



EFFICACY OF ULTRASOUND-GUIDED BILATERAL SUPRAZYGOMATIC MAXILLARY NERVE BLOCK WITH LEVOBUPIVACAINE FOR PERIOPERATIVE ANALGