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Single-flap versus double-flap approach for periodontal pocket reduction in supraosseous defects: a comparative study

Venkata Lakshmi Mathala, Santosh Venkata Ramesh Konathala *, Naga Venkata Satya Sruthima Gottumukkala, Mohan Kumar Pasupuleti, Vivek Bypalli, Radharani Korukonda

Department of Periodontics, Vishnu Dental College, Bhimavaram, India

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***Correspondence:**
Santosh Venkata Ramesh Konathala
Department of Periodontics, Vishnu Dental College, Vishnupur, Bhimavaram, Andhra Pradesh 534202, India.
E-mail: rameshksv@vdc.edu.in
Tel: +91-8886157669

ORCID iDs
Venkata Lakshmi Mathala
https://orcid.org/0000-0002-5995-906X
Santosh Venkata Ramesh Konathala
https://orcid.org/0000-0001-7022-0023
Naga Venkata Satya Sruthima Gottumukkala
https://orcid.org/0000-0002-7126-5829
Mohan Kumar Pasupuleti
https://orcid.org/0000-0001-7797-1890
Vivek Bypalli
https://orcid.org/0000-0003-3040-4148
Radharani Korukonda
https://orcid.org/0000-0003-1280-8739

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Author Contributions
Conceptualization: Santosh Venkata Ramesh Konathala; Data curation: Santosh Venkata Ramesh Konathala, Venkata Lakshmi

ABSTRACT

Purpose: The single-flap approach (SFA) is a minimally invasive technique with limited mucoperiosteal flap elevation to gain access to the buccal/palatal aspects, thus limiting post-surgical complications. The purpose of the present study was to gain insights into the impact of the SFA over the double-flap approach (DFA) on periodontal flap treatment outcomes and patient compliance in terms of discomfort and time taken for surgical procedures.
Methods: Twenty patients with persistent probing pocket depths of ≥5 mm were scheduled for the SFA (test site) and for the DFA (control site). All the clinical periodontal parameters were recorded at baseline, 3 months, and 6 months. Radiographic bone level (cone-beam computed tomography) was evaluated at baseline and 6 months. Patients' postoperative pain perception and wound healing were also assessed.
Results: The SFA showed a significant reduction in periodontal pocket depth, gain in clinical attachment level (CAL), and gain in bone level when compared with the DFA. The SFA substantially improved wound healing and induced less postoperative pain than the DFA.
Conclusions: The SFA resulted in substantial improvement in the composite outcome measures, as shown by a reduction in pocket depth with minimal gingival recession, gain in CAL, early wound healing, less postoperative discomfort, and better patient-centered outcomes.

Trial Registration: Clinical Trials Registry-India Identifier: CTRI/2018/05/013562

Keywords: Minimally invasive surgery; Periodontal disease; Periodontal pocket; Single flap approach; Wound healing

INTRODUCTION

Periodontitis is a group of diseases that result in the loss of supporting structures of the teeth and lead to apical migration of the epithelial attachment, resulting in pocket formation, destruction of the alveolar bone, and eventually tooth loss if not treated [1,2]. Hence, periodontal therapy is directed at slowing or arresting the disease progression and regeneration of lost periodontal tissues. From this perspective, various treatment modalities have been proposed with modifications to minimize the surgical trauma involved during periodontal treatment and to improve patient compliance [3,4].

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Conflict of Interest

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

Although various flap surgery designs have been advocated and implemented, conventional access flap surgery, which involves the reflection of 2 flaps (i.e., buccal and palatal/lingual), still remains the basic surgical procedure of periodontal therapy for pocket reduction or elimination, despite its drawbacks such as postsurgical recession and dentinal hypersensitivity [5,6]. To overcome these drawbacks, several new techniques have come into existence, including minimally invasive surgery (MIS) [7].

MIS is an innovative approach that aims to produce minimal flap reflection with gentle handling of the soft and hard tissues, thereby resulting in less tissue injury. MIS has been reported not only to reduce postoperative pain and improve healing, but also to yield significant improvements in clinical outcomes [8]. Initially, minimally invasive surgical procedures were proposed for the treatment of intraosseous defects through the single-flap approach (SFA) in 2007. Later, several authors proposed variants of the SFA to access intraosseous defects. In 2008, Checchi et al. [9] modified the SFA technique with the intention of minimizing the esthetic impairment related to the surgical procedure and optimizing the soft-tissue closure at the incision margin. In 2009, Cortellini and Tonetti [10] proposed the modified minimally invasive surgical technique (MIST), which shares several technical aspects with the SFA. Finally, in 2017, Azuma et al. [11] performed an *in vitro* study to compare early healing after the SFA. Further findings on the SFA and its variants were elaborated by Trombelli et al. [12].

