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RESEARCH ARTICLE

Comparison of Minimally Invasive and Conventional Flap Surgery for Treatment of Intrabony Periodontal Defects: A Pilot Case Controlled Study

Matthew R Steffer, Stephen K Harrel, Jeffrey A Rossmann, David G Kerns, Francisco Rivera-Hidalgo Celeste M Abraham, Ibtisam Al-Hashimi, Eric S Solomon, Daisha J Cipher

ABSTRACT

The purpose of this study was to compare the clinical outcome of conventional flap surgery and minimally invasive surgery for the regenerative treatment of periodontal intrabony defects in a prospective, case-controlled study design. For this purpose, nine healthy individuals with 15 periodontal intrabony defects were included in the study. Patients were randomly assigned to undergo either minimally invasive surgery or conventional flap surgery for treatment of their intrabony periodontal defect. Each patient had preoperative and postoperative X-ray and measurement of periodontal parameters by a blinded examiner. All bony defects were treated with allograft consisting of enamel matrix derivative and demineralized freeze-dried bone. Results of this study indicated that both minimally invasive and conventional flap surgery improved pocket depth and clinical attachment levels after 6 months of surgery with no significant difference between the two surgeries. The overall result of our study suggests that minimally invasive surgery is as effective as conventional flap surgery in the treatment of intrabony periodontal defects and that both techniques appear to provide a comparable outcome.

Keywords: Minimally invasive surgery, Flap surgery, Guided bone regeneration.

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INTRODUCTION

Recent trends in medicine and dentistry promote the use of minimally invasive procedures. The use of laparoscopic and endoscopic instruments as well as high powered magnification devices, have allowed physicians to decrease the morbidity of many procedures by eliminating the need for large surgical incisions. In dentistry, minimally invasive techniques have evolved through the development of surgical microscopes for endodontic and periodontal use, bondable restorative materials, and microincisions for hard and soft tissue periodontal surgical techniques.

Conventional periodontal regenerative techniques involve the use of large periodontal flaps for access. Using conventional flap techniques, the use of enamel matrix derivative (EMD) with xenografts and collagen membranes has shown success in periodontal regeneration with 10-year follow-up results.[1,2]

An alternative approach to accessing the intrabony defects is through minimally invasive techniques. In a case series, Harrel described the approach as well as indications for its use and clinical results.[3] The author describes using incisions just large enough for debridement, which generally involves reflecting only the papilla. Specialized instruments, such as a narrowed Orban knife and a degranulating bur, are used for access and debridement. Demineralized freeze-dried bone allograft (DFDBA) is placed in the defect and covered with a vicryl mesh, and a vertical mattress suture is used for primary closure. Average probing depth (PD) reductions of 4.1 mm and CAL gains of 4.2 mm were observed in 10 patients. Another case series discussed the advantages and disadvantages of the MIS approach as well as indications and contraindications.[3] The MIS approach has been proven successful in periodontal regeneration with long-term follow-up studies.[4] Minimally invasive surgery (MIS) with the use of EMD has also been described in the literature with successful results.[5] A case report utilizing MIS for treatment of a cemental tear demonstrated the approach to be effective in reducing PDs.[6]

Since MIS was originally described, variants of this technique have been published. Cortellini et al described a minimally invasive surgical technique (MIST) in 2007 with notable differences from MIS in grafting and suturing techniques.[7] The authors described minor variations in the MIS protocol, including accessing the periodontal defects with a simplified or modified papilla preservation technique.[8] In the original description, the authors describe grafting with an EMD only. The papillae are secured with 6-0 e-PTFE (Goretex®) sutures using a modified internal mattress approach.[9] A follow-up study indicated that the MIST procedure could be used successfully to treat multiple defects with limited patient morbidity.[10]

The M-MIST or modified-MIST is a variant to the MIST also described by Cortellini et al.[11] The main difference in this approach from the MIST is that incisions are made in the sulcus around the facial surfaces only and the lingual side of the papilla remains intact. The granulation tissue is dissected from the defect using a blade and a curette. If the M-MIST does not provide sufficient access to the lingual

side of the defect, the lingual papilla may be elevated as described in the MIST. The defect is then presutured with either 6-0 or 7-0 e-PTFE suture and grafted with EMD alone. This approach provided statistically significant improvements in both PD reduction and gain in clinical attachment levels (CALs).

