, anti-inflammatory properties, and cell proliferation and migration are its biological features. Non-crosslinked hyaluronic acid was mixed with carboxymethyl chitosan (HA-CMC) in the present study to increase its molecular weight and enhance its biological properties, such as water absorption, oxygen permeability, hemostasis, and antibacterial activity. We standardized all shots and recorded measurements in Photoshop CC for each spot at each follow-up photo as done by³.

The main aim of this study was to evaluate and compare the effectiveness of surgical intervention versus hyaluronic acid injection in the treatment of buccal triangle class II papillary deficiencies. The findings indicated that although both methods initially decreased the buccal triangle height and surface area, surgical intervention yielded markedly superior and more enduring results at the six-month follow-up. Specifically, the surgery group demonstrated a consistent reduction in triangle dimensions over time. In contrast, the hyaluronic acid injection group experienced a statistically significant relapse, indicated by a gradual increase in the black triangle dimensions between three and six months. Conversely, the injection relapse group demonstrated an initial decrease in triangle dimensions at three months, followed by a substantial increase in height and surface area between three and six months. The same finding was reported in a previous study³.

A statistically significant reduction in the height of the black triangle after 3 months ($p \approx 0.001$) in the HA group compared with the saline group has been reported³. Between 3 and 6 months, no statistically significant difference was observed in height-distance measurements. However, the mean height-distance measurements after six months demonstrated a statistically significant reduction compared with baseline measurements, consistent with the findings in our study within the HA group. The HA injection group in the current study showed substantial initial improvement. Hyaluronic acid acted as an immediate space-filler, expanding soft tissue volume through its hydrophilic properties. However, as the present results showed, this initial "swelling" effect diminishes over time as the gel undergoes enzymatic degradation and metabolic turnover.

The present results also coincide with those of previous studies^{8,13,15} at two-week and one-month follow-up periods regarding the reduction in the

surface area of the black triangle, but they could maintain their results for six months. The findings of the present study also align with previous findings¹⁵ that revealed mean percentage reductions of $29.52 \pm 18.72\%$ from baseline to 3 months and $47.33 \pm 20.20\%$ from baseline to 6 months. A case study revealed a mean reduction percentage of $91.1 \pm 11.99\%$ after a 25-month follow-up following HA injection²². No baseline data on SABT were provided; only the injection of HA gel for minor papillary abnormalities was indicated. The greater percentage of reduction in that study is presumably due to the smaller baseline size of the black triangles and the extended follow-up period. Unlike fillers, surgical techniques such as the advanced papillary flap rely on the anatomical repositioning of the patient's own vascularized tissue. This creates a permanent structural change and a biological seal that are more resistant to relapses typically observed with resorbable materials¹⁵.

Furthermore, the findings of the present study are in accordance with evidence from a systematic review², where it seems that the most effective intervention for papilla reconstruction is the use of a subepithelial connective tissue graft. In contrast, nonsurgical interventions, such as hyaluronic acid, appear to offer fewer clear benefits. The integration of surgical flaps allows for a more robust connective tissue attachment and steady blood supply. While injections offer a minimally invasive advantage, they lack the structural support needed to maintain interdental closure in larger defects where the distance to the bone crest is great. In comparing the results of group I with those of group II, HA injection alone was unable to maintain the reduction in the black triangle's width, height, and surface area between 3 to 6-month follow-up

Limitations

There are a few limitations of the present study, including the small sample size and the short follow-up period. A split-mouth design could be preferred to provide a more unbiased comparison of the surgical techniques.

CONCLUSION

- The use of the tube technique is a very effective way for papilla reconstruction when compared to HA injection over the same examination period.
- The use of HA injection for papilla reconstruction is effective but may not allow the long-term structural support provided by the surgical technique.
- The healing after the surgical tube technique is good, with less morbidity of the blood supply and gives better appearance than the hyaluronic acid technique.

DECLARATION

Ethics approval and consent to participate:

.Consent for publication:

Availability of data and materials: Research data supporting this publication is available from the corresponding author upon request.

Competing interests: The authors declare no competing interests.

Funding: It is a self-funded study.