The SFA is a simplified minimally invasive surgical approach that optimizes primary closure and minimizes surgical trauma. The principle behind single-flap surgery consists of elevating a limited mucoperiosteal flap to allow surgical access from either the buccal or palatal/lingual aspect only, depending on the extension of the lesion, and leaving the interproximal supracrestal gingival tissues intact [13]. In supraosseous defects, as there is no available space under the gingival flap to allow new bone formation, MIST may prevent the marginal bone loss that may be expected after periodontal surgical procedures. Di Tullio et al. [14] have reported minimal bone loss compared to conventional surgical procedures using a conservative surgical approach in the management of supraosseous defects.

The primary advantage of the SFA compared to the double-flap approach (DFA) is flap repositioning and suturing to the undetached papilla, thereby preventing contamination by blood clots and reduction in the post-surgical recession. The SFA, when used alone or in combination with guided tissue regeneration or any other bone substitutes to treat deep intrabony defects, has shown significant clinical outcomes. The SFA helps optimize primary closure of the flap, thus enabling functional and esthetic outcomes to be achieved [15,16].

Performing these surgical techniques by means of surgical loupes and microsurgical instruments would further reduce stress, thereby minimizing the surgical time to the operator, reducing postoperative pain, and enabling faster wound healing with improved clinical outcomes [17].

Although studies have been carried out regarding the SFA for regenerative procedures [18], there is sparse literature comparing the SFA and DFA for periodontal pocket reduction/elimination and in terms of patient compliance. Therefore, this study was designed to gain insights into the impact of the SFA over the DFA on periodontal flap treatment outcomes, especially periodontal pocket reduction and patient compliance in terms of discomfort and time taken for surgical procedures.

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MATERIALS AND METHODS

Ethical aspects and study design

This single-center clinical trial was conducted at Vishnu Dental College, India from February 2018 to November 2019. The study protocol was approved by the Institutional Ethical Committee and also registered under the Clinical Trials Registry of India (CTRI/2018/05/013562). All the clinical procedures were performed in full accordance with the Declaration of Helsinki and the Good Clinical Practice Guidelines. Every patient provided written informed consent before participation.

Patient population

Sample size analysis was done using G*Power 3.1 software based on an effect size of 0.67 with an alpha level of 0.05. Considering a 20% dropout rate, the sample size was calculated as 24 patients, and at the end of the study only 20 patients were considered for statistical analysis. Patients ranging from 18 to 60 years in age (mean age, 42 years) were included. The follow-up schedule for every patient was 1 month, 3 months, and 6 months (Figure 1).

Screening procedure

Patients visiting the postgraduate Department of Periodontics, Vishnu Dental College who were diagnosed with chronic periodontitis were included in the study. A preliminary examination, including a medical and dental history, was done to evaluate each patient's eligibility for inclusion in the study.

Patient eligibility

Inclusion criteria:

- Patient-related criteria: patients who had not undergone periodontal procedures in the last 6 months, and were 18–60 years of age.
- Tooth-related criteria: at least 3 teeth involved with a ≥5 mm probing pocket depth (PPD) and horizontal bone loss.

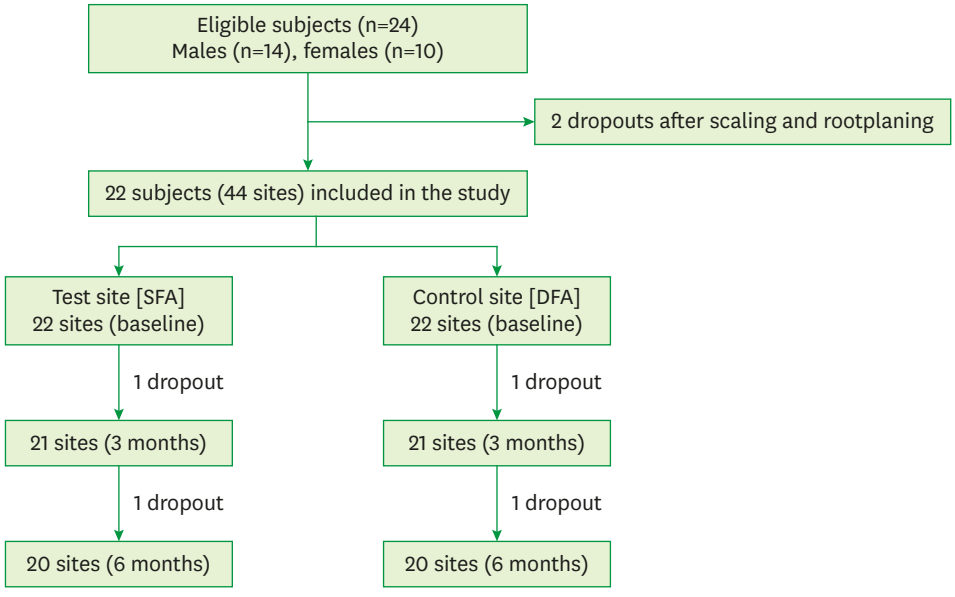

Figure 1. Study population and sample size.
SFA: single-flap approach, DFA: double-flap approach.

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Exclusion criteria:

- Patient-related criteria: patients who had uncontrolled systemic diseases, were using medications affecting periodontal status, were smokers, or were pregnant or lactating.
- Tooth-related criteria: patients with grade III mobility, teeth with furcation involvement, teeth with active caries or other dental problems, or patients with severe periodontal disease.