Studies evaluating MISTs have demonstrated the effectiveness of this technique in reducing PDs and improving CAL. However, none of these studies compared the clinical outcome of MIS to that of conventional flap surgery. Therefore, the purpose of this study was to compare the clinical outcomes of conventional flap surgery and MIS for the treatment of periodontal intrabony defects in a prospective, case-controlled design.

MATERIALS AND METHODS

Subject Selection

The study population consisted of individuals seeking periodontal treatment at the Department of Periodontics. All patients signed an informed consent, which was approved by the Institutional Review Board at Baylor College of Dentistry-Texas A and M University System. Each patient had clinical and radiographic evaluation for periodontal disease. The inclusion criteria for the study were: (1) 18 years of age; (2) at least one periodontal intrabony defect that must involve an anterior or premolar tooth or mesial surface of a molar tooth; and (3) defects must be associated with a PD ≥5 mm. Exclusion criteria were: (1) tooth is periodontally hopeless (i.e. mobility >2, furcation >2, etc.); (2) previous periodontal surgery within the last 2 years in area of interest; (3) systemic conditions which are generally considered to be a contraindication to periodontal surgery which included but were not limited to: severe osteoporosis, uncontrolled diabetes, blood dyscrasias; (4) pregnant or lactating females and (5) current smokers.

Prior to surgery, a stent was fabricated for each site using diagnostic casts and acrylic resin (Triad, Dentsply International, York, PA, USA). Each stent rested on the occlusal surfaces of at least 4 teeth and had a vertical notch marking the facial and lingual position of the intrabony defect. A computer program (Microsoft Excel®, Microsoft, Redmond, WA, USA) randomly assigned sites to the conventional flap (FLAP) group, or the MIS group. There were eight sites treated using the FLAP technique, and seven sites using the MIS technique. Baseline clinical measurements were made by a calibrated and blinded periodontist prior to surgery using a prefabricated stent and a periodontal probe (CP 15 UNC, Hu-Friedy, Chicago, IL, USA) to the nearest 0.5 mm. Periodontal measurements of the tooth associated with the defect as well as the tooth adjacent to the defect, included six sites per tooth and comprised the PD, CAL, recession (REC) and bleeding on probing (BOP). In addition, the facial and lingual papilla height as described by Haghighati et al[12] and tooth mobility were also measured. A periapical radiograph was obtained using a custom film holder (XCP, Dentsply Rinn, Tulsa, OK, USA). Triad acrylic was placed on the biting surface of the film holder to record the patient's bite, and the acrylic was subsequently cured with a curing light after exposure of the radiograph.

Surgical Procedures

A single operator (MRS) performed all surgical procedures. The surgical sites were anesthetized with 2% xylocaine HCl with 1:100,000 epinephrine. For the FLAP technique, buccal and lingual intrasulcular incisions extended at least one tooth mesial and distal to the tooth associated with the intrabony defect. Full thickness mucoperiosteal flaps were reflected to allow access for debridement of the defect. For the MIS technique, incisions were made on the facial as described by Harrel.[3] The intrabony defect and root surfaces were debrided using an ultrasonic scaler and hand instruments. Root surfaces were conditioned for 2 minutes using 24% ethylenediaminetetraacetic acid (EDTA) (PrefGel®, Straumann USA, Andover, MA, USA) according to manufacturer's instructions. After thoroughly rinsing the site with sterile saline, EMD (Emdogain®, Straumann USA, Andover, MA, USA) was applied to the root surfaces. Additional EMD was mixed with a DFDBA (Straumann Allograft, Straumann USA, Andover, MA, USA), and the bone-EMD mixture was applied to the defect. In the FLAP technique, flap margins were sutured using 4-0 chromic gut interrupted loop sutures. In the MIS technique, papilla were sutured using 4-0 chromic gut vertical mattress sutures as described by Harrel.[3]

