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Periodontal granulation tissue preservation in surgical periodontal disease treatment: a pilot prospective cohort study

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Author Contributions
Conceptualization: Jose A. Moreno Rodríguez; Formal analysis: Antonio J. Ortíz Ruíz; Investigation: Jose A. Moreno Rodríguez; Methodology: Jose A. Moreno Rodríguez; Project administration: Antonio J. Ortíz Ruíz; Writing - original draft: Jose A. Moreno Rodríguez; Writing - review & editing: Antonio J. Ortíz Ruíz.

ABSTRACT

Purpose: The aim of this study was to evaluate the clinical outcomes of periodontal granulation tissue preservation (PGTP) in access flap periodontal surgery.
Methods: Twenty patients (stage III–IV periodontitis) with 42 deep periodontal pockets that did not resolve after non-surgical treatment were consecutively recruited. Access flap periodontal surgery was modified using PGTP. The clinical periodontal parameters were evaluated at 9 months. The differences in the amount of granulation tissue width (GTw) preserved were evaluated and the influence of smoking was analyzed.
Results: GTw >1 mm was observed in 97.6% of interproximal defects, and the granulation tissue extended above the bone peak in 71.4% of defects. At 9 months, probing pocket depth reduction (4.33±1.43 mm) and clinical attachment gain (CAG; 4.10±1.75 mm) were statistically significant (P<0.001). The residual probing depth was 3.2±0.89 mm. When GTw extended above the interproximal bone peak (i.e., the interproximal supra-alveolar granulation tissue thickness [iSUPRA-GT] was greater than 0 mm), a significant CAG was recorded in the supra-alveolar component (1.67±1.32 mm, P<0.001). Interproximal gingival recession (iGR) was significant (P<0.05) only in smokers, with a reduction in the interdental papillary tissue height of 0.93±0.76 mm. In non-smokers, there was no increase in the iGR when the iSUPRA-GT was >0 mm. The clinical results in smokers were significantly worse.
Conclusions: PGTP was used to modify access flap periodontal surgery by preserving affected tissues with the potential for recovery. The results show that preserving periodontal granulation tissue is an effective and conservative procedure in the surgical treatment of periodontal disease.

Keywords: Bone regeneration; Granulation tissue; Microsurgery; Periodontitis

INTRODUCTION

Periodontal lesions start with dental biofilm accumulation, resulting in a cascade of degenerative changes in periodontal tissues. These changes are characterized by connective tissue inflammatory infiltrate, alterations in the dentogingival junction, the collapse of collagen structures, detachment of periodontal tissues, and bone demineralization, exposing bone collagen and leading to periodontal bone defects [1]. Periodontal tissues recede and heal through the migration of the epithelium and periodontal pocket conformation [2].

However, the periodontal pocket is a scar due to periodontal disease that functions as an anatomic reservoir for biofilm and calculus retention, promoting disease progression [3].

Following non-surgical periodontal treatment, access flap periodontal surgery is needed to complete cause-related therapy for periodontal disease (step III of periodontal therapy) in cases of moderate to advanced periodontitis (stage >II) [4] for unresolved deep periodontal pockets (probing depth [PD] >5 mm and bleeding on probing [BoP]) [5,6]. The objectives are to remove the biofilm and calculus in the deepest aspect, reduce or eliminate pockets, and reattach periodontal tissues [5,6]; conventionally, this is done by resection of the soft wall of the pocket [7,8]. However, this resection-oriented approach changed with the development of biomaterials for tissue regeneration [9], magnification tools [10], and the papilla preservation flap design, which have collectively led to a trend for preserving soft tissue [11-13]. Access flap procedures have several common characteristics: 1) intra-sulcular or para-marginal buccal and lingual incisions, 2) extensive flap elevation to treat affected areas and multiple teeth with deep pockets in the same surgery, 3) periodontal pocket and granulation tissue debridement, 4) root surface detoxification and conditioning, and 5) flap adaptation and suturing. Granulation tissue debridement is one of the main steps [14,15]. However, studies have shown that periodontal granulation tissue contains pluripotential mesenchymal stem cells [16,17], even in infected tissues [18]. The preservation of these cells has been shown to be of vital importance in regeneration [19].

The aim of this study was to describe and present the preliminary results of periodontal granulation tissue preservation (PGTP) in access flap periodontal surgery to complete periodontitis treatment from a conservative/regenerative perspective. The alternative hypothesis of the study was that the preservation of granulation tissue would improve the clinical outcomes of access flap periodontal surgery.

MATERIALS AND METHODS

Study design

We conducted a prospective cohort study to investigate modified surgical treatment of periodontal disease using PGTP. Twenty patients were consecutively treated with access flap periodontal surgery and PGTP. The patients received supportive care, and clinical outcomes were evaluated at 9 months. All patients were informed about the interventions and provided written informed consent. All procedures were conducted in accordance with the guidelines of the World Medical Association Declaration of Helsinki and Good Clinical Practice Guidelines 2013 revision. The study protocol was approved by the Research Ethics Committee of the University of Murcia (Spain) (protocol number: 3111/2020).

Study population

Healthy patients with moderate to advanced periodontitis were included. The inclusion criteria were: 1) stage III or IV periodontitis, including all grades, as evaluated according to the 2017 classification of periodontal and peri-implant disease and conditions [4]; 2) unresolved deep pockets (probing pocket depth [PPD] >5 mm + BoP) 4 to 6 weeks after non-surgical treatment [5,6]; 3) interproximal plaque index <35% [20] maintained during periodontal treatment and maintenance; 4) adherence to periodontal maintenance appointments. The exclusion criteria were: 1) systemic disease contraindicating periodontal surgery, 2) teeth with incorrect endodontic treatment or restoration, and 3) stage I or II periodontitis [4].

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Presurgical procedure

One week before surgery, periodontal pockets and gingival tissues were pre-surgically conditioned using ultrasonic micro-tips, including all roots associated with the pocket. The periodontal pockets were irrigated sub-gingivally with 10% povidone-iodine (polyvinylpyrrolidone-iodine complex [PVP-iodine]). It was required that the soft tissue presented a fibrous aspect with minimal or no inflammation at the time of surgery.