Surgical protocol

Before surgery, every patient underwent thorough mechanical debridement manually and with ultrasonic scaling. All patients were educated on the importance of the maintenance of oral hygiene and were advised with oral hygiene instructions. Periodontal re-evaluation was performed after 4–6 weeks. Surgery was postponed until the plaque and bleeding scores decreased and patients exhibited minimal inflammation with good soft tissue conditions.

Incisions were made using microsurgical instruments to minimize the trauma to the tissues, which can help to promote early wound healing. A site with only probing depths on either the buccal or palatal/lingual side was scheduled for the SFA (test site). A site with pocket depths on both buccal and palatal/lingual sides was scheduled for the DFA (control site) considering the fact that the presence of pockets on both sides is an ideal indication for DFA.

All surgical procedures were performed by 1 investigator using surgical loupes (×3.5) using 2% lignocaine with adrenaline (1:200,000) under aseptic conditions.

At the test site, where the SFA was performed (either buccal or palatal/lingual), sulcular incisions were made along the gingival margin using a microsurgical blade. A full-thickness mucoperiosteal flap without vertical incisions was reflected on only 1 side (i.e., the buccal or palatal/lingual side). Incisions were restricted to the extension of the defect to minimize the surgical site involvement. After gaining access to the base of the pocket complete root planing was performed manually to ensure that any subgingival calculus and altered cementum present was removed. After complete debridement, the mucoperiosteal flap was repositioned and secured with 5-0 nonresorbable sutures (Mersilk™) using the continuous sling method of suturing (Figure 2).

At the control site, the DFA (both buccal and palatal/lingual) was performed using crevicular and interdental incisions. A full-thickness mucoperiosteal flap on both sides was reflected and thorough debridement and root planing were done. Then the mucoperiosteal flap was repositioned and secured with 5-0 nonresorbable sutures (Mersilk™) using the simple interrupted method of suturing (Figure 3).

Postoperative care

The patients all received antibiotics (amoxicillin, 500 mg) and analgesics (diclofenac, 50 mg) for 3 days as per the Indian pharmacopoeia. The subjects were instructed to refrain from toothbrushing at the surgical site for 1 week and were instructed to rinse with 0.2% chlorhexidine gluconate mouthwash twice daily for 1 week. After 1 week, the periodontal dressing and sutures were removed and oral hygiene instructions were reinforced.

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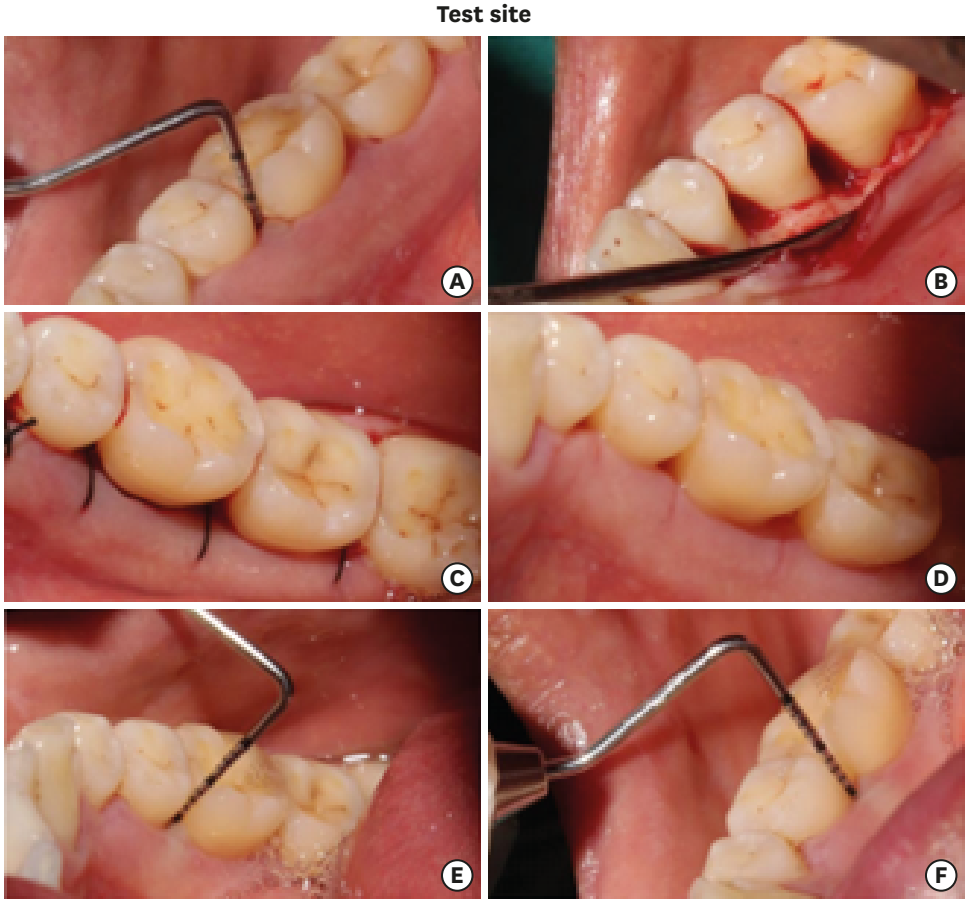