Author contributions:

Acknowledgments:

REFERENCES

1. Abdelraouf, Sara Amr, Omnia Aboul Dahab, Ahmed Elbarbary, Amany Mohy El-Din, and Basma Mostafa. 2019. "Assessment of Hyaluronic Acid Gel Injection in the Reconstruction of Interdental Papilla: A Randomized Clinical Trial." *Open Access Macedonian Journal of Medical Sciences* 7(11):1834–40. doi:10.3889/oamjms.2019.478.
2. Ainamo, J., and I. Bay. 1975. "Problems and Proposals for Recording Gingivitis and Plaque." *International Dental Journal* 25(4):229–35.
3. Awartani, Fatin A., and Dimitris N. Tatakis. 2016a. "Interdental Papilla Loss: Treatment by Hyaluronic Acid Gel Injection: A Case Series." *Clinical Oral Investigations* 20(7):1775–80. doi:10.1007/s00784-015-1677-z.
4. Awartani, Fatin A., and Dimitris N. Tatakis. 2016b. "Interdental Papilla Loss: Treatment by Hyaluronic Acid Gel Injection: A Case Series." *Clinical Oral Investigations* 20(7):1775–80. doi:10.1007/s00784-015-1677-z.
5. Azzi, R., D. Etienne, and F. Carranza. 1998. "Surgical Reconstruction of the Interdental Papilla." *The International Journal of Periodontics & Restorative Dentistry* 18(5):466–73.
6. Barakat, Sanabel O. 2024. "Interdental Papilla Recession and Reconstruction of the Lost Triangle: A Review of the Current Literature." *Frontiers in Dental Medicine* 5:1537452. doi:10.3389/fdmed.2024.1537452.
7. Beagle, J. R. 1992. "Surgical Reconstruction of the Interdental Papilla: Case Report." *The International Journal of Periodontics & Restorative Dentistry* 12(2):145–51.
8. Becker, William, Ildor Gabitov, Misha Stepanov, John Kois, Ami Smidt, and Burton E. Becker. 2010. "Minimally Invasive Treatment for Papillae Deficiencies in the Esthetic Zone: A Pilot Study." *Clinical Implant Dentistry and Related Research* 12(1):1–8. doi:10.1111/j.1708-8208.2009.00247.x.
9. Blatz, M. B., M. B. Hürzeler, and J. R. Strub. 1999a. "Reconstruction of the Lost Interproximal Papilla--Presentation of Surgical and Nonsurgical

