REVIEW

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Minimally invasive procedures using injectable hyaluronic acid gel (HA) for the reconstruction of deficient interdental papillae – a systematic review of the literature.

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Abstract

Introduction: The gingival papilla, also known as the interdental papilla, is the triangular portion of gum tissue that occupies the space between two neighboring teeth. In the anterior region, papillae typically appear more pyramidal, while in the posterior they tend to be more blunted. Its shape and height are determined by factors such as the position of the contact points and the underlying bone structure. When the papilla is absent, it creates a "dark triangle", which can lead to esthetic issues, increased root sensitivity, and a greater risk of plaque accumulation.

Aim of the study: The purpose of the study involves highlighting the minimum invasive reconstruction techniques using the hyaluronic acid for papilla regeneration.

Material and Methods: This article aimed to provide a comprehensive review of the recent techniques used in minimally invasive procedures for papilla regeneration. Relevant literature was identified through a search of electronic databases, including PubMed, ResearchGate, and Google Scholar using the following keywords: "interdental papilla regeneration", "hyaluronic acid", "minimally invasive treatment".

Results: The initial literature search yielded 114 articles. Later a step-by-step selection process was carried out based on clear inclusion criteria. Free-full text versions of the selected articles were then reviewed in detail to ensure they met the inclusion criteria. Based on the analysis performed, 11 articles extracted from literature were used in the present study.

Conclusions: Within the constraints of this study, the application of a commercially available hyaluronic acid (HA) gel for treating interdental papillary deficiency appears to be both effective and promising. However, the current body of evidence is still limited, with few high-quality clinical trials conducted on this technique. Future studies should address larger sample sizes, optimal HA concentrations, and standardized injection protocols to better assess its long-term efficacy and safety.

Keywords: hyaluronic acid, interdental papilla, minimally invasive techniques, regenerative treatment of gingival papilla.

Introduction

The space between two adjacent teeth is occupied by interdental papilla, specifically located in the interproximal area beneath the contact point. This small but essential structure plays several important roles in oral health and function [1].

Esthetically, it contributes significantly to the overall appearance of the smile by creating a harmonious gum line, preventing the formation of unsightly "black triangles" between the teeth [1].

Functionally, the interdental papilla is a protective barrier against food impaction, it reduces the risk of bacterial accumulation and periodontal disease. Additionally, it assists in proper phonation by helping to direct airflow and of sound production during speech [2]. In a healthy state, the embrasure is completely filled by the interdental papilla, with no space between the papilla tip and the contact point. Interdental papilla deficiency and gingival black triangles (GBT) are major esthetic concerns for both patients and clinicians, especially when their size exceeds 3 mm, as they are often considered unattractive [3].

The loss of interdental papilla is commonly observed across various populations, and it tends to become more prevalent with advancing age and the presence of periodontal disease [3,4].

Reconstructing papillary insufficiency remains one of the most complex and demanding procedures in periodontal therapy, because the papilla is a tiny and fragile structure and its blood supply is limited [5].

One of the key factors influencing the presence or loss of the interdental papilla is the

vertical distance from the interproximal contact point to the alveolar bone crest. Research has shown that when this distance is 5mm or less, the papilla is present in nearly 100% of cases. However, when the distance increases to 6 mm, the presence of the papilla drops to approximately 56%. At 7 mm or more, the papilla is present in only about 27% of cases or fewer, highlighting the significant impact of this anatomical relationship on papillary integrity [6-7].

Surgical approaches are often intricate and technique-sensitive, with unpredictable outcomes in papilla regeneration and limited long-term stability [8].

This has led to the development of less invasive treatment options. Among these, tissue volumizing methods using bioactive molecules have emerged as a promising strategy offering the potential for more consistent esthetic and functional results [9].

Hyaluronic acid (HA) is a glycosaminoglycan found in the extracellular matrix of periodontal tissues, and it is synthesized by most cell types. It plays a vital role in tissue repair by promoting cell proliferation, migration and interaction with a range of growth factors. Thanks to its strong water-binding capacity, HA helps maintain tissue volume, improve hydration, lubrication, and elasticity [10].

The study objectives were as follows: to conduct a systematic review of the published literature on the therapeutic effects of injecting HA with the purpose of reconstruction of the gingival papilla, having the aim of gathering and analyzing existing published information on the various uses of hyaluronic acid, with a particular emphasis on its application within the field of periodontology for its anti-inflammatory, healing and regenerative properties [8-10].