Figure 2. Treatment of periodontal pocket with the SFA. (A) Preoperative view showing probing pocket depth of 7 mm. (B) The SFA was performed by making crevicular and interdental incisions using a microsurgical blade. A full-thickness single-side mucoperiosteal flap was reflected using a microsurgical periosteal elevator. Thorough debridement and root planing were done.(C) The mucoperiosteal flap was repositioned and secured with 5-0 Mersilk sutures using the continuous sling method of suturing. (D) Healing after suture removal (1 week postoperatively), (E) at 3 months of follow-up, (F) at 6 months of follow-up.
SFA: single-flap approach.

Recording the periodontal parameters

A stent was used to standardize the periodontal clinical parameters before and after surgery, especially while measuring the pocket depths. The periodontal parameters included the plaque index (PI) and gingival index (GI) recorded at baseline, 1 month, 3 months, and 6 months. The PPD, clinical attachment level (CAL), gingival recession (GR), and sulcus bleeding index (SBI) were recorded using a UNC-15 probe to the nearest millimeter at both the test and control sites at baseline, 3 months, and 6 months.

Pain assessment was done using a visual analogue scale (VAS) ranging from 0 (no pain) to 10 (worst pain) 2 hours after surgery and 7 days postoperatively at both surgical sites. Wound healing was evaluated on day 7 day postoperatively using the early wound healing index (EHI) [19].

In the present study, to evaluate the effect of the SFA compared to the DFA, a composite outcome measure (COM) was used [15], involving a combination of PPD, CAL, and GR parameters. A systematic review showed a CAL gain of about 1.2 mm, PPD reduction of 1.2 mm, and GR increase of 0.5 mm. The residual PPD was 3.83 mm. Although these results are

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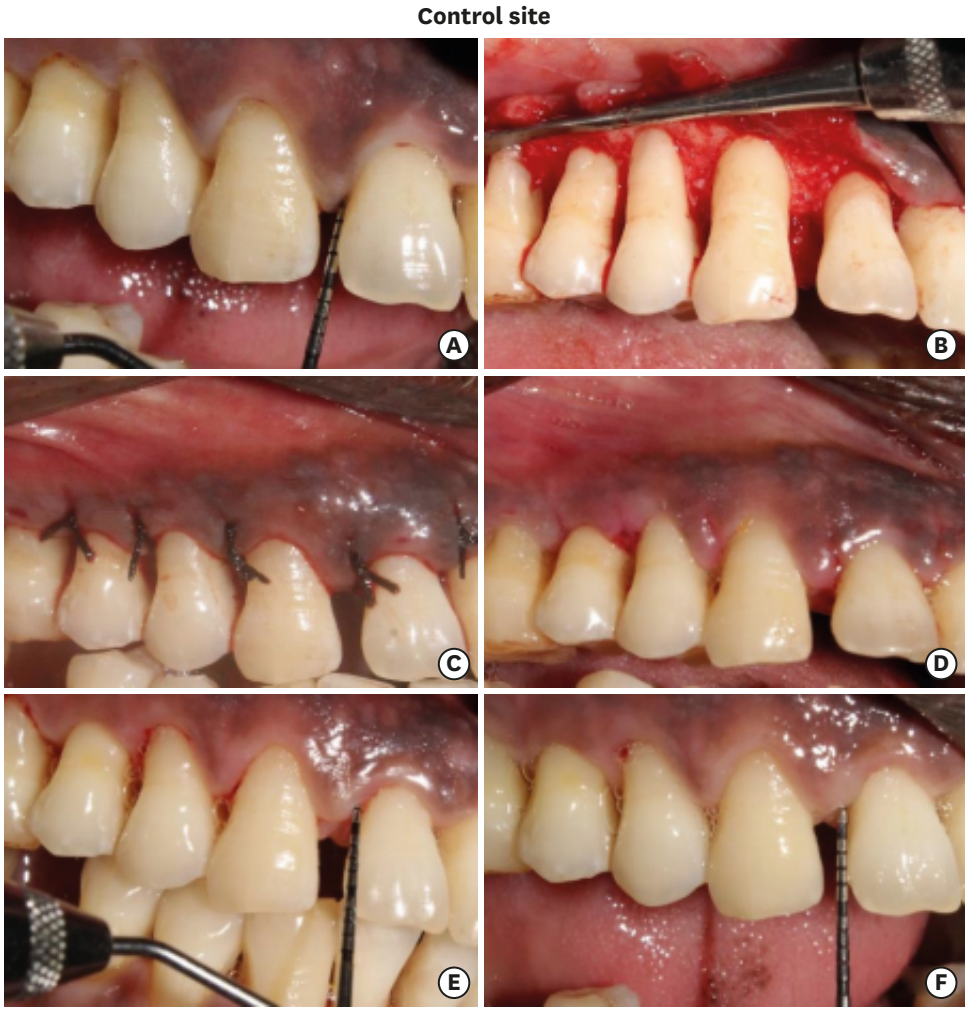