Postoperatively, patients were prescribed amoxicillin (500 mg tabs, 2 tabs starting dose then 1 tab TID for 7 days) and chlorhexidine rinse 0.12% (BID for 30 days). Ibuprofen 600 mg or hydrocodone 5/500 tablets 1 tab, q6h as needed was recommended for pain control. Postoperative instructions included no mechanical oral hygiene for the first 24 hours in the surgical area, followed by gentle brushing using the Stillman's technique if tolerated. Postoperative evaluation was performed at 1, 3 weeks and 3, 6 months postsurgery. Each subject was asked to complete three surveys at 24 hours, 1 week and 6 months after completion of the treatment. The surveys asked each subject to evaluate his/her level of pain, ability to chew, swallow and speak as well as his/her opinion on the esthetics and overall satisfaction of the procedure using a 10-point visual

analog scale. The 24-hour survey was given to the patient after the surgical appointment to complete the next day, and 1 week and 6-month surveys were completed during follow-up appointments. At the 6-month appointment, a radiograph was taken and the periodontal parameters were measured using the same periodontal probe.

Statistical Analysis

Mean and standard deviations were calculated for all clinical measurements. Linear mixed models were constructed to compare the two procedures on changes over time in facial and lingual measurements of PD, CALs and papilla height. The fixed-effects portion of each model was 'procedure' (FLAP or MIS), and the random effects portion of each model was the patient, with teeth nested within each patient. Time was specified as the repeated effect, with two levels (baseline and 6-month postoperative) with a first-order autoregressive covariance structure. Friedman tests were computed to test change over time in pain, chewing, swallowing, speaking and patient satisfaction from 24 hours to 1 week and 6 months post-treatment. A Wilcoxon signed ranks test was computed to test change over time in esthetics from 1 week to 6 months post-treatment.

RESULTS

The study population consisted of five females and four males with age range between 52 and 77 years (mean: 61 years). All of the nine subjects had one or more periodontal intrabony defects. Four patients had a single periodontal defect, four patients had two, and one patient had three periodontal defects. A total of 15 sites fulfilled the inclusion criteria for the study (seven MIS and eight FLAP). The teeth consisted of one maxillary incisor, four maxillary premolars, four maxillary molars, two mandibular cuspids and four mandibular premolars. All teeth were vital as determined by their responsiveness to thermal stimuli.

Table 1 shows mean and standard deviations of all clinical measurements. The linear mixed model for lingual PDs indicated that there was no significant effect for procedure, $F(1,6.7) = 0.24$, $p = 0.64$. However, all patients significantly improved over time, $F(2,24.7) = 30.7$, $p < 0.0001$. PDs averaged 5.6 ± 1.1 mm at baseline and improved to 3.9 ± 0.8 mm at 6 months for FLAP technique. For MIS technique, lingual PDs averaged 6.6 ± 1.4 mm at baseline and improved to 3.4 ± 0.5 mm at 6 months. In summary, all patients showed reduction of lingual PDs regardless of the procedure received (Table 1).

Regardless of the surgical technique employed, all patients showed a significant improvement in periodontal parameters over time, $F(1,10.2) = 17.9$, $p < 0.0001$. For FLAP technique facial PDs averaged 5.5 ± 1.3 mm at baseline and improved to 3.3 ± 0.7 mm at 6 months (Figs 1A to N). For MIS technique, the mean facial PDs was 5.8 ± 1.9 mm at baseline and improved to 3.3 ± 0.5 mm at 6 months (Figs 2A to J). Therefore, all patients showed reduction in facial PDs (see Table 1).

The linear mixed model for lingual CALs indicated that there was no significant effect for procedure, $F(1,9.5) = 1.96$, $p = 0.19$. However, all patients significantly improved over time, $F(1,7.3) = 19.9$, $p < 0.0001$. CALs averaged 5.9 ± 2.0 mm at baseline and improved to 4.4 ± 1.5 mm at 6 months for FLAP subjects. For MIS subjects, lingual CALs averaged 7.6 ± 1.8 mm at baseline and improved to 5.4 ± 1.9 mm at 6 months. Therefore, all patients showed improved lingual CALs regardless of the procedure received (see Table 1).