Surgical procedure

All surgical procedures were carried out by the same periodontal surgeon (JAMR) under magnification (×4–10) and using micro-surgical instruments. The surgical area was anesthetized using articaine-epinephrine 1:100.000. Deep periodontal pockets were accessed by a modification of the modified flap operation proposed by Kirkland in 1931 [21]. A sulcular incision was made in the affected teeth, followed by an incision from the buccal aspect in the mid-portion of the interproximal tissues. The tip of the microblade penetrated the mesial pocket in the interproximal space until the deepest mid-portion was reached, and the microblade was distally rotated, incising the deep aspects of the interproximal tissue until contact with the deepest mid-portion of the adjacent tooth root surface. From this point, the microblade was moved apico-coronally, incising and dividing the interproximal soft tissue into 2 portions (the buccal and lingual papilla). The buccal and lingual flaps were elevated with a micro-papillae elevator until they reached the first millimeters of the alveolar crest, delimiting the bone defects, exposing the soft tissue filling, and covering the defects. For PGTP, the flaps were elevated using micro-periosteotomes and the tip of the microblade for the most deeply inserted area, without uncovering the bony surfaces. Soft tissues covering the alveolar crest were prepared. A beveled paramarginal incision following the root contour and in proximity to the root surface was made until contact with the deepest aspect of the intrabony pocket or the bone. This incision separated the pocket epithelium from the soft tissue (granulation tissue) attached to the bone. The pocket epithelium was removed with a micro-curette, taking care not to damage the granulation tissue. The inner aspect of the flap was analyzed and the remains of the pocket epithelial tissue were eliminated from the margin of the flap using micro-scissors or a microblade. The root surfaces were carefully scaled and planed with micro-curettes and micro-ultrasonic tips to remove dental plaque and calculus, preserving any fibers attached to the cementum. Ethylenediaminetetraacetic acid (24%) was applied to the root surfaces and removed after 2 minutes with abundant saline solution. The preserved attached soft tissue and the space between it and the root surface were irrigated with 10% PVP-iodine. Finally, the flaps were positioned and sutured using vertical and horizontal mattress sutures. The number, disposition, and size of the sutures varied according to the width and anatomy of the interproximal tissue in order to achieve maximum tissue adaptation and sealing of the interproximal space (**Figures 1** and **2**).

Postsurgical procedure

Patients were instructed to maintain hygiene in the surgical area using chlorhexidine digluconate 0.2% twice a day for 1 week. Sutures were removed at 1 week and patients were instructed to start brushing with a soft toothbrush and a rolling technique, with interproximal brushing when there were open interproximal spaces. Check-ups took place at 1, 2, 3, and 4 weeks and then every 3 months during the first 9 months, in which patients received periodontal maintenance care to remove any dental plaque or calculus deposits and reinforcement of oral hygiene instructions.

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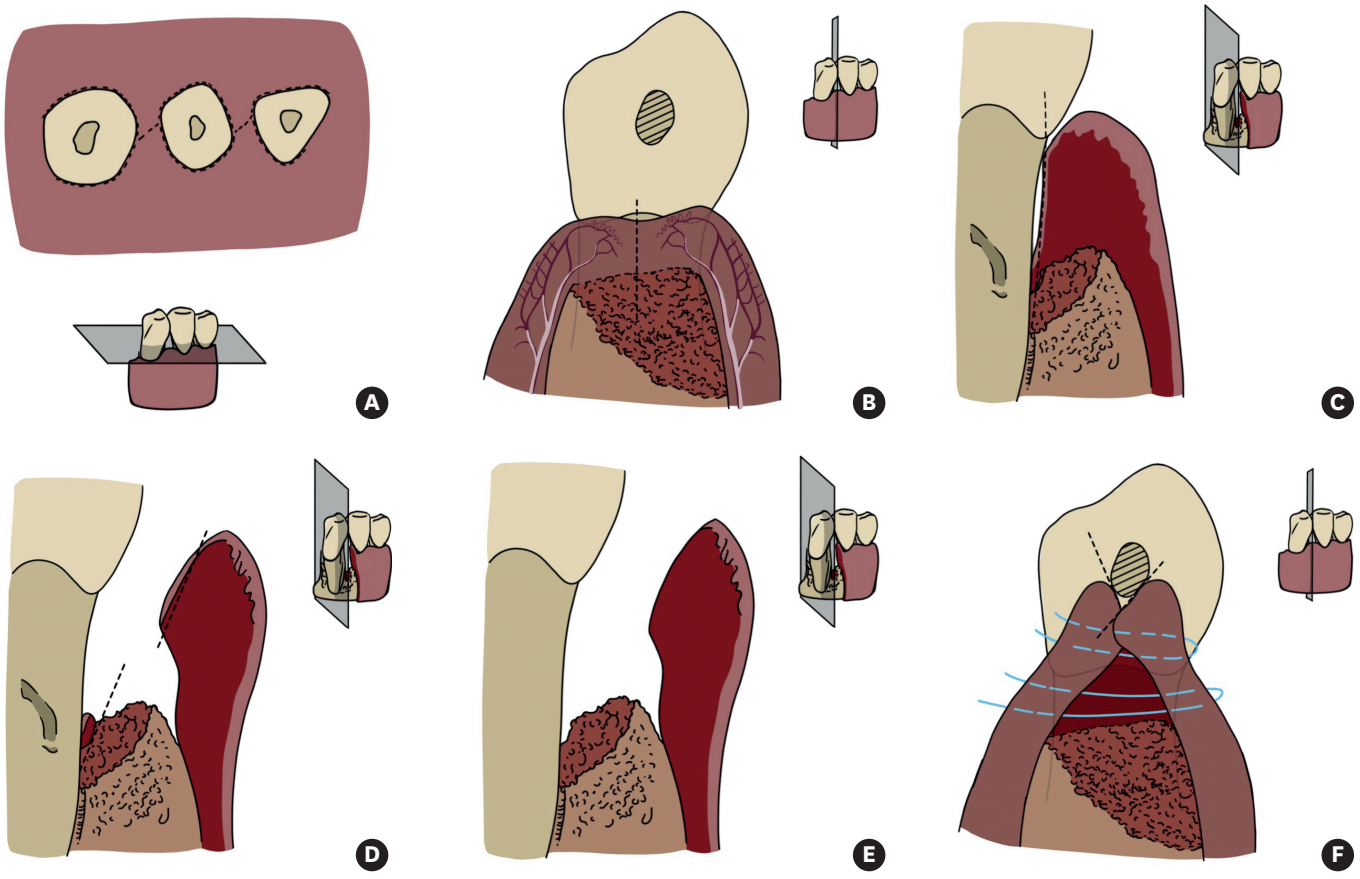

Figure 1. Periodontal granulation tissue preservation in access flap periodontal surgery. Schematic illustrations. (A) Axial view. Flap design and midportion interproximal soft tissue incisions. (B) Lateral view at the interproximal soft tissue level. Supraperiosteal vessels. Granulation tissue filling the bone defect. Incision in the interproximal soft tissue midportion. (C) Lateral section of the dental surface and periodontal pocket. Deep periodontal pocket and granulation tissue filling the bone defect. Residual calculus in deep aspects. Intrasulcular incision. (D) Minimal flap elevation until exposure of the bone defect limits. Granulation tissue preparation: a beveled paramarginal incision to excise deep portion of the periodontal pocket. Excision of the remaining pocket epithelium from the inner aspect of the flap. (E) Granulation tissue preparation, conditioning, and preservation filling the bone defects. Root surface conditioning. (F) Lateral view at interproximal soft tissue level. Internal mattress sutures. Adaptation of tissues and sealing in the interproximal space.