Figure 3. Treatment of the periodontal pocket with the DFA. (A)Preoperative view showing a probing pocket depth of 5 mm. (B) The DFA was performed by making crevicular and interdental incisions using a microsurgical blade. A full-thickness single-side mucoperiosteal flap was reflected using a microsurgical periosteal elevator. Thorough debridement and root planing were done.(C)The mucoperiosteal flap was repositioned and secured with 5-0 Mersilk sutures using the simple interrupted method of suturing. (D) Healing after suture removal (1 week postoperatively), (E) at 3 months of follow-up, at (F) 6 months of follow-up.
DFA: double-flap approach.

inferior to the performance of the access flap in intraosseous defects, a PPD reduction of approximately ≥3 mm and CAL gain of ≥1 mm is not clinically negligible [14,20]. Similarly, in a case-control study by Gupta et al. [21], comparing the outcomes of open flap debridement and closed debridement with an Er,Cr:YSGG laser, conservative open flap debridement showed a PPD reduction of 3.6 and 3.8 mm with a CAL gain of 1.93 and 2 mm at 3 and 6 months postoperatively, respectively. Based on this, successful treatment was defined as a CAL gain of ≥1 mm, residual PPD ≤ 3 mm or nearing 3 mm, and GR <1 mm.

Radiographic assessment

The bone level around each tooth was measured at 6 sites (mesiobuccal, mesiolingual, midbuccal, midlingual, distobuccal, and distolingual) from 2 mm apical to the cemento-enamel junction to the crest of the alveolar bone. These bone level measurements were

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recorded for each tooth at the test and control sites and the mean score was calculated for both surgical sites at baseline and 6 months postoperatively.

Statistical analysis

The data obtained were analyzed statistically using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). The mean values of the parameters were compared across groups using analysis of variance. Intragroup comparisons of all clinical parameters were made using the unpaired *t*-test. A *P* value <0.05 was considered to indicate statistical significance in all analyses.

A total of 48 sites in 24 patients were included in the study and the gingival inflammatory indices (i.e., the PI and GI) were considered and compared at baseline and 1, 3, and 6 months after surgery. Four of the 24 did not participate until the end of the study period. Periodontal parameters were recorded at baseline, 3 months, and 6 months postoperatively. Patients' pain perception was evaluated at 2 hours after surgery and on day 7 postoperatively. Wound healing was assessed on day 7 postoperatively. Radiographic bone levels were measured at baseline and 6 months after surgery using cone-beam computed tomography (CBCT).

RESULTS

Four of the 24 patients did not complete the study. One of the patients who discontinued participation did so due to being transferred for work, 2 did not attend the follow-up visits because of other health-related problems, and 1 patient did not present to follow-up because of subsided bleeding from the gums. A total of 20 participants completed the study protocol and were included in the statistical analysis. All the periodontal parameters considered were from the surgically treated sites and did not include the whole mouth.

Demographic variables

The study group comprised 12 men and 8 women, ranging from 18 years to 60 years of age (mean age, 42.6±12.4 years).

Periodontal variables

The PI and GI scores decreased significantly from baseline to 1 and 3 months, but no significant difference was observed in the PI scores from baseline to 6 months and the GI scores from 3 to 6 months. The SBI scores decreased significantly from baseline to 3 and 6 months.

At the test sites, the mean PPD decreased from baseline to 3 months (2.00 mm) and 6 months (1.86 mm), which was highly statistically significant (P=0.000). Similarly, the control sites showed a mean PPD reduction of 2.41 mm from baseline to 3 months and 2.21 mm at 6 months; these changes were also highly significant.

There was no statistically significant difference in the mean PPD values between the test and control sites at 3 months (P=0.225) and 6 months (P=0.091) (Table 1).

The mean gain in CAL at the test sites was 1.76 mm from baseline to 3 months (P=0.043) and 1.61 mm at 6 months (P=0.048), showing a statistically significant difference. At the control sites, the gain in CAL from baseline to 3 months was 1.41 mm and that from baseline to 6 months was 1.12 mm; these changes were not significant. Intergroup comparisons of CAL between the test and control sites showed no significant difference at any time points (Table 1).