Table 1: Clinical parameters at baseline and 6 months following surgery

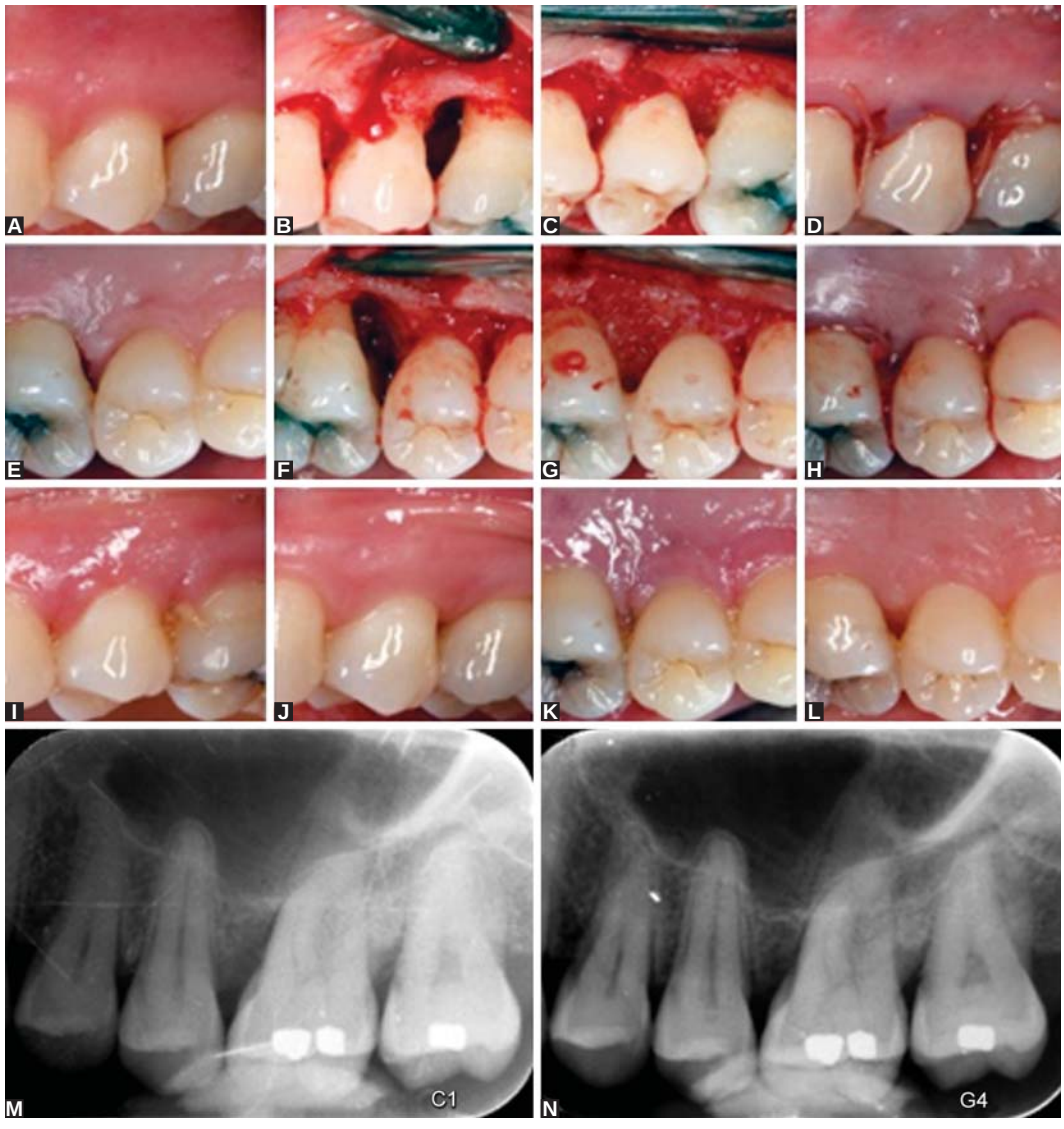
mm	*Baseline*		*6 months*		**p-value*
	FLAP	*MIS*	*FLAP*	*MIS*	
PD-lingual	5.6 ± 1.1	6.6 ± 1.4	3.9 ± 0.8	3.4 ± 0.5	<0.0001
PD-facial	5.5 ± 1.3	5.8 ± 1.9	3.3 ± 0.7	3.3 ± 0.5	<0.0001
CAL-lingual	5.9 ± 2.0	7.6 ± 1.8	4.4 ± 1.5	5.4 ± 1.9	<0.0001
CAL-facial	6.1 ± 1.9	6.9 ± 2.5	4.5 ± 1.6	4.4 ± 1.6	0.04
PAP-lingual	1.4 ± 1.9	1.5 ± 1.7	1.4 ± 1.5	1.2 ± 1.1	0.82
PAP-facial	1.9 ± 1.5	1.6 ± 2.0	1.8 ± 1.8	1.0 ± 1.1	0.42