Primary and secondary outcomes

The primary outcome was clinical attachment gain (CAG), and the secondary outcomes were residual PD (rPD), PPD reduction (PPDr), interproximal gingival recession (iGR), the early wound healing index (EHI), and supra-alveolar attachment gain (SUPRA-AG).

Clinical parameters evaluated

Periodontal parameters were recorded using a periodontal probe (PCP UNC 15; Hu-Friedy, Chicago, IL, USA), taking the highest value in the interproximal aspect of each affected tooth as the reference.

The periodontal parameters analyzed at the time of surgery and during follow-up included: 1) BoP, 2) interproximal PPD, 3) interproximal clinical attachment level (CAL), and 4) the tip of the papilla location (TP), taking the buccal cemento-enamel junction (CEJ) zenith as a reference. The difference between baseline and follow-up in CAL was interpreted as the CAG, while the corresponding changes in TP and PPD were interpreted as the iGR and rPD, respectively.

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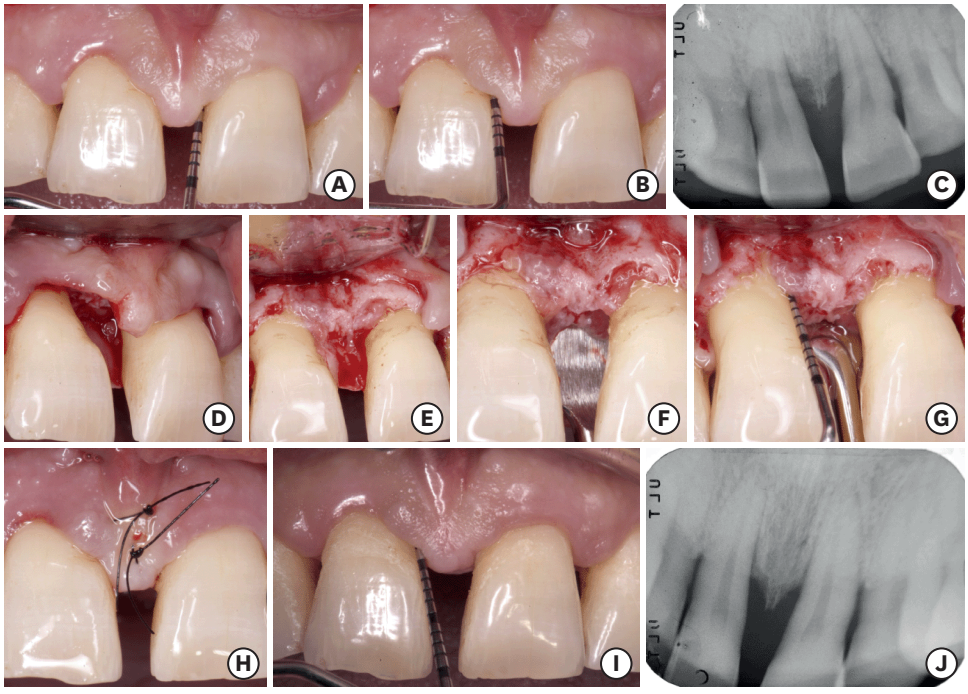

Figure 2. Periodontal granulation tissue preservation in the surgical treatment of periodontal disease. (A, B) Presurgical view. Deep pockets in the upper anterior region not resolved after non-surgical treatment. (C) Periapical X-ray at baseline. Deep pockets with combined intrabony and supra-alveolar components. (D) Flap preparation. Incisions in the midportion of the interproximal soft tissue. (E) Buccal flap elevation and deep bone defects filled and covered by soft tissues. Note the periodontal pocket associated with palatal tissues in close contact with the root surfaces in the upper right incisor. (F) Both flaps are elevated. Soft tissue covering the bone defects and pocket epithelium remains. (G) Granulation tissue prepared by pocket excision. Note the attached bone soft tissues filling and covering the bone above the bony peak in the buccal and interproximal aspects. (H) Suture. (I, J) Follow-up. Residual probing depth and periapical X-ray showing periodontal pocket resolution and improvement of bone defects.

Intraoperatively, the following parameters were recorded before suturing the flaps (**Figure 3**): 1) the intrabony component, measured as the distance from the interproximal bony peak to the bottom of the intrabony defect (INTRA), 2) the suprabony component of the defect (SUPRA) as the distance from the interproximal CEJ to the bone crest, 3) the interproximal supra-alveolar soft tissue thickness (iSUPRA-ST), recorded before lingual flap elevation and measured from the bone crest to the TP, 4) the interproximal supra-alveolar periodontal granulation tissue (iSUPRA-GT), measured from the interproximal bony peak to the crest of the soft tissue inserted and preserved interproximally, with a negative value when the granulation tissue was located below the bony peak (**Figure 4**), 5) the periodontal granulation tissue width (GTw), measured in the interproximal aspect from the bottom of the defect to the crest of the preserved granulation tissue. The EHI was recorded 1 week after surgery [22] and the SUPRA-AG nine months post-surgery [23].

Statistical analysis

The sample size (minimum, n=11) was calculated to recognize a mean CAG value [24] of 1.34 mm with a standard deviation of 1.5 mm, accepting an alpha risk of 0.05 and a beta risk of 0.2 in a 2-sided test, with a drop-out rate of 10%.