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Table 1. Intergroup comparisons of PPD, GR, and CAL at test and control sites

Periodontal clinical parameter	Duration	Site	Mean±SD	Mean difference	*P* value
PPD	Baseline	Test	4.99±0.80	−0.25	0.065
		Control	5.25±0.82		
	3 months	Test	2.99±0.48	−0.25	0.225
		Control	3.24±0.74		
	6 months	Test	3.13±0.53	−0.30	0.091
		Control	3.43±0.57		
Recession	Baseline	Test	3.05±1.89	0.02	0.981
		Control	3.03±2.10		
	3 months	Test	3.24±2.10	−0.79	0.241
		Control	4.03±2.09		
	6 months	Test	3.25±2.07	−0.88	0.185
		Control	4.13±2.03		
CAL	Baseline	Test	7.99±2.37	−0.693	0.382
		Control	8.68±2.57		
	3 months	Test	6.23±2.17	−1.03	0.141
		Control	7.27±2.18		
	6 months	Test	6.38±2.19	−1.185	0.088
		Control	7.56±2.07		

PPD: probing pocket depth, GR: gingival recession, CAL: clinical attachment level, SD: standard deviation.

The mean increase in GR depth at the test sites was 0.19 mm from baseline to 3 months and 0.20 mm at 6 months, which was not statistically significant (P=0.953 and P=0.948, respectively). The mean increase in GR depth at control sites was 0.99 mm from baseline to 3 months and 1.09 mm at 6 months, which was also not statistically significant (P=0.292 and P=0.227, respectively). However, the intergroup comparison of GR depth showed a notable difference between the groups at 3 months (0.79 mm) and 6 months (0.88 mm), with the test group showing better results (Table 1).

A substantial difference in the COM was consistently evident between the SFA and DFA. Specifically, 80% of the SFA sites (16 sites) showed CAL gain ≥1 mm, whereas 11% sites of the DFA sites showed a CAL gain ≥1 mm, reflecting a good rate of clinically relevant success. However, 40% of the SFA sites showed a residual PPD ≤3 mm, corresponding to a successful outcome, whereas only 10% of the DFA sites exhibited residual PPD ≤3 mm. Furthermore, 40% of the SFA sites had a residual PPD >3 mm, while 45% of the DFA sites had a residual PPD >3 mm, indicating treatment success. Meanwhile, 20% of the SFA sites and 45% of the DFA sites showed a CAL gain <1 mm and a residual PPD ≤3 mm, indicating treatment failure. Interestingly, 90% of the SFA sites exhibited a GR <1 mm, indicating success, whereas only 55% of the DFA sites displayed a GR <1 mm (Table 2). In the present study, considering CAL gain as important outcome, CAL gain ≥1 mm was considered as treatment success.

The mean VAS score decreased from baseline to day 7 in both groups (i.e., at both the control and test sites) with a statistically significant difference (P=0.000) (Table 2). The intergroup comparison of pain scores at baseline showed significantly better results in the test group, with a mean difference of 0.9 (P=0.041). Instead, on day 7, the mean VAS score was slightly better in the test group, but with no statistical significance (P=0.574) (Table 3).

The mean EHI on the day after surgery at the test and control sites was 1.55±0.51 and 1.70±0.57, respectively, without any statistically significant difference (P=0.387) (Table 4).

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Table 2. Patient-related characteristics, patient distribution according to treatment strategy, and evaluation of treatment outcomes including conventional probing measurements and the COM

Characteristics	Values
Age	42.6±12.48
Sex	
Male	12 (60)
Female	8 (40)
Treatment strategies	
SFA	20 sites (50)
DFA	20 sites (50)
SFA (conventional) at 6 months	
CAL change (mm)	1.61±0.18 (0–3)
Six-month pocket depth (mm)	3.13±0.53 (2–4)
SFA (COM) (20 sites) at 6 months	
CAL gain ≥1 mm	
Residual pocket depth ≤3 mm	8 sites (40)
Residual pocket depth >3 mm	8 sites (40)
CAL gain <1 mm	
Residual pocket depth ≤3 mm	2 sites (10)
Residual pocket depth >3 mm	2 sites (10)
DFA (conventional) at 6 months	
CAL change (mm)	1.12±0.52 (0–3)
Six-month pocket depth (mm)	3.43±0.57 (2–4)
DFA (COM) (20 sites) at 6 months	
CAL gain ≥1 mm	
Residual pocket depth ≤3 mm	2 sites (10)
Residual pocket depth >3 mm	9 sites (45)
CAL gain <1 mm	
Residual pocket depth ≤3 mm	2 sites (10)
Residual pocket depth >3 mm	7 sites (35)
SFA (20 sites) at 6 months	
Recession <1 mm	18 (90)
Recession >1 mm	2 (10)
DFA (20 sites) at 6 months	
Recession <1 mm	11 (55)
Recession >1 mm	9 (45)

Values are presented as number (%) or mean±standard deviation (range). Data are shown as follow: CAL gain ≥1 mm, recession <1 mm: treatment successful; CAL gain <1 mm, recession >1 mm: treatment failure; residual pocket depth, no significance in COM.
COM: composite outcome measure, SFA: single-flap approach, DFA: double-flap approach, CAL: clinical attachment level, SD: standard deviation.