Material and Methods

Data Sources and Search Strategy

A comprehensive literature search was executed across three major electronic databases: PubMed, ResearchGate, and GoogleScholar. The search strategy was formulated using a combination of controlled vocabulary (MeSH terms, where applicable) and full-free text keywords to ensure broad coverage of the topic. Key search terms included: "hyaluronic acid", "hyaluronic acid in dentistry", "papilla reconstruction"

The initial search yielded a total of 114 articles (Figure 1).

To refine these results and focus on publications most pertinent to the objective of the review, a stringent set of filters was applied.

A total of 114 articles were initially found through a combined database search using different keyword combinations. To narrow this down and focus on studies relevant to the research topic, a step-by-step selection process was carried out based on clear inclusion criteria.

Free full-text versions of the selected articles were then reviewed in detail to ensure they met the inclusion criteria. Following the application of predefined filters and a thorough eligibility assessment, several studies were excluded based on specific criteria.

These included duplicate datasets (n = 5), studies conducted on animal models (n = 48), and articles that were found to be unrelated to the topic of interest (n = 47).

After this rigorous selection process, a total of only 11 studies that fulfilled the predefined inclusion criteria were selected and incorporated into the final analysis of this systematic review. These studies were included specifically due to their direct focus on evaluating the clinical benefits of hyaluronic acid injections for the reconstruction of the interdental papilla, providing relevant data for the objective of this review.

The selection criteria included:

- Free full text
- No restriction regarding the year of publication
- Only articles published in English were considered
- Conducted on human subjects, no restrictions on race, sex, age, or geographic location
- Not duplicated across multiple source
- Directly relevant to the topic

The exclusion criteria of the study were as follows:

- Articles not available as free full text
- Articles published in languages other than English
- Studies conducted on animals or in vitro
- Duplicate publications across multiple sources
- Articles not directly relevant to the topic

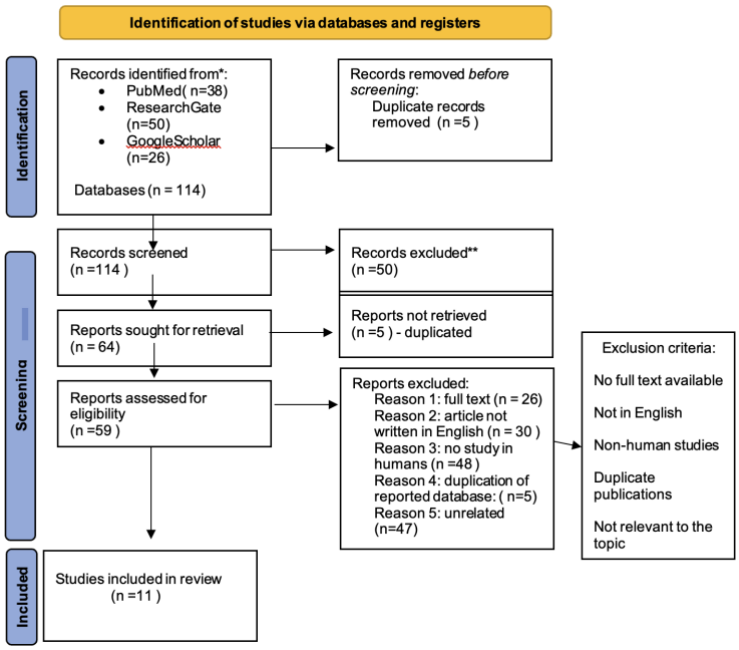

Figure 1. PRISMA Flow Diagram Data

Results

The results of the present research are presented in Table 1.

Table 1. Main outcomes of the included studies.

STUDY AUTHORS (REF. NO.)	YEAR	STUDY TYPE	NO. OF PATIENTS	DEFECTS LOCALIZATION OR NUMBER	TYPE OF HA AND INJECTED QUANTITY	HEALING TIME &/OR STUDY TIME	CONCLUSIONS	RESULT
ABDELRAOUFSA ET AL. [11]	2019	Randomized Clinical Trial	10 – 2 patients excluded	36	0.1 ml	Injections: baseline – 3 weeks-6 weeks intervals 6 months check up Study time: 6 months	Reduction of the black triangles and papilla gain	Not applicable
BERTLK ET AL. [12]	2017	Randomized Clinical Trial	21-patient excluded 2	22	0.12-0.18 ml HA Hyadent Barrier Gel	Study time: 6 months Time points: Baseline 4 weeks 6 months	Improvement in the regeneration of papilla	Height papilla gain: 1.8 mm – 2.3 mm
BARAKAT ET AL. [3]	2025	REVIEW	1	1	1%, 2%, and 5% HA	Study time: 6 months	5% of HA gel showed significant papilla enhancement at 6 months than HA with lower concentrations	The average height increase achieved was about 0.43 mm