We conducted a descriptive analysis of patient characteristics, the morphology of the defects, and the pre- and post-surgical measurements at 9 months. Values are expressed as means

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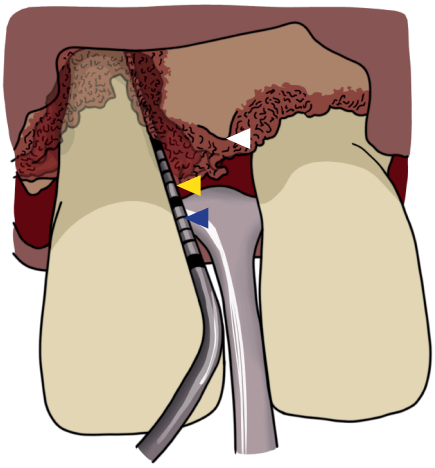

Figure 3. Intraoperative measurements. The intrabony component, measured as the distance from the interproximal bone peak (white arrow) to the bottom of the intrabony defect. The suprabony component of the defect, measured from the interproximal cemento enamel junction (blue arrow) to the bone crest (white arrow). Periodontal granulation tissue width, measured from the bottom of the defect to the crest of the preserved granulation tissue (yellow arrow). Supra-alveolar periodontal granulation tissue, measured from the interproximal bony peak (white arrow) to the crest of the soft tissue preserved interproximally (yellow arrow).

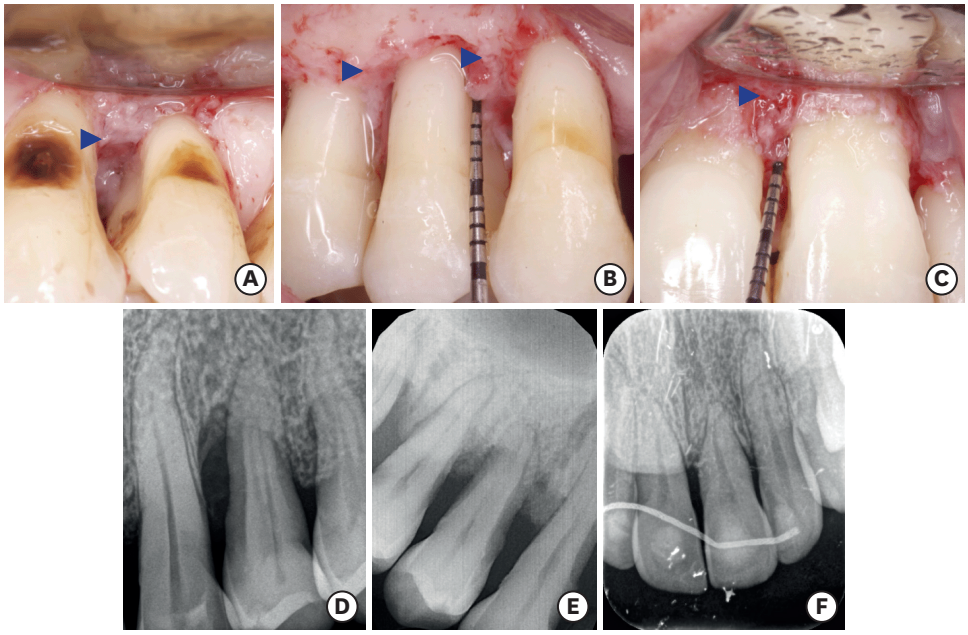

Figure 4. Periodontal granulation tissue preserved in different situations. Dark blue arrow indicates the interproximal bone peak. Intrasurgical photo and periapical X-ray. (A, D) Periodontal granulation tissue limited to the intrabony defects. (B, E) Periodontal granulation tissue filling the intrabony defects and extending to the supra-alveolar components. (C, F) Periodontal granulation tissue in supra-alveolar defects present in the interproximal and buccal aspect.

and SD. The Shapiro-Wilk normality test and the Levene equality of variance test were applied. Between-group comparisons were made using the t-test when there was normality and homogeneity of variance and the Mann-Whitney test when there was not. To detect differences in the evolution of the main outcomes, the paired *t*-test was used when there was normality and homogeneity of variance and the Wilcoxon test when there was not.

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We considered smoking status (smoker/non-smoker) and iSUPRA-GT as covariates. A value of $P<0.05$ was considered to indicate statistical significance. The analysis was conducted using R statistical software version 4.1.0.

RESULTS

Baseline patient and defect characteristics

The baseline patient and defect characteristics are shown in **Tables 1-3.** Forty-two deep periodontal pockets in 20 patients (age range, 35–70 years) with BoP that remained unresolved after non-surgical treatment were included. The non-smoker/smoker ratio was 2.33. At baseline, PPD ranged from 6 mm to 12 mm (7.62±1.50 mm) and CAL from 6 mm to 14 mm (8.14±1.76 mm). INTRA ranged from 1 to 9 mm (3.33±1.52 mm), SUPRA from 3 to 9 mm (5.05±1.65 mm) and iSUPRA-ST from 3 mm to 9 mm (5.00±1.45). Granulation tissue was located predominantly in the interproximal aspect and the GTw ranged from 0 to 12 mm, with only 1 interproximal area not having available granulation tissue after flap elevation. GTw >1 mm was observed in 97.6% of interproximal defects and in 71.4% of defects, the preserved granulation tissue was above the interproximal bony peak.

Table 1. Patient and defect characteristics

Characteristics	Values
Patients	20
Smoker/non-smoker	6/14
Defects	42
Sex (male/female)	M10/F10
Age (yr)	45.90±8.73
Dental arch (upper/lower)	33/9
Tooth type (Incisors/canines/premolars/molars)	13/5/17/7
Intraoperative measurements (mm)	
SUPRA	5.05±1.65
iSUPRA-ST	5.00±1.45
INTRA	3.33±1.52
iSUPRA-GT	1.31±1.57
GTw	4.81±1.90

Data are shown as mean±SD.
SUPRA: suprabony component of the defect, INTRA: intrabony defect, iSUPRA-ST: interproximal supra-alveolar soft tissue, iSUPRA-GT: interproximal supra-alveolar granulation tissue, GTw: granulation tissue width.

