



Efficacy of Single Flap Approach with and without Diode Laser in Managing Periodontal Intra-Bony Defects: A Randomised Clinical Trial

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Abstract

Introduction: Chronic periodontitis leads to progressive loss of periodontal support, necessitating effective surgical interventions. Conventional open flap debridement (OFD) is widely practiced but is associated with post-surgical morbidity. The single flap approach (SFA), a minimally invasive technique, may offer superior healing, and the adjunctive use of diode laser (DL) could further enhance clinical outcomes.

Materials and Methods: A randomized controlled, split-mouth clinical trial was conducted on 18 patients (36 sites) with probing pocket depth (PPD) > 5 mm after Phase I therapy. Sites were randomly assigned to Group I (OFD) and Group II (SFA with DL). Clinical parameters including Gingival Index (GI), Modified Sulcus Bleeding Index (mSBI), PPD, Relative Attachment Level (RAL), and Visual Analogue Scale (VAS) pain score were recorded at baseline, 1, 3, and 6 months postoperatively. Statistical analysis was performed using ANOVA and Tukey's post hoc test, with significance set at $p < 0.05$.

Results: Both groups showed significant improvement in clinical parameters compared to baseline ($p < 0.001$). Intergroup comparison revealed greater reduction in GI, mSBI, PPD, and RAL in Group II at 3 and 6 months ($p < 0.05$). Postoperative pain scores (VAS) were significantly lower in the SFA + DL group immediately and on day 7 ($p < 0.001$).

Discussion: The adjunctive use of diode laser in SFA demonstrated superior improvements in clinical parameters and patient comfort compared to conventional OFD. Enhanced wound healing and reduced morbidity highlight the potential benefits of laser-assisted minimally invasive approaches.

Conclusion: The single flap approach with diode laser is a clinically effective and patient-friendly alternative to open flap debridement in the management of chronic periodontitis. Further long-term studies with larger sample sizes are recommended.

Keywords: Periodontal Pocket; Periodontal Attachment Loss; Periodontal Debridement; Lasers; Semiconductor; Surgical Flaps; Pain Measurement; Treatment Outcome

Introduction

Periodontitis is a chronic multifactorial inflammatory disease characterized by microbial dysbiosis and an aberrant host immune-inflammatory response, ultimately leading to the destruction of periodontal ligament, alveolar bone, and formation of periodontal pockets with gingival recession [1,2]. While conventional mechanical debridement through scaling and root planing (SRP) remains the cornerstone of periodontal therapy, its inability to completely eliminate pathogens from deep pockets and pocket lining tissues limits its long-term efficacy [3].

Open flap debridement (OFD), considered the gold standard surgical technique, provides improved access for debridement and significant clinical attachment gain in deep pockets [4]. However, drawbacks such as post-surgical bleeding, swelling, gingival recession, and dentinal hypersensitivity have been consistently reported [5]. To overcome these limitations, minimally invasive surgical techniques (MIS) have been introduced, emphasizing reduced flap reflection, preservation of soft tissue integrity, primary closure, and enhanced postoperative comfort [6]. Among these, the Single Flap Approach (SFA) has emerged as a simplified technique, particularly suited for localized defects, offering optimal healing with reduced surgical trauma [7].

The adjunctive use of lasers in periodontal surgery has gained considerable attention. Diode lasers, operating in the near-infrared spectrum (800–980 nm), exhibit high absorption in hemoglobin and pigmented tissues, enabling selective removal of diseased pocket epithelium and bacterial reduction while promoting hemostasis [8]. In addition, diode lasers are associated with reduced postoperative pain, edema, and accelerated wound healing [9]. Despite promising reports, evidence directly comparing SFA with diode laser versus conventional OFD in the management of chronic periodontitis remains limited.

Hence, the present study was undertaken to evaluate the clinical efficacy of the single flap approach with adjunctive diode laser in comparison with open flap debridement for the treatment of chronic periodontitis.

Materials and Methods

Study design and ethical approval

This randomized, controlled, split-mouth clinical trial was conducted in the Department of Periodontology and Oral Implantology. The study protocol was reviewed and approved by the Institutional Ethical Committee and conformed to the principles of the Declaration of Helsinki (2000 revision) [10]. Written informed consent was obtained from all participants prior to enrollment.