MIS: Minimally invasive surgery; FLAP: Conventional flap; PD: Probing depth; CAL: Clinical attachment level; PAP: Papilla height; *Friedman tests

Table 2: Descriptive statistics of survey data at 24 hours, 1 week and 6 months

	24 hours		*1 week*		*6 months*	
	FLAP	*MIS*	*FLAP*	*MIS*	*FLAP*	*MIS*
Pain	1.3 ± 0.5	1.2 ± 1.0	0.3 ± 0.5	0.3 ± 0.5	0.3 ± 0.7	0.0 ± 0.0
Esthetics	–	–	9.8 ± 0.7	9.9 ± 0.4	10.0 ± 0.0	9.9 ± 0.2
Patient satisfaction	9.8 ± 0.7	9.7 ± 0.8	9.9 ± 0.4	9.9 ± 0.4	10.0 ± 0.0	9.9 ± 0.2

Visual analog scale of 1 to 10



Figs 1A to N: Defect treated with FLAP protocol: (A) preoperative facial view of #14 treated with FLAP protocol, (B) after flap reflection of A, (C) after grafting with DFDBA + EMD, (D) after suturing of C, (E) preoperative palatal view of A, (F) palatal view after flap reflection, (G) palatal view after grafting with DFDBA + EMD, (H) palatal view after suturing, (I) one week postoperative view of #14, (J) six-month postoperative view of #14, (K) one week postoperative palatal view of I, (L) six-month postoperative palatal view of J, (M) preoperative PA radiograph of #14 depicting vertical bone loss on the mesial of #14 and (N) six-month postoperative PA radiograph of #14 depicting radiographic bone fill of defect