Table 2. Clinical measurements

Parameters	Baseline	9 Months	Change	Significance, *P*
PPD	7.62±1.50	3.29±0.89[a]	4.33±1.43[b]	$P<0.001$[e]
Smoker	7.85±1.52	4.08±0.76[a]	3.77±1.48[b]	$P<0.001$[e]
Non-smoker	7.51±1.50	2.93±0.70[a]	4.59±1.35[b]	$P<0.001$[e]
Significance, *P*	$P=0.451$[f]	$P<0.001$[f]	$P=0.061$[f]	
CAL	8.14±1.76	4.05±1.59	4.10±1.75[c]	$P<0.001$[e]
Smoker	8.38±2.43	5.23±1.74	3.15±1.57[c]	$P<0.001$[g]
Non-smoker	8.03±1.40	3.51±1.21	4.51±1.68[c]	$P<0.001$[g]
Significance, *P*	$P=0.967$[f]		$P=0.018$[h]	
TP[d]	1.60±1.62	1.26±1.77	0.33±0.69	$P=0.003$[e]
Smoker	1.54±1.51	0.61±1.71	0.93±0.76	$P<0.001$[g]
Non-smoker	1.62±1.70	1.55±1.74	0.07±0.45	$P=0.50$[e]
Significance, *P*	$P=0.911$[f]		$P<0.001$[f]	

Data are shown as mm±SD.
PPD: probing pocket depth, CAL: clinical attachment level, TP: tip of the papilla.
[a]PPD at 9 months= residual PPD; [b]PPD change=PPD reduction; [c]CAL change=clinical attachment gain; [d]TP change=interproximal gingival recession. A positive value of TP indicates apical displacement of the papillae; [e]Wilcoxon test; [f]Mann-Whitney; [g]Paired *t*-test; [h]*t*-test.

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Table 3. Clinical measurements

EHI	1.98±1.28	SUPRA-AG[a]	1.00±1.58
Smoker	3.23±1.09	Smoker	0.15±0.99
Non-smoker	1.14±0.91	Non-smoker	1.38±1.66
Significance, *P*	*P*<0.001[b]	Significance, *P*	*P*=0.014[b]

Data are shown as mm±SD.
EHI: early wound healing index, SUPRA-AG: supra-alveolar attachment gain.
[a]A positive value of SUPRA-AG indicates complete resolution of the intrabony defect; [b]Mann-Whitney.

Surgical outcomes

Complete wound closure (EHI=1–3) was achieved in 71.4% of interproximal spaces during early healing, with fibrin formation in the line of incision in 42.8%. There was partial necrosis (EHI=4) in 16.6% of the interproximal spaces, but no case of complete necrosis of the interproximal tissue. All cases of necrosis were recorded in smokers (53.8% of interproximal spaces). The EHI could not be evaluated in 12% of the remaining interproximal spaces because the soft tissue had completely sealed the interproximal space, meaning the incision line could not be visualized. No post-surgical bleeding or swelling was recorded during the immediate post-surgical period.

The clinical results at 9 months are shown in **Tables 2** and **3**. A positive BoP was recorded in 9.5% of interproximal pockets, all in smokers. PPDr (4.33±1.43 mm; range, 2–9 mm) and CAG (4.10±1.75 mm; range 1 to 9 mm) were statistically significant (*P*<0.001). A positive value was obtained for SUPRA-AG. rPD was 3.29±0.89 mm (range, 2–5 mm). One-third of interproximal pockets had an rPD of ≥4 mm. In the 5 residual pockets with rPD=5 mm, BoP was recorded in 3 pockets, and in 1 of the 9 residual pockets with rPD=4 mm. Changes in TP (i.e., iGR) were significant (*P*<0.05) with a decrease in the papilla height of 0.33±0.69 mm. The iGR was significant (0.93±0.76 mm, *P*<0.001) in smokers, but there was no significant change in TP in non-smokers. The clinical results showed significant differences between smokers and non-smokers in terms of the EHI (*P*<0.001), rPD (*P*<0.001), CAG (*P*<0.05), iGR (*P*<0.001) and SUPRA-AG (*P*<0.05), with worse results in smokers (**Tables 2** and **3**).

To evaluate the influence of GTw on the clinical results, the interproximal bony peak was taken as a reference, and we distinguished between the tissue preserved coronally to the bony peak (iSUPRA-GT >0 mm) and tissue limited to the intrabony component (iSUPRA-GT ≤0 mm) (**Tables 4** and **5**): significant differences were found in the SUPRA-AG (*P*<0.001). Attachment gain was observed in the supra-alveolar component (positive SUPRA-AG) when the preserved granulation tissue was coronal to the bony peak (iSUPRA-GT >0 mm), and attachment gain was noted below the bony peak (negative SUPRA-AG) when the granulation tissue was limited to the intrabony component (iSUPRA-GT ≤0 mm). A significant difference

Table 4. Changes in clinical parameters in patients with different granulation tissue preservation width

Variables (mm)	iSUPRA-GT ≤0 (n=12)	iSUPRA-GT >0 (n=30)	Significance, *P*
rPD	3.42±0.90	3.23±0.90	*P*=0.599[d]
PPDr	3.83±1.11	4.53±1.50	*P*=0.133[d]
CAG	3.41±1.44	4.37±1.81	*P*=0.113[c]
TP change[a]	0.50±0.67	0.27±0.69	*P*=0.189[d]
SUPRA-AG[b]	−0.67±0.65	1.67±1.32	*P*<0.001[d]

Data are shown as mm±SD.
iSUPRA-GT: interproximal supra-alveolar granulation tissue, rPD: residual probing depth, PPDr: probing pocket depth reduction, CAG: clinical attachment gain, TP: tip of the papilla, SUPRA-AG: supra-alveolar attachment gain.
[a]A positive value in iGR indicates papillae apical displacement; [b]A negative value of SUPRA-AG indicates incomplete resolution of the intrabony defect; [c]*t*-test; [d]Mann-Whitney.

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Table 5. Changes in clinical parameters in patients with different granulation tissue preservation width

Variables (mm)	Smoker			Non-smoker		
	iSUPRA-GT ≤0 (n=6)	iSUPRA-GT >0 (n=7)	Significance, *P*	iSUPRA-GT ≤0 (n=6)	iSUPRA-GT >0 (n=23)	Significance, *P*
rPD	4.00±0.89	4.14±0.69	*P*=0.751[c]	2.83±0.41	2.96±0.77	*P*=0.852[d]
PPDr	3.33±0.82	4.14±1.86	*P*=0.445[d]	4.33±1.21	4.65±1.40	*P*=0.615[c]
CAG	2.83±0.75	3.43±2.07	*P*=0.836[d]	4.00±1.79	4.65±1.67	*P*=0.408[c]
iGR[a]	0.50±0.55	1.29±0.76	*P*=0.101[d]	0.50±0.84	−0.04±0.21	*P*=0.013[d]
SUPRA-AG[b]	−0.67±0.52	0.86±0.69	*P*<0.001[c]	−0.67±0.82	1.91±1.38	*P*<0.001[d]

Data are shown as mm±SD.
rPD: residual probing depth, PPDr: probing pocket depth reduction, CAG: clinical attachment gain, iGR: interproximal gingival recession, SUPRA-AG: supra-alveolar attachment gain.
[a]A positive value in iGR indicates papillae apical displacement; [b]A negative value of SUPRA-AG indicates incomplete resolution of the intrabony defect; [c]*t*-test; [d]Mann-Whitney.

was observed in TP ($P<0.05$) in non-smokers, with preservation of the interproximal soft tissue when the granulation tissue above the interproximal bony peak was preserved (iSUPRA-GT >0 mm).