- Approaches.” *The International Journal of Periodontics & Restorative Dentistry* 19(4):395–406.
10. Blatz, M. B., M. B. Hürzeler, and J. R. Strub. 1999b. “Reconstruction of the Lost Interproximal Papilla—Presentation of Surgical and Nonsurgical Approaches.” *The International Journal of Periodontics & Restorative Dentistry* 19(4):395–406.
11. Cardaropoli, Daniele, Stefania Re, and Giuseppe Corrente. 2004. “The Papilla Presence Index (PPI): A New System to Assess Interproximal Papillary Levels.” *The International Journal of Periodontics & Restorative Dentistry* 24(5):488–92. doi:10.11607/prd.00.0596.
12. Castro-Calderón, Adriana, Andrea Rocuzzo, Martina Ferrillo, Sneha Gada, José González-Serrano, Manrique Fonseca, and Pedro Molinero-Mourelle. 2022. “Hyaluronic Acid Injection to Restore the Lost Interproximal Papilla: A Systematic Review.” *Acta Odontologica Scandinavica* 80(4):295–307. doi:10.1080/00016357.2021.2007282.
13. Fawzy El-Sayed, Karim M., Moushira A. Dahaba, Shadw Aboul-Ela, and Mona S. Darhous. 2012. “Local Application of Hyaluronan Gel in Conjunction with Periodontal Surgery: A Randomized Controlled Trial.” *Clinical Oral Investigations* 16(4):1229–36. doi:10.1007/s00784-011-0630-z.
14. Glavind, L., and H. Løe. 1967. “Errors in the Clinical Assessment of Periodontal Destruction.” *Journal of Periodontal Research* 2(3):180–84. doi:10.1111/j.1600-0765.1967.tb01887.x.
15. Haghghat, Kamran. 2006. “Modified Semilunar Coronally Advanced Flap.” *Journal of Periodontology* 77(7):1274–79. doi:10.1902/jop.2006.050426.
16. Han, T. J., and H. H. Takei. 1996. “Progress in Gingival Papilla Reconstruction.” *Periodontology* 2000 11:65–68. doi:10.1111/j.1600-0757.1996.tb00184.x.
17. Ialenti, A., and M. Di Rosa. 1994. “Hyaluronic Acid Modulates Acute and Chronic Inflammation.” *Agents and Actions* 43(1–2):44–47. doi:10.1007/BF02005763.
18. Kashani, Hooshang, Manali V. Vora, Ryutaro Kuraji, Hanna Brody, and Yvonne L. Kapila. 2021. “Rebuilding the Interproximal Papilla: Description of ‘Tube’ Technique and Two Case Reports.” *Clinical Advances in Periodontics* 11(1):17–21. doi:10.1002/cap.10109.
19. Miller, P. D. 1985. “A Classification of Marginal Tissue Recession.” *The International Journal of Periodontics & Restorative Dentistry* 5(2):8–13.
20. Nordland, W. P., and D. P. Tarnow. 1998. “A Classification System for Loss of Papillary Height.” *Journal of Periodontology* 69(10):1124–26. doi:10.1902/jop.1998.69.10.1124.
21. Oliveira, Guilherme H. C., and Eduardo A. G. Muncinelli. 2012. “Efficacy of Root Surface Biomodification in Root Coverage: A Systematic Review.” *Journal (Canadian Dental Association)* 78:c122.
22. Patel, Monal, Alaa Guni, Luigi Nibali, and Ruben Garcia-Sanchez. 2024. “Interdental Papilla Reconstruction: A Systematic Review.” *Clinical Oral Investigations* 28(1):101. doi:10.1007/s00784-023-05409-0.
23. Singh, Dhanavendra, Rajesh Jhingran, Vivek Kumar Bains, Rohit Madan, and Ruchi Srivastava. 2019. “Efficacy of Platelet-Rich Fibrin in Interdental Papilla Reconstruction as Compared to Connective Tissue Using Microsurgical Approach.” *Contemporary Clinical Dentistry* 10(4):643–51. doi:10.4103/ccd.ccd_936_18.
24. Trimble, W. S., P. W. Johnson, N. Hozumi, and J. C. Roder. n.d. “Inducible Cellular Transformation by a Metallothionein-Ras Hybrid Oncogene Leads to Natural Killer Cell Susceptibility.” *Nature* 321(6072):782–84. doi:10.1038/321782a0.
25. Truong, Van Mai, Soyeon Kim, Yang-Jin Yi, and Young-Seok Park. 2023. “Food Impaction in Dentistry: Revisited.” *Oral Health & Preventive Dentistry* 21:229–42. doi:10.3290/j.ohpd.b4172837.
26. Truong, Van Mai, Soyeon Kim, Yang-Jin Yi, and Young-Seok Park. 2023. “Food Impaction in Dentistry: Revisited.” *Oral Health & Preventive Dentistry* 21:229–42. doi:10.3290/j.ohpd.b4172837.
27. Zaidi, Abeeha Batool, Atiya Abdul Karim, Sidra Mohiuddin, and Khizra Rehman. 2020. “Effects of Dental Aesthetics on Psycho-Social Wellbeing among Students of Health Sciences.” *JPMA. The Journal of the Pakistan Medical Association* 70(6):1002–5.
28. Ziahosseini, P., F. Hussain, and B. J. Millar. 2014a. “Management of Gingival Black Triangles.” *British Dental Journal* 217(10):559–63. doi:10.1038/sj.bdj.2014.1004.
29. Ziahosseini, P., F. Hussain, and B. J. Millar. 2014b. “Management of Gingival Black Triangles.” *British Dental Journal* 217(10):559–63. doi:10.1038/sj.bdj.2014.1004.