Table 3. Intragroup and intergroup comparisons of pain at the test and control sites at baseline and day 7

Variables	Site	Duration	Mean±SD	Mean difference	*P* value
Intragroup (pain)	Test	Baseline	2.90±1.16	2.50	0.000[a]
		Day 7	0.40±0.60		
	Control	Baseline	3.80±1.50	3.30	0.000[a]
		Day 7	0.50±0.51		
Intergroup (pain)	Test	Baseline	2.90±1.16	−0.90	0.041[a]
	Control		3.80±1.15		
	Test	Day 7	0.40±0.60	−0.10	0.574
	Control		0.50±0.51		

SD: standard deviation.
[a]$P<0.05$, statistically significant.

Table 4. Intergroup comparison of EHI at the test and control sites on day 7

Variables	Mean±SD	Mean difference	*P* value
EHI		−0.15	0.387
Test (20 sites)	1.55±0.51		
Control (20 sites)	1.70±0.57		

EHI: early wound healing index, SD: standard deviation.

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Table 5. Intragroup and intergroup comparisons of radiographic bone level at the test and control sites

Variables	Site	Duration	Mean±SD	Mean difference	*P* value
Intragroup	Test group	Baseline	2.80±0.83	0.50	0.000[a]
		6 mon	2.30±0.86		
	Control group	Baseline	2.90±1.07	0.45	0.107
		6 mon	2.45±0.82		
Intergroup	Test group	Baseline	2.80±0.83	−0.10	0.744
	Control group		2.90±1.07		
	Test group	6 mon	2.30±0.86	−0.15	0.578
	Control group		2.45±0.82		

SD: standard deviation.
[a]*P*<0.05, statistically significant.

Radiographic parameters

The mean radiographic bone level (using CBCT) was assessed from a distance of 2 mm apical of the cementoenamel junction to the crest of the alveolar bone showed a significant improvement in bone height from baseline to 6 months at the test sites, with a mean difference of 0.50 mm (*P*=0.000). Instead, at the control sites, the mean difference in the radiographic bone level from baseline to 6 months was not significant (*P*=0.107) (Table 5).

DISCUSSION

The goal of periodontal flap surgery is to improve the accessibility and visibility of the root surfaces and underlying bone, thereby allowing clinicians to alleviate the disease activity and to perform regenerative procedures [4]. The conventional approach (i.e., the DFA) is the primary surgical procedure used to gain access to root surfaces and to eliminate the pocket. However, disadvantages of the DFA include post-surgical complications such as bleeding, swelling, postoperative pain, GR, root hypersensitivity, lack of primary closure of the interdental space, flap dehiscence, and membrane exposure [15]. Some complications have been reported to be avoidable, whereas others are inevitable under certain circumstances [6]. Therefore, contemporary treatment approaches are useful to overcome these potential post-surgical complications.

The emergence of minimally invasive techniques such as MIS and the use of magnification greatly influenced clinical outcomes in delicate tissues such as the gingiva. With continuous modifications to these techniques from papilla preservation technique to modified MIS procedures, the SFA was proposed as a way to limit the flap elevation in relation to the periodontal defect and to handle the soft and hard tissues gently [11,17,22,23].

Magnification-assisted surgical procedures have several advantages, such as minimal flap elevation and reflection without periosteal incisions, which potentially reduce bleeding during surgery with ample exposure of underlying tissues. Precise incisions at the interdental edges promote faster healing with minimal postoperative swelling or hematoma [17]. Therefore, in an attempt to obtain a synergistic effect, the SFA for management of periodontal defects was done under magnification.

The SFA may offer several clinical advantages. Foremost, it may provide flap repositioning and suturing, wherein the flap can easily be stabilized to the undetached papilla, thus optimizing wound closure for healing by primary intention. Furthermore, by limiting the surgical trauma to the vascular supply of the interproximal supracrestal soft tissues due to

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limited flap elevation, a faster wound-healing process is promoted, particularly at the level of the incision line [8,13,15].Wound stabilization and preservation of an intact interdental papilla leads to primary intention healing and minimizes the post-surgical shrinkage of gingival tissues and, therefore, limits the esthetic impairment of the patient [15,24].

In the present study, the improvement in the PI, GI, and SBI scores are suggestive of good oral hygiene maintenance and favorable clinical outcomes in both groups.

The mean PPD reduction in both groups from baseline to 3 and 6 months is in accordance with several studies by Trombelli et al. [8,15,25]. However, the PPD scores did not show any significant changes from 3 to 6 months at either site, suggestive of stable periodontal support and good oral health maintenance after surgery. These results indicate that the SFA and DFA are equally effective for reducing PPD as long as patients maintain good oral hygiene.

Pocket depth was measured at baseline, 3 months, and 6 months in our study. Pocket depth was measured at 3 months because healing during the third week features the first histological evidence of new connective tissue attachment of the flap. From the fourth week until the end of the third month, the healing features less proliferative activity, and connective tissue maturation and osseous remodeling become more dominant elements. Within 4–5 weeks, the flap is completely reattached to the bone and teeth, with no differences from the neighboring tissue [26,27].