DISCUSSION

The main objective of PGTP is to preserve the affected periodontal tissues with regenerative potential to counteract undesirable surgical effects and improve the clinical outcomes of periodontal surgery. Access flap periodontal surgery and PGTP were performed in patients with stage III or IV periodontal disease [4] to treat isolated and multiple contiguous unresolved deep pockets after steps I and II of periodontal therapy [5,6].

The periodontal pockets were assessed using the modified operation flap proposed by Kirkland in 1931 [21] to reduce damage to the blood supply of the gingival tissues. Periodontal disease increases the supra-alveolar soft tissue width, mainly irrigated by the supraperiosteal vessels. The access flap cuts off these vessels and severely damages the blood perfusion of marginal tissues [25,26]. The intention of the modified flap [21] is to incise the interproximal tissues at the midline, thereby preserving more supraperiosteal vessels to supply blood to the buccal/lingual papilla. Wound healing depends on the damage to the blood supply, and the recovery time and healing determine clinical outcomes [22,27]. Incision line dehiscence, fibrin formation, and tissue necrosis delay the healing process and increase the risk of bacterial contamination and the formation of inflammatory infiltrate and may result in soft tissue collapse or loss and incomplete defect resolution [22,28]. We found partial necrosis of the interproximal tissue in 1 of 6 interproximal pockets treated, always in smokers (50% of interproximal pockets in smokers presented partial necrosis). Few studies have analyzed early healing by means of access surgery, and the results vary according to the design of the flap. In a study in which microsurgical access was made using a papilla preservation design, necrosis of the interproximal tissue was recorded in 11.1% of interproximal spaces, although only intrabony defects were treated [22]. Another study analyzed healing in supra-alveolar defects using a single flap approach, and recorded necrosis of the interproximal tissue in 30% of interproximal tissues treated [29].

The main objective of surgical treatment for periodontal disease is to resolve the periodontal pocket by clinical reattachment with minimal consequences for the marginal soft tissue. However, clinical studies of access flap periodontal surgery have reported different outcomes. Access flap periodontal surgery is used in extensively affected areas with advanced loss of support and increased supra-alveolar soft tissue width, in which optimal wound stability may

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not always be achieved, imposing surgical limitations and, consequently, undesirable clinical outcomes that surgical modifications try to reduce. Papilla preservation flaps with or without the use of biomaterials have been used in supra-alveolar defects in non-smokers, and at 1 year, the main results were rPD=4.12±0.83 mm and CAG=1.04±0.61 mm [30]. Access flap microsurgery alone with a papilla preservation incision was used in patients including smokers (<10 cigarettes/day) and the results were rPD=4.4±1.1 mm and CAG=1.7±1.4 mm [22]. In other studies using access flap periodontal surgery alone and without papilla preservation flap designs, the results at 1 year were rPD=4±1.03 mm, and CAG=0.83±0.86 mm [31], rPD=3.66±0.83 mm and CAG=0.07±0.55 mm [32]; rPD=4.9±0.7 mm and CAG=1.8±1.0 mm [33], rPD=4.9±1.8 mm [34]; CAG=2.8±0.6mm [35]; and rPD=3.7±1.3 mm and CAG=2.5±0.8 mm [36].

Interproximal attachment is a key factor in the prognosis of periodontal disease [37]. An increase in iGR decreases the amount of interproximal attachment that may be achieved. However, few studies have analyzed iGR, which is one of the most frequent and undesirable secondary effects in access flap periodontal surgery [8]. Using access flap periodontal surgery with papilla preservation flaps, with a single flap for the treatment of severe supra-alveolar defects [29] or 2 flaps [38] for the treatment of severe combined supra-alveolar and intrabony defects, a significant iGR (1.0±1.1 mm and 0.85±1.31 mm, respectively) was found at 1 year. Both studies included smokers (<10 cigarettes/day). The present study also included smokers, and the preliminary clinical outcomes (rPD=3.29±0.89 mm, CAG=4.10±1.75 mm, iGR=0.33±0.69 mm) showed improvements compared to the results of most previous studies using access flap periodontal surgery alone without preservation of the granulation tissue. A significant iGR (0.93±0.76 mm) may be expected in smokers, but in non-smokers no significant changes in the interdental papillary tissue were observed.

As a result of the incision and elevation of the flaps, the periodontal pockets are usually divided into 2 parts: the apical part of the periodontal pocket is united with the soft, fibrous tissue inserted in the alveolar bone, filling the bony defects, while the marginal part is united with the internal face of the flap. The superficial layer of the inner part of the flap is examined directly and the remnants of the pocket epithelium are removed, together with a minimal part of the connective tissue, to avoid soft tissue recession. The novel modification with PGTP is that the attached soft tissues covering and filling the bone defects are preserved, prepared, and conditioned. Firstly, the flaps are elevated avoiding exposure of the bone in the defect margins. Secondly, the epithelium of the pocket is excised from the granulation tissue by a beveled incision close to the root, removing periodontal scarring, and the granulation tissue is isolated. Thirdly, the granulation tissue is disinfected using PVD-iodine. Some studies have analyzed the granulation tissue excised from periodontal lesions during surgical treatment of deep pockets unresolved after non-surgical treatment [18,39] and found cells that expressed markers of embryonic stem cells [18], with characteristics similar to those found in healthy periodontal tissue [39]. This suggests that periodontal granulation tissue has the potential for regeneration. In addition, bacteria are occasionally found [18]. We used PVD-iodine to aid in disinfection of the potentially infected granulation tissue. The addition of PVP-iodine irrigation to mechanical therapy has been shown to be effective in reducing periodontal pathogens, with significant clinical results [40]. Therefore, periodontal granulation tissue may be considered an affected tissue with regenerative potential, and its removal as a resective procedure within the surgical approach.