Study population

Eighteen systemically healthy patients (25–60 years) diagnosed with generalized chronic periodontitis were recruited based on the following inclusion criteria: (1) presence of ≥ 20 teeth, (2) probing pocket depth (PPD) > 5 mm at selected sites following initial therapy, and (3) willingness to comply with follow-up visits. Exclusion criteria included: (1) smoking, (2) pregnancy or lactation, (3) systemic illness, (4) periodontal therapy in the preceding 6 months, and (5) physical or mental disability.

Sample size calculation

Sample size was estimated using OpenEpi software (version 3.0), with significance set at 5% and power at 80%. Based on previous data [11], 16 sites per group were required; accounting for potential dropouts, 18 sites per group (total 36 sites) were included.

Randomisation and grouping

A split-mouth design was employed. (Figure 1) Selected sites were randomly allocated by coin toss into:

- **Group I (Control):** Open flap debridement (OFD)
- **Group II (Test):** Single flap approach (SFA) with adjunctive diode laser (DL)

Clinical parameters

The following clinical parameters were recorded at baseline, 1, 3, and 6 months using customized acrylic stents and UNC-15 periodontal probe for reproducibility:

- Gingival Index (GI) [12]
- Modified Sulcus Bleeding Index (mSBI) [13]
- Probing Pocket Depth (PPD)
- Relative Attachment Level (RAL)
- Visual Analogue Scale (VAS) for postoperative pain [14]

Surgical procedure

All surgeries were performed by a single operator under local anesthesia (2% lignocaine with adrenaline 1:80,000).

- **Group I (OFD):** Buccal and lingual/palatal sulcular incisions were given, and mucoperiosteal flaps were reflected. Thorough debridement and scaling were performed with Gracey curettes and ultrasonic scalers, followed by saline irrigation. Flaps were repositioned and sutured with 3-0 silk using interrupted technique. A periodontal dressing was placed for 7 days.
- **Group II (SFA + DL):** Sulcular incision and full-thickness flap reflection were limited to one aspect (buccal/lingual/palatal). After debridement, a diode laser (980 nm; 2 W, continuous contact mode) was applied to the inner flap surface in

overlapping horizontal strokes from the base to the margin. Flaps were repositioned and sutured as in Group I, and a periodontal pack was placed.

Postoperative care

All patients received antibiotics (amoxicillin-clavulanate 625 mg, twice daily for 5 days), analgesics (aceclofenac + paracetamol + serratiopeptidase, twice daily for 5 days), and chlorhexidine digluconate 0.2% rinse twice daily for 14 days. Sutures and dressing were removed after 7 days. Oral hygiene instructions were reinforced at each recall visit.

Statistical analysis

Data were analyzed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). Quantitative data were expressed as mean $\pm$ standard deviation (SD). Normality was tested using the Shapiro-Wilk test. Intragroup comparisons were made using repeated measures ANOVA, and intergroup comparisons were performed using one-way ANOVA with Tukey's post hoc test. A p-value < 0.05 was considered statistically significant.

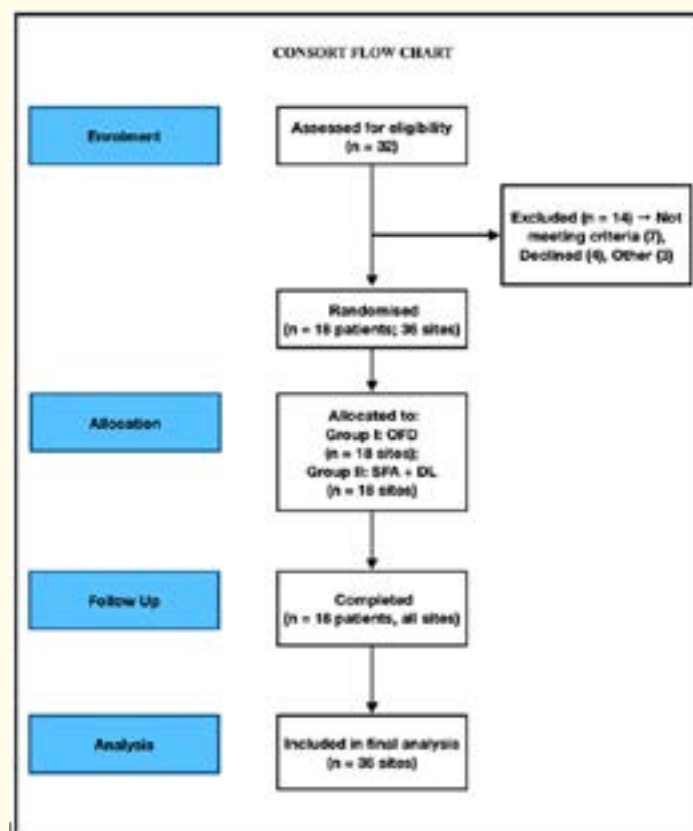


Figure 1: Consort flow chart diagram.