ABDEL RAOUF ET AL. [4]	2019	Randomized Clinical Trial	10	36	0.1 ml HA gel	Study time: 6 months Six months – three injections per deficient papilla: first one- 1 week after re-evaluation second injection- 3 weeks third injection -6 weeks	A significantly greater decrease in black triangles height and surface	Not relevant
PATIL ET AL. [5]	2021	Case Series	8	8	<0.2 mL HA	Study time: 3 months - repeated infiltrations up to 2–3 times	Small papillary deficiencies between teeth can be enhanced by the injection of HA gel	Eight sites had complete interdental papilla reconstruction and six sites showed improvements
TANWAR ET AL. [6]	2016	Case Report	1 (24 year old female)	1	< 0.2 ml HA gel	Study time: 3 months – at the 3 weeks recall, another infiltration with 0.2 ml HA was done	Improvements in lost papilla and removal of black triangle	Photography was used to measure the black triangle
AWARTANI, ET AL. [7]	2016	Case series	9 females- 1 patient was excluded after the 3rd visit	17	0.2 ml cross-linked HA clear gel The material used in the present study is a non-animal based, composed primarily of low molecular weight HA	Study time: 6 months – HA injection repeated at 21 days and 42 days	Improvement in the regeneration of papilla	1.2 ± 1.8 mm2 , 0.6 ± 0.9 mm2, 0.7 ± 0.7 mm2 gain
PAL, ET AL. [8]	2021	Case report	7	25	0.2 ml of HA-pure cross-linked GENOSS® (MONALISA, Genoss Co. Ltd., Gyeonggi R&DB Center IF, Suwon-si Yeongtong-gu, Gyeonggi-do, Korea)	Study time: 6 months – just 1 infiltration	improvement in the regeneration of recession defects at 3 and 6 months	Not applicable
SÁNCHEZ ET AL. [9]	2017	CASE REPORT	1	1.1 - 2.1.	1 ml HA used in this clinical case was Vbiotek Mexico 3%.	Infiltrations were accomplished 7, 14, and 21 days after the initial infiltration	Papilla covered all the space found underneath the interproximal contact point, and was found at the same height as adjacent papillae	Not applicable
FIRKOVA ET AL. [10]	2020	Case series	19	57	HA gel, composed of a mixture of cross-linked (1,6%) and natural (0,2%), marketed as HyaDent BG	Study time: 6-months Time point: baseline and after 20 days	Reduction of the black triangles and in the increase of papillary height (papilla gain)	Not relevant

					(BioScience, Germany)- etreatment sites			
ÇANKAYA, ET AL. [14]	2020	Case series	20	200	HA non-cross-linked and HA cross-linked (hyaDENT BG, BioScience) - 0.5 mL and a maximum of 1.5 mL of HA for a single arch	Study time: 24 months Time point: 3 months, 1st year and 2nd year	A significant improvement was determined in the area values	Not relevant
SILVA, ET AL. [13]	2019	case report	1	Between 1.1 2.1 and 2.1. 2.2	Approx. 0.2 ml HA Rennova Fill gel (Innovapharma, São Paulo, Brazil)	Study time: 4 months – injection repeated 2 more times at 21-day intervals	Interdental papilla tissue gain	0.6 to 1.2 mm

Discussions

HA is presently defined as linear glycosaminoglycan formed by di-saccharide units (GAGs) constituted by glucuronic acid and N-acetylglucosamine (NacGlu). HA is assembled by enzymes of the plasmatic membrane. Glycosaminoglycans are long polymers composed of certain repeated di-saccharides, where one or both of them contain a sulfate residue. They are molecules of great volume [3-5].

The high level of cross linking alters the ability of water to bind to HA and thereby creates tissue lift, increases cell division and the tubulin concentration, which helps in the proliferation of fibroblasts [8].