Periodontal granulation tissue is formed as a result of periodontal inflammation and the disease course, and its condition depends on the inflammatory activity [2]. The active

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phase is associated with a connective tissue rich in inflammatory infiltrate, collagen destruction, and the proliferation of the pocket epithelium [2]. Pre-surgical periodontal tissue conditioning may help to provisionally halt the destructive phase, preserve residual collagen fibers, and increase the delimitation between the organized collagen fibers and the connective tissue with advanced denaturalized fibers together in the superficial layer of the periodontal pocket. Therefore, pre-surgical control of inflammation may increase the availability of granulation tissue and facilitate its intraoperative detection and manipulation. In periodontal surgery, after elevating both flaps and removing the pocket epithelium from the soft tissues filling the bone defect and covering the alveolar crest, the rest of the soft tissue was examined to determine which part of the granulation tissue should be removed and which preserved. Only tissue with a solid consistency attached to the bone and/or the root surface was preserved—that is, the periodontal tissue with more organized collagen fibers and less destruction caused by periodontitis.

The surgical treatment of periodontal disease includes the removal of granulation tissue and the treatment of the root surface. Posteriorly, the flaps are adapted over the bony peaks of the defect, producing a collapse in the supra-alveolar component. Using PGTP, we found that the granulation tissue may occupy a thickness of 4.81±1.90 mm and extend to 1.31±1.57 mm in the supra-alveolar compartment. The amount of granulation tissue preserved does not seem to influence the resolution of the periodontal pocket (rPD). However, after analysis of CAG with respect to the interproximal bony peak (SUPRA-AG), granulation tissue preservation showed a trend for the resolution of intrabony defects (positive SUPRA-AG) and extension of the attachment gain above the bony peak. In non-smokers, when the granulation tissue in the supra-alveolar component was preserved, the preservation of the interdental papillary tissues was greater and significantly reduced post-surgical iGR. Therefore, preservation of the granulation tissue above the bony peaks seems to aid the maintenance of stability and prevent the collapse of soft tissues.

In all cases in the present study, magnification was used to perform surgery. Magnification is essential in the surgical treatment of periodontitis for several reasons: decontamination or calculus removal without magnification might not guarantee the cleanliness of the root surface [41]; magnification assists in less invasive management of the soft tissues [10], thereby improving early wound healing [22], and permits the preservation of residual inserted periodontal fibers [10].

Smoking has a negative influence on the treatment of periodontal disease. We found that smoking negatively influenced healing and the contraction of interproximal soft tissue in the resolution of the residual pocket and clinical reattachment. Smoking is a frequent factor in moderate and advanced periodontal disease [42] and its control is as important as treating the etiology of the disease. However, periodontal disease treatment (steps I to III) [5,6] is often carried out in patients unable to stop smoking.

Despite the limitations of a pilot study, we found that preservation of granulation tissue may improve the clinical results of periodontal surgery. Using PGTP, the soft tissues that remain inserted in the bony defects after flap elevation are prepared, conditioned, and disinfected to avoid the removal of tissue with the potential to recover. The width of the preserved granulation tissue is directly related to the attachment gain and the preservation of the interproximal soft tissue. Smoking is a negative prognostic factor that is decisive for the clinical outcome.

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REFERENCES

1. Henderson B, Kaiser F. Bacterial modulators of bone remodeling in the periodontal pocket. Periodontol 2000 2018;76:97-108.
PUBMED | CROSSREF
2. Bosshardt DD. The periodontal pocket: pathogenesis, histopathology and consequences. Periodontol 2000 2018;76:43-50.
PUBMED | CROSSREF
3. Sculean A, Gruber R, Bosshardt DD. Soft tissue wound healing around teeth and dental implants. J Clin Periodontol 2014;41 Suppl 15:S6-22.
PUBMED | CROSSREF
4. Tonetti MS, Greenwell H, Kornman KS. Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. J Periodontol 2018;89 Suppl 1:S159-72.
PUBMED | CROSSREF
5. Caffesse RG, Echeverría JJ. Treatment trends in periodontics. Periodontol 2000 2019;79:7-14.
PUBMED | CROSSREF
6. Sanz M, Herrera D, Kebschull M, Chapple I, Jepsen S, Beglundh T, et al. Treatment of stage I-III periodontitis-The EFP S3 level clinical practice guideline. J Clin Periodontol 2020;47 Suppl 22:4-60.
PUBMED | CROSSREF
7. Ramfjord SP, Nissle RR. The modified widman flap. J Periodontol 1974;45:601-7.
PUBMED | CROSSREF
8. Jenkins WM, Wragg PF, Gilmour WH. Formation of interdental soft tissue defects after surgical treatment of periodontitis. J Periodontol 1990;61:564-70.
PUBMED | CROSSREF
9. Miron RJ, Sculean A, Cochran DL, Froum S, Zucchelli G, Nemcovsky C, et al. Twenty years of enamel matrix derivative: the past, the present and the future. J Clin Periodontol 2016;43:668-83.
PUBMED | CROSSREF
10. Cairo F, Carnevale G, Billi M, Prato GPP. Fiber retention and papilla preservation technique in the treatment of infrabony defects: a microsurgical approach. Int J Periodontics Restorative Dent 2008;28:257-63.
PUBMED
11. Takei HH, Han TJ, Carranza FA Jr, Kenney EB, Lekovic V. Flap technique for periodontal bone implants. Papilla preservation technique. J Periodontol 1985;56:204-10.
PUBMED | CROSSREF
12. Cortellini P, Prato GP, Tonetti MS. The modified papilla preservation technique. A new surgical approach for interproximal regenerative procedures. J Periodontol 1995;66:261-6.
PUBMED | CROSSREF
13. Cortellini P, Prato GP, Tonetti MS. The simplified papilla preservation flap. A novel surgical approach for the management of soft tissues in regenerative procedures. Int J Periodontics Restorative Dent 1999;19:589-99.
PUBMED
14. Knowles JW, Burgett FG, Nissle RR, Shick RA, Morrison EC, Ramfjord SP. Results of periodontal treatment related to pocket depth and attachment level. Eight years. J Periodontol 1979;50:225-33.
PUBMED | CROSSREF
15. Kaldahl WB, Kalkwarf KL, Patil KD, Molvar MP, Dyer JK. Long-term evaluation of periodontal therapy: I. Response to 4 therapeutic modalities. J Periodontol 1996;67:93-102.
PUBMED | CROSSREF
16. Park JC, Kim JM, Jung IH, Kim JC, Choi SH, Cho KS, et al. Isolation and characterization of human periodontal ligament (PDL) stem cells (PDLSCs) from the inflamed PDL tissue: in vitro and in vivo evaluations. J Clin Periodontol 2011;38:721-31.
PUBMED | CROSSREF
17. Gousopoulou E, Bakopoulou A, Apatzidou DA, Leyhausen G, Volk J, Staufenbiel I, et al. Evaluation of stemness properties of cells derived from granulation tissue of peri-implantitis lesions. Clin Exp Dent Res 2021;7:739-53.
PUBMED | CROSSREF
18. Ronay V, Belibasakis GN, Schmidlin PR, Bostanci N. Infected periodontal granulation tissue contains cells expressing embryonic stem cell markers. A pilot study. Schweiz Monatsschr Zahnmed 2013;123:12-6.
PUBMED