Results

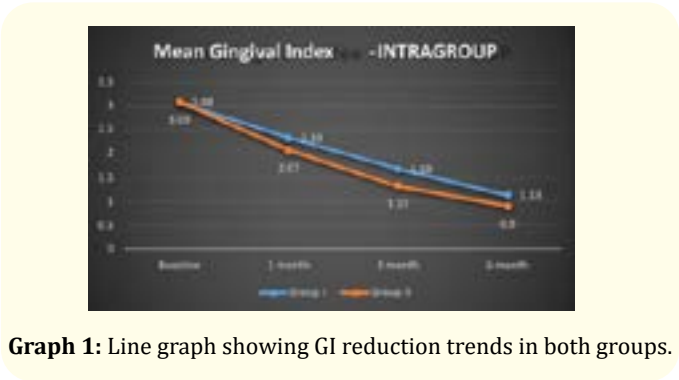
A total of 18 patients (36 sites) with a mean age of 36 years were included in the study. Among them, 56.6% were female and 44.4% were male. All patients completed the study with no dropouts.

Gingival Index (GI)

Both groups showed significant intra-group reduction in GI scores from baseline to 6 months ($p < 0.001$). In the OFD group (Group I), GI reduced from 3.08 ± 0.45 at baseline to 1.13 ± 0.25 at 6 months, while in the SFA + DL group (Group II), GI reduced

	Group I Mean (SD)	Group II Mean (SD)	Unpaired t test	P-value, Significance
Baseline	3.08 (0.45)	3.09 (0.41)	$t = -0.077$	$p = 0.939$
1 month	2.33 (0.45)	2.07 (0.38)	$t = 1.895$	$p = 0.067$
3 month	1.68 (0.43)	1.32 (0.26)	$t = 3.02$	$p = 0.005^*$
6 month	1.13 (0.25)	0.90 (0.13)	$t = 3.405$	$p = 0.002^*$
Change in score	1.95 (0.29)	2.18 (0.33)	$t = -2.279$	$p = 0.029^*$
P value	$P < 0.001^{**}$	$P < 0.001^{**}$		
(overall)				
[Repeated Anova F test]				
Baseline vs	$P < 0.001^{**}$	$P < 0.001^{**}$		
1 month^				
Baseline vs	$P < 0.001^{**}$	$P < 0.001^{**}$		
3 month^				
Baseline vs	$P < 0.001^{**}$	$P < 0.001^{**}$		
6 months^				

Table 1: Comparison of mean GI scores between groups across time intervals.



Graph 1: Line graph showing GI reduction trends in both groups.

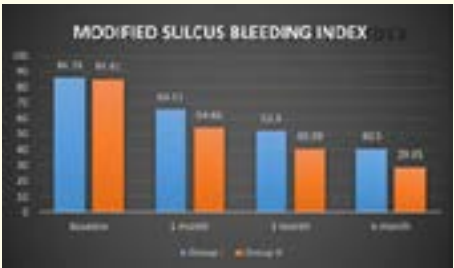
from 3.09 ± 0.41 at baseline to 0.90 ± 0.13 at 6 months. Intergroup comparison showed significantly greater reduction in Group II at 3 and 6 months ($p < 0.05$).

Modified sulcus bleeding index (mSBI)

Significant intragroup reduction was observed in both groups ($p < 0.001$). Group I showed reduction from 86.28 ± 6.21 to 40.50 ± 8.85 , while Group II showed reduction from 85.61 ± 5.60 to 29.05 ± 7.65 at 6 months. Intergroup differences were statistically significant at 1, 3, and 6 months ($p < 0.001$).

(in %)	Group I Mean (SD)	Group II Mean (SD)	Unpaired t test	P-value, Significance
Baseline	86.28 (6.21)	85.61 (5.6)	t = 0.342	p = 0.735
1 month	66.11 (7.74)	54.46 (8.15)	t = 4.391	P < 0.001**
3 month	52.3 (10.85)	40.39 (7.36)	t = 3.851	P < 0.001**
6 month	40.5 (8.85)	29.05 (7.65)	t = 4.152	P < 0.001**
Change in score	45.78 (7.94)	56.55 (6.82)	t = -4.368	P < 0.001**
P value	P < 0.001**	P < 0.001**		
(overall)				
[Repeated Anova F test]				
Baseline vs	P < 0.001**	P < 0.001**		
1 month^				
Baseline vs	P < 0.001**	P < 0.001**		
3 month^				
Baseline vs	P < 0.001**	P < 0.001**		
6 months^				

Table 2: Comparison of mean mSBI between groups at different time points.