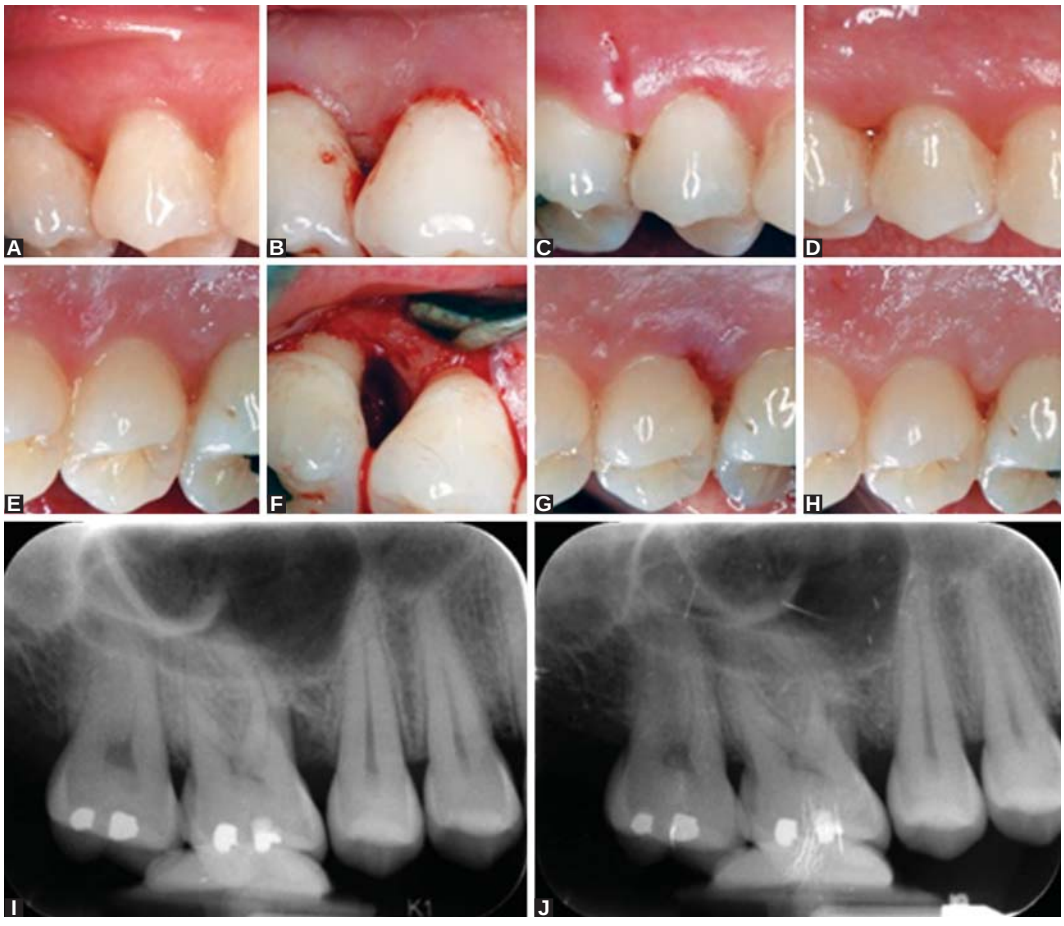
Similar improvement was observed for facial CALs averaging 6.1 ± 1.9 mm at baseline and improved to 4.5 ± 1.6 mm at 6 months for FLAP technique. For MIS subjects, facial CALs averaged 6.9 ± 2.5 mm at baseline and improved to 4.4 ± 1.6 mm at 6 months (Table 1).

A significant difference was also observed in the reduction of facial papilla height with MIS *vs* FLAP procedures, 1.6 ± 2.0 mm at baseline to 1.0 ± 1.1 mm at 6 months *vs* 1.9 ± 1.5 mm at baseline to 1.8 ± 1.8 mm at 6 months respectively ($p = 0.03$).

Nonparametric tests for repeated measures subsequently were computed and indicated that patients' pain was significantly changed over time (Table 2). Pain significantly decreased over time, $p < 0.0001$. However, patient satisfaction did not significantly change over time ($p = 0.14$). Similarly, scores for esthetics did not significantly change over time.

No subject reported pain greater than 4/10 (mean: 1.3/10) at 24 hours, regardless of the procedure received, and only one subject reported any discomfort at 6 months.

Eight of nine subjects reported some limitations in chewing (mean: 3.6/10, range: 0-7) at 24 hours, regardless of procedure. Patients generally had little difficulty swallowing (mean: 0.4/10, range: 0-1) or speaking (mean: 0.1, range: 0-1) at 24 hours, and no limitations for each at 6 months. Patients were generally pleased with the esthetics of both procedures at 6 months (mean: 9.97/10, range: 9.5-10) as well as overall satisfaction (mean: 9.97/10, range: 9.5-10) (Graph 1A to C).



Figs 2A to J: Defect treated with MIS protocol: (A) preoperative view of #3 treated with MIS protocol, (B) facial view of #3 demonstrating incision design, (C) one week postoperative facial view of #3, (D) six-month postoperative facial view of #3, (E) preoperative palatal view of A, (F) papilla elevation on facial of #3, (G) one week postoperative palatal view of C, (H) six-month postoperative palatal view of D, (I) preoperative radiograph depicting vertical bone loss on mesial of #3, (J) six-month postoperative radiograph depicting partial bone fill of defect

DISCUSSION

This study was designed to compare the effectiveness of MIS compared to conventional surgical techniques for regeneration of periodontal defects using EMD and DFDBA. To date, the literature regarding MIS has been comparative in nature with no controlled studies.[3-5,7,10-11,13-14]