Due to its vast hydration, the extracellular matrix behaves like a gel, this allows tissues possessing high proportions of glycosaminoglycans to withstand strong mechanical pressures, favoring a moreover high rate of substance diffusion among cells. Within the glycosaminoglycans group, HA is the only non-sulfated; it constitutes a special case since it does not form covalent links with other molecules of the extracellular matrix, it is extracellularly synthesized by enzymes located on the cell surface, called hyaluronic acid-synthetases [9, 10].

Hyaluronic acid is commonly found in association with collagen molecules and proteoglycans within the extracellular matrix. Together, these components help maintain tissue flexibility and resilience, support structural integrity, and facilitate smooth movement between cells and tissues. The interaction between hyaluronic acid and these molecules is crucial for sustaining the proper function and homeostasis of connective tissues throughout the body. Its role is especially significant during developmental stages and in areas of the body characterized by rapid cell proliferation, as it aids in facilitating cell movement and migration. By providing a supportive and hydrated extracellular environment, it enables cells to displace more easily, which is essential for processes such as tissue growth, repair, and regeneration [6-8].

Since it is a large and rather inflexible molecule, it fills considerable volume with many free spaces. HA can be considered a union bridge for central proteins, and example of this would be the cartilage union protein [10].

Hyaluronic acid plays the role of axis or structure for large proteoglycan complexes; it adheres to surface receptors which regulate cell migration and proliferation, such as CD44. CD44 is an HA receptor acting as adhesion molecule and expressed in leukocytes, epithelial cells, fibroblasts, and muscle cells. HA plays definitive roles in the genesis, maintenance and resolution of underlying inflammation. It decreases prostaglandin types, which are causes of inflammation, and decreases inflammatory processes, moreover, it

improves collagen disposition, causing better tissue healing and reparation. [9]

Previous studies, such as Sanchez et al. ([9], 2017) and Silva et al. ([13], 2019), confirmed similar outcomes. In clinical cases, the use of HA to regenerate the papilla yielded favorable results. Clinically, the papillae were observed to move in the coronal direction, effectively filling the space beneath the interdental contact point. As a result, the black triangle was no longer visible.

In 2020, Ficho el al. ([15], 2021) conducted a systematic review on the same topic, reporting a 77.4% papillary reconstruction rate after 6 months, with an average of 3.17 applications. Also, Abdelraouf et al. ([4], 2019) and Pal et al. ([8], 2021) observed improvements in the regeneration of recession defects after 6 months.

Considering that multiple studies as Abdelraouf SA et al. ([11], 2019), Patil et al. ([5],2021) , Tanwar et al. ([6], 2016) have demonstrated favorable outcomes using less than 0.2 ml of hyaluronic acid (HA) for the reconstruction of lost interproximal tissue, this method has shown promising potential as a minimally invasive approach. The significant clinical improvements observed – such as increased papillary volume and the reduction or complete elimination of black triangles – suggest that the use of small volumes of HA can be both efficient and effective. Therefore, this technique may serve as a reliable alternative to traditional surgical interventions for soft tissue regeneration, contributing to more conservative treatment protocols in the coming years.

Becker et al. ([16], 2010) concluded that hyaluronic acid (HA) gel is a biocompatible synthetic material, free from drug interactions, and represents a safe and effective option for significantly reducing interdental black triangles in the esthetic zone.

In the studies conducted by Singh et al. ([17], 2019) and Barakat et al. ([3], 2025), various concentrations of hyaluronic acid used in injectable form were compared in order to assess their clinical efficacy. The findings from both studies suggested that a 5% concentration of HA demonstrates superior effectiveness in comparison to lower concentrations such as 2% and 1%.

Considering the limitations of this study, the application of commercially available hyaluronic acid gel appears to be promising and effective option for managing interdental papillary deficiencies.

However, it is essential to provide patients with realistic understanding of the expected outcomes and inform them that repeated HA infiltrations may be necessary over time to maintain or enhance results. Clear and specific treatment indications must be established and patient selection should be carried out with care [1-3].

Conclusions

The minimally invasive reconstruction of lost interdental papillae using hyaluronic acid has emerged as a simple, cost-effective, and predictable technique. It offers a practical solution that meets the esthetic expectations of both patients and dental professionals, with results that can be maintained for at least six months. This conservative approach to managing papillary deficiencies aligns with the increasing demand for non-surgical esthetically focused treatments. As public interest continues to grow in achieving a harmonious and natural-looking smile, the use of hyaluronic acid presents a valuable tool in contemporary dental practice to address these cosmetic concerns. Although initial results are promising, current evidence is limited and further randomized clinical trials are required.

Conflict of interest: None to declare.

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