Graph 2: Bar chart comparing mSBI reduction across groups

Probing pocket depth (PPD)

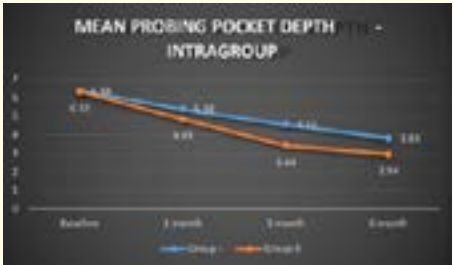
Group I showed mean reduction from 6.38 ± 0.50 mm at baseline to 3.83 ± 0.51 mm at 6 months. Group II showed greater reduction from 6.33 ± 0.59 mm to 2.94 ± 0.23 mm at 6 months. Both intragroup and intergroup differences were statistically significant (p < 0.001).

Relative attachment level (RAL)

Both groups demonstrated significant gain in attachment. Group I improved from 5.55 ± 0.61 mm at baseline to 2.94 ± 0.63 mm at 6 months, while Group II improved from 5.61 ± 0.60 mm

PPD	Group I Mean (SD)	Group II Mean (SD)	Unpaired t test	P-value, Significance
Baseline	6.38 (0.5)	6.33 (0.59)	t = 0.303	p = 0.764
1 month	5.38 (0.69)	4.83 (0.61)	t = 2.528	P = 0.016*
3 month	4.55 (0.7)	3.44 (0.61)	t = 5.037	P < 0.001**
6 month	3.83 (0.51)	2.94 (0.23)	t = 6.664	P < 0.001**
Change in score	2.55 (0.51)	3.38 (0.6)	t = -4.452	P < 0.001**
P value	P < 0.001**	P < 0.001**		
(overall)				
[Repeated Anova F test]				
Baseline vs	P < 0.001**	P < 0.001**		
1 month^				
Baseline vs	P < 0.001**	P < 0.001**		
3 month^				
Baseline vs	P < 0.001**	P < 0.001**		
6 months^				

Table 3: PPD changes within and between groups.



Graph 3: Line graph comparing mean PPD reduction trends.

to 2.05 ± 0.63 mm at 6 months. Intergroup comparison showed significantly greater gain in Group II at 3 and 6 months (p < 0.05).

Postoperative pain (VAS Score)

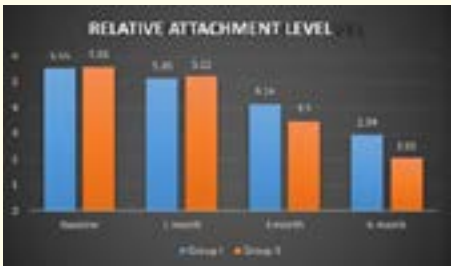
Immediately after surgery, mean VAS scores were significantly lower in Group II (3.72 ± 0.66) compared with Group I (7.33 ± 0.84) (p < 0.001). On day 7, pain further reduced in both groups, with Group II reporting 1.44 ± 0.70 compared with Group I at 5.27 ± 0.66 (p < 0.001).

Summary of findings

- Both surgical modalities resulted in significant improvement in clinical parameters.
- The SFA with diode laser demonstrated superior outcomes in GI, mSBI, PPD, RAL, and VAS compared to OFD.

RAL	Group I Mean (SD)	Group II Mean (SD)	Unpaired t test	P-value, Significance
Baseline	5.55 (0.61)	5.61 (0.6)	t = -0.272	p = 0.787
1 month	5.16 (0.51)	5.22 (0.54)	t = -0.313	P = 0.756
3 month	4.16 (0.51)	3.5 (0.61)	t = 3.516	P = 0.001*
6 month	2.94 (0.63)	2.05 (0.63)	t = 4.172	P < 0.001**
Change in score	2.61 (0.97)	3.55 (0.78)	t = -3.196	P = 0.003*
P value	P < 0.001**	P < 0.001**		
(overall)				
[Repeated Anova F test]				
Baseline vs	P < 0.001**	P < 0.001**		
1 month^				
Baseline vs	P < 0.001**	P < 0.001**		
3 month^				
Baseline vs	P < 0.001**	P < 0.001**		
6 months^				

Table 4: RAL gain across groups.