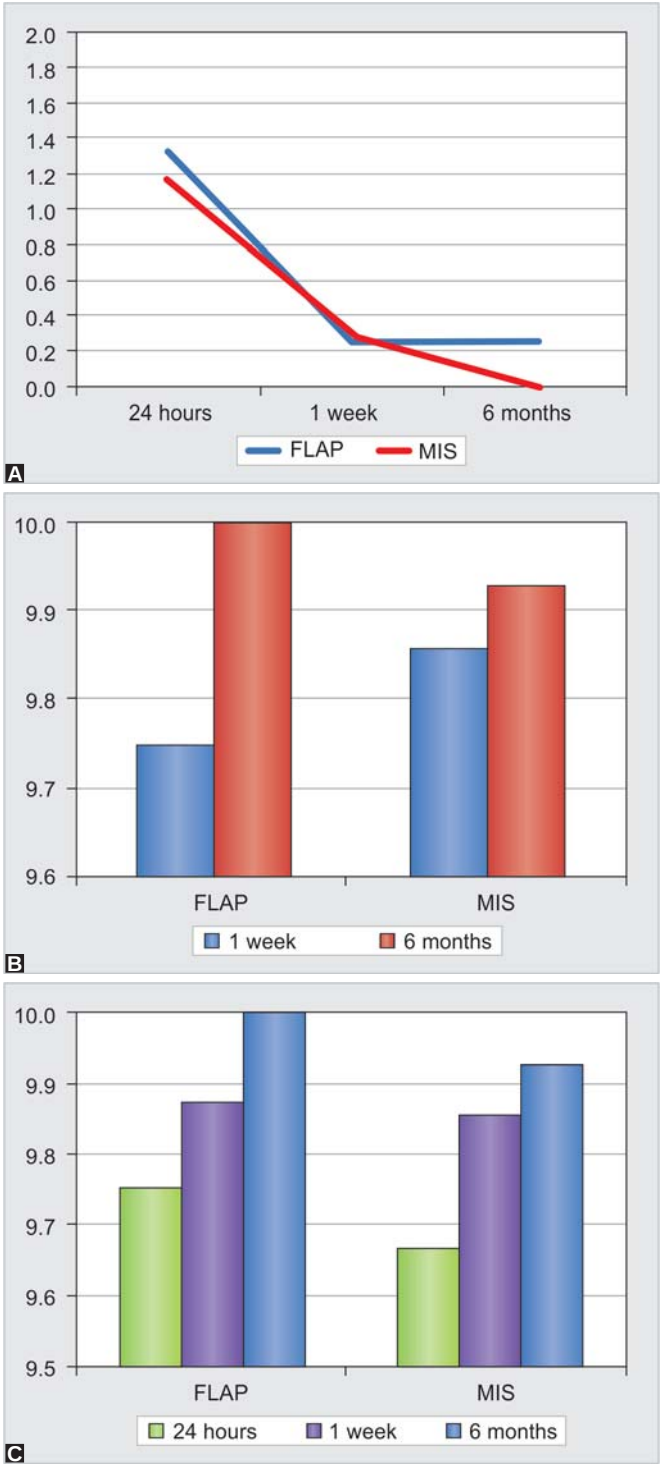
Previous studies reported improvement in clinical periodontal parameters after MIS, and often times to a greater extent than comparable traditional surgical approaches.

Fifteen deep intrabony periodontal defects were treated in the study. Six months follow-up evaluation revealed a significant reduction in pocket depth (2.50 mm facially and 3.14 mm lingually for the MIS group *vs* 2.19 mm facially and 1.75 mm lingually for the FLAP group). This was also accompanied by CAL gains for the MIS group of 2.50 mm facially and 2.21 mm lingually *vs* 1.63 mm facially and 1.50 mm lingual for the FLAP group. Facial and lingual PD and CAL improvements were significant for each group from baseline. Although MIS demonstrated slightly better improvement in PD and CAL, there was no significant difference in the outcome between the two surgical approaches. Similar improvement in periodontal parameters was also reported by several studies.[3,4,7,11,14]

Change in papilla height observed in this study was greater than other studies utilizing minimally invasive techniques.[3,7,10] There was significantly more loss of papillary height on the facial with the MIS technique than the FLAP technique (0.64 *vs* 0.13 mm respectively). However, no significant difference was observed in the lingual aspect between the two procedures (0.29 *vs* – 0.06 mm respectively).