The SFA group showed a significantly greater CAL gain from baseline to 3 months, and a slight improvement in CAL from 3 to 6 months. In the DFA, there was no significant CAL gain. The difference in the CAL gain might be explained by the 2 different flap approaches influencing the extent of defect resolution. These results are in accordance with previous studies in which a significant mean CAL gain was reported for the SFA when compared with the DFA [8,15,25]. However, the amount of CAL gain was minimal as compared to previous studies that included deep intraosseous defects (e.g., 4.5 mm) [8].

In the present study, a COM was used along with single probing measurements. The assessment of the COM in the treatment of supraosseous defects would provide more accurate and useful results in terms of interpreting the outcomes in future research.

The GR depth increased by 1.09 mm at 6 months at the DFA sites as compared to 0.20 mm at 6 months at the SFA sites, which could be due to postsurgical tissue remodeling; this finding is in accordance with various studies by Farina et al. [8,13,15,28,29].The SFA limits the surgical trauma to the papilla's vascular supply, enabling faster wound healing and greater wound stabilization, and the intact papilla may minimize recession [15,25].

Clinical studies have reported that the SFA for periodontal intrabony defects resulted in a significant added benefit when compared to the DFA in terms of various clinical parameters such as PPD, CAL, and GR. However, it should be noted that the present results were obtained in the treatment of periodontal supraosseous defects/horizontal bone loss. Even though horizontal bone loss accounts for 92% [30] of the total bone loss, most previous studies were done in intraosseous defects, whereas prevalence of intrabony defects has been shown to be significantly lower, ranging from 8% to 30.2% [31-33]. Although the SFA and DFA are surgical techniques designed for the treatment of intraosseous defects, in the current study an attempt was made to compare the SFA to the DFA for supraosseous defects.

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Supraosseous defects are less predictable than intraosseous defects due to the horizontal pattern of tissue destruction and relative scantiness of cellular sources for wound healing. In a recent systematic review by Graziani et al. [20], comparing the performance of enamel matrix derivatives and open flap debridement in the treatment of supraosseous defects 6 months after surgery, the conservative approach of open flap debridement with DFA showed significant changes. Therefore, in the current investigation, composite treatment outcome measures of a CAL gain ≥1 mm and residual PPD ≤3 mm were considered to indicate success.

In the present study, although the results obtained by the EHI did not show any statistically significant improvement after surgery on day 7, clinically, the SFA showed noticeably faster healing than the DFA. Earlier studies reported that the SFA minimized trauma and improved wound healing. The surgical management of clots seems to be of paramount importance in controlling the chances of wound failure during the early phases of healing, thereby preserving clot stability and providing good primary intention healing through the SFA [11,15].

To date, no substantive efforts have been made to assess radiographic bone levels using CBCT when comparing the SFA and DFA. In the present study, there was significant radiographic bone level gain from baseline to 6 months at the SFA sites, whereas no significant gain observed was observed at the DFA sites.

Even though the new surgical technique yielded improvement in all clinical periodontal parameters, these changes in the soft tissues are least perceived and appreciated by the patient. Therefore, patient-centered outcomes (i.e., pain perception) was evaluated in the current investigation. Two hours after surgery, patients felt less pain at the SFA sites than at the DFA sites. However, on day 7, the pain perception was almost the same at both sites. These results align with the findings of various studies [8,13,34,35]. The SFA has an added advantage of a reduced time of surgery due to minimal flap elevation [13].

However, the SFA with vertical releasing incisions is not well established and has not often been used to treat intraosseous defects, The SFA with vertical releasing incisions might be helpful in decreasing the exposure of the surgical field [36]. Overall, these observations are suggestive that the SFA as a stand-alone procedure provides ample surgical access for adequate subgingival instrumentation. The SFA initiates the primary intention of healing by stabilizing the wound, thereby allowing uneventful tissue formation and maturation [37].

Minimally invasive procedures, and in particular the SFA, are also suited for treatment in conjunction with biologically active agents, such as amelogenins or growth factors, which are associated with grafting materials. The SFA has an advantage of better retention of the graft material and maintenance of tissue height when compared to the traditional surgical approach. Most earlier studies on MIS were done on regenerative approaches, but the present study mainly focused on periodontal flap surgery outcomes.

Long-term multicenter randomized controlled clinical trials with a larger sample size are required to prove the efficacy of SFA for periodontal pocket reduction. These 2-flap approaches were originally designed for periodontal regeneration, but bone grafts and biomaterials were not used in the present study.

Although evidence supports the superiority of the SFA to the DFA, no previous studies have compared these procedural outcomes in periodontal pocket reduction. The COM for the SFA

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showed predictable improvement in all the periodontal parameters with minimal GR, gain in CAL, and better patient-centered outcomes (patient compliance).

Scientific rationale for the study: The DFA results in postoperative GR, compromised esthetics, and dentinal hypersensitivity; furthermore, it is time-consuming. Therefore, minimally invasive SFA would be a better alternative to reduce these complications by providing better wound stability.

Principal findings: The SFA resulted in greater CAL gain, minimal GR, and reduced postoperative pain.

Practical implications: The magnification-assisted SFA is more operator-friendly and less time-consuming with better patient comfort and compliance.

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