Graph 4: Bar graph depicting mean attachment level gain.

VAS Pain	Group I Mean (SD)	Group II Mean (SD)	Unpaired t test	P value, Significance
Immediately after surgery	7.33 (0.84)	3.72 (0.66)	t = 14.264	P < 0.001**
On 7 th day after surgery	5.27 (0.66)	1.44 (0.7)	t = 16.735	P < 0.001**
Change in score	2.05 (0.54)	2.27 (0.46)	t = -1.329	P = 0.193
P value (Paired t test)	P = 0.032*	P = 0.008*		

Table 5: Comparison of VAS scores between groups.



Graph 5: Bar chart showing postoperative pain at immediate and 7-day intervals.

- Patient-reported outcomes confirmed reduced postoperative discomfort in the diode laser-assisted group.

Discussion

The present study compared the clinical efficacy of the single flap approach (SFA) with adjunctive diode laser to conventional open flap debridement (OFD) in patients with chronic periodontitis. Both treatment modalities demonstrated significant improvements in clinical parameters over six months; however, the SFA with diode laser group consistently showed superior outcomes in terms of gingival inflammation, probing pocket depth reduction, clinical attachment gain, and postoperative comfort.

The significant reduction in Gingival Index (GI) and Modified Sulcus Bleeding Index (mSBI) in both groups is consistent with previous evidence that surgical therapy effectively reduces local inflammation [3,4]. The adjunctive use of diode laser in the SFA group, however, yielded a greater reduction, in line with reports that diode lasers improve decontamination and epithelial removal, leading to enhanced healing [8,9,15].

Both groups showed marked reduction in probing pocket depth (PPD) and gain in relative attachment level (RAL), with the SFA + diode laser group achieving significantly superior results. These findings corroborate earlier studies demonstrating that minimally invasive approaches preserve soft tissue integrity and facilitate primary closure, resulting in better attachment gains

compared to conventional access flaps [6,7,16]. Trombelli, *et al.* emphasized that SFA enhances surgical outcomes by minimizing flap trauma and optimizing clot stability [6]. The adjunctive role of diode laser likely potentiated these effects through bactericidal and biostimulatory properties, as also suggested by Aoki, *et al.* [9].

Patient-reported outcomes, measured by the Visual Analogue Scale (VAS), revealed substantially lower pain scores in the SFA + diode laser group, both immediately postoperatively and at 7 days. This aligns with previous clinical trials reporting that laser-assisted procedures result in reduced postoperative pain, edema, and need for analgesics compared to conventional flap techniques [8,9,17]. Improved patient comfort is a critical determinant of treatment acceptance and compliance in periodontal therapy.

Overall, the findings of this trial support the growing body of evidence favoring minimally invasive and laser-assisted periodontal procedures over conventional OFD. While OFD remains effective, the SFA with diode laser appears to offer additional advantages in terms of clinical outcomes and patient-centered benefits.

Limitations of the present study include the relatively short follow-up duration (6 months) and modest sample size. Furthermore, histological evaluation and long-term radiographic assessment of bone fill were not performed. Future studies with larger populations, longer follow-up, and adjunctive microbiological analyses are warranted to confirm and expand upon these results.

Conclusion

Within the limitations of this randomised controlled clinical trial, both open flap debridement and single flap approach with adjunctive diode laser demonstrated significant improvements in periodontal clinical parameters over six months. However, the single flap approach with diode laser achieved superior outcomes in terms of probing pocket depth reduction, clinical attachment gain, control of gingival inflammation, and patient-reported postoperative comfort. These findings highlight the potential of diode laser as a valuable adjunct to minimally invasive periodontal surgery, offering enhanced healing and improved patient acceptance compared to conventional approaches. Further long-term studies with larger sample sizes, radiographic and microbiological assessments are warranted to validate these results and establish the broader clinical applicability of diode laser-assisted minimally invasive techniques in periodontal therapy.

Clinical Significance

The single flap approach with adjunctive diode laser offers superior clinical outcomes and greater patient comfort compared to conventional open flap debridement in the management of chronic periodontitis. This minimally invasive, laser-assisted technique may serve as a valuable alternative in routine periodontal surgical practice, enhancing both healing and patient compliance.

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