In this study, all mesiodistal papillary incisions were made on the facial aspect which may account for the greater facial loss of papilla height observed. Limited surgical experience may account for the overall lack of comparable results in papilla height as well as PD and CAL improvements.

The results for the FLAP procedure were consistent with previous studies using EMD and bone graft for GTR procedures. Sculean et al[2] published a 10-year follow-up study on the effects of using EMD, GTR and EMD + GTR



Graphs 1A to C: Graphical representation of survey data: (A) Post-operative pain, (B) postoperative esthetics and (C) postoperative satisfaction

compared to open flap debridement in 38 patients. When using EMD with GTR, the authors reported a mean PD reduction of 3.5 mm and mean CAL gain of 2.9 mm at 10 years, with a mean change in REC of 0.6 mm. The authors also reported no significant changes from 1 to 10 years, indicating that the results are stable over time. Hoidal et al[15] compared EMD + DFDBA to DFDBA alone when treating periodontal intrabony defects in 32 patients. The authors reported mean PD reductions of 2.56 ± 1.42 mm and 1.47 ± 1.40 mm CAL gains after 6 months for the EMD ± DFDBA group, which compares favorably with the results of the present study. The authors also reported 1.09 ± 0.99 mm of REC change, which is slightly more than that observed in the present study.

MISTs are promoted as being less painful.[3] Postoperative pain after a MIS procedure was evaluated in a previous study using a 100 mm VAS scale.[10]

The authors reported a mean intensity of pain of 19 ± 9 (range: 11-31), which compares favorably to the other studies.[3,14]

Patients in the current study reported no more post-operative pain in FLAP procedures than MIS procedures, which questions the validity of minimal postoperative pain as an advantage of minimally invasive periodontal procedures. The occurrence of 'black triangles' after many periodontal procedures is a subject of concern for many clinicians. Despite having greater loss of papilla fill after MIS and FLAP procedures than reported in other studies, patients were very pleased with the esthetics and clearly not critical of this in their rating of overall esthetics.

CONCLUSION

The overall result of our study suggests that MIS is as effective as conventional flap surgery in the treatment of deep intrabony periodontal defects and that both techniques appear to provide a comparable outcome in reduced PDs and gain of CALs.

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ABOUT THE AUTHORS

Matthew R Steffer

Private Practice, Former Graduate Student, Department of Periodontics Baylor College of Dentistry, Texas A&M University, Dallas, TX, USA

Stephen K Harrel

Clinical Professor, Department of Periodontics, Baylor College of Dentistry, Texas A&M University, Dallas, TX, USA

Jeffrey A Rossmann (Corresponding Author)

Professor, Department of Periodontics, Baylor College of Dentistry Texas A&M University, 3302 Gaston Ave, Dallas, TX 75246, USA Fax: 214-874-4532, e-mail: jrossmann@bcd.tamhsc.edu

David G Kerns

Professor, Department of Periodontics, Baylor College of Dentistry Texas A&M University, Dallas, TX, USA

Francisco Rivera-Hidalgo

Professor, Department of Periodontics, Baylor College of Dentistry Texas A&M University, Dallas, TX, USA

Celeste M Abraham

Associate Professor, Department of Periodontics, Baylor College of Dentistry, Texas A&M University, Dallas, TX, USA

Ibtisam Al-Hashimi

Professor, Department of Periodontics, Baylor College of Dentistry Texas A&M University, Dallas, TX, USA

Eric S Solomon

Professor, Department of Public Health Sciences, Baylor College of Dentistry, Texas A&M University, Dallas, TX, USA

Daisha J Cipher

Associate Professor, Department of Nursing, University of Texas at Arlington, Arlington, TX, USA