19. Lin NH, Menicanin D, Mrozik K, Gronthos S, Bartold PM. Putative stem cells in regenerating human periodontium. J Periodontal Res 2008;43:514-23.
PUBMED | CROSSREF

20. Lange DE, Plagmann HC, Eenboom A, Promesberger A. Clinical methods for the objective evaluation of oral hygiene. Dtsch Zahnarztl Z 1977;32:44-7.
PUBMED

21. Kirkland O. Modified flap operation in surgical treatment of periodontoclasia. J Am Dent Assoc 1932;19:1918-21.

22. Wachtel H, Schenk G, Böhm S, Weng D, Zuhr O, Hürzeler MB. Microsurgical access flap and enamel matrix derivative for the treatment of periodontal intrabony defects: a controlled clinical study. J Clin Periodontol 2003;30:496-504.
PUBMED | CROSSREF

23. Moreno Rodríguez JA, Ortiz Ruiz AJ, Caffesse RG. Supra-alveolar attachment gain in the treatment of combined intra-suprabony periodontal defects by non-incised papillae surgical approach. J Clin Periodontol 2019;46:927-36.
PUBMED | CROSSREF

24. Nibali L, Koidou VP, Nieri M, Barbato L, Pagliaro U, Cairo F. Regenerative surgery versus access flap for the treatment of intra-bony periodontal defects: a systematic review and meta-analysis. J Clin Periodontol 2020;47 Suppl 22:320-51.
PUBMED | CROSSREF

25. Retzepi M, Tonetti M, Donos N. Comparison of gingival blood flow during healing of simplified papilla preservation and modified Widman flap surgery: a clinical trial using laser Doppler flowmetry. J Clin Periodontol 2007;34:903-11.
PUBMED | CROSSREF

26. Retzepi M, Tonetti M, Donos N. Gingival blood flow changes following periodontal access flap surgery using laser Doppler flowmetry. J Clin Periodontol 2007;34:437-43.
PUBMED | CROSSREF

27. Haney JM, Nilvéus RE, McMillan PJ, Wikesjö UM. Periodontal repair in dogs: expanded polytetrafluoroethylene barrier membranes support wound stabilization and enhance bone regeneration. J Periodontol 1993;64:883-90.
PUBMED | CROSSREF

28. De Sanctis M, Zucchelli G, Clauser C. Bacterial colonization of barrier material and periodontal regeneration. J Clin Periodontol 1996;23:1039-46.
PUBMED | CROSSREF

29. Simonelli A, Minenna L, Trombelli L, Farina R. Single flap approach with or without enamel matrix derivative in the treatment of severe supraosseous defects: a retrospective study. Clin Oral Investig 2021;25:6385-92.
PUBMED | CROSSREF

30. Di Tullio M, Femminella B, Pilloni A, Romano L, D'Arcangelo C, De Ninis P, et al. Treatment of supra-alveolar-type defects by a simplified papilla preservation technique for access flap surgery with or without enamel matrix proteins. J Periodontol 2013;84:1100-10.
PUBMED | CROSSREF

31. Okuda K, Momose M, Miyazaki A, Murata M, Yokoyama S, Yonezawa Y, et al. Enamel matrix derivative in the treatment of human intrabony osseous defects. J Periodontol 2000;71:1821-8.
PUBMED | CROSSREF

32. Jentsch H, Purschwitz R. A clinical study evaluating the treatment of supra-alveolar-type defects with access flap surgery with and without an enamel matrix protein derivative: a pilot study. J Clin Periodontol 2008;35:713-8.
PUBMED | CROSSREF

33. Kasaj A, Röhrig B, Reichert C, Willershausen B. Clinical evaluation of anorganic bovine-derived hydroxyapatite matrix/cell-binding peptide (P-15) in the treatment of human infrabony defects. Clin Oral Investig 2008;12:241-7.
PUBMED | CROSSREF

34. Sculean A, Kiss A, Miliauskaite A, Schwarz F, Arweiler NB, Hannig M. Ten-year results following treatment of intra-bony defects with enamel matrix proteins and guided tissue regeneration. J Clin Periodontol 2008;35:817-24.
PUBMED | CROSSREF

35. Slotte C, Asklöw B, Sultan J, Norderyd O. A randomized study of open-flap surgery of 32 intrabony defects with and without adjunct bovine bone mineral treatment. J Periodontol 2012;83:999-1007.
PUBMED | CROSSREF

36. Cortellini P, Buti J, Pini Prato G, Tonetti MS. Periodontal regeneration compared with access flap surgery in human intra-bony defects 20-year follow-up of a randomized clinical trial: tooth retention, periodontitis recurrence and costs. J Clin Periodontol 2017;44:58-66.
PUBMED | CROSSREF

37. Rasperini G, Tavelli L, Barootchi S, McGuire MK, Zucchelli G, Pagni G, et al. Interproximal attachment gain: the challenge of periodontal regeneration. J Periodontol 2021;92:931-46.
PUBMED | CROSSREF

38. Moreno-Rodríguez JA, Ortiz-Ruiz AJ. Papilla preservation periodontal surgery in periodontal reconstruction for deep combined intra-suprabony defects. Retrospective analysis of a registry-based cohort. J Clin Exp Dent 2021;13:e769-75.
PUBMED | CROSSREF

39. Apatzidou DA, Nile C, Bakopoulou A, Konstantinidis A, Lappin DF. Stem cell-like populations and immunoregulatory molecules in periodontal granulation tissue. J Periodontal Res 2018;53:610-21.
PUBMED | CROSSREF

40. Hoang T, Jorgensen MG, Keim RG, Pattison AM, Slots J. Povidone-iodine as a periodontal pocket disinfectant. J Periodontal Res 2003;38:311-7.
PUBMED | CROSSREF

41. Liao H, Zhang H, Xiang J, Chen G, Cao Z. The effect of the surgical microscope on the outcome of root scaling. Am J Transl Res 2020;12:7199-210.
PUBMED

42. Chang J, Meng HW, Lalla E, Lee CT. The impact of smoking on non-surgical periodontal therapy: a systematic review and meta-analysis. J Clin Periodontol 2021;48:60-75.
PUBMED | CROSSREF

https://doi.org/10.5051/jpis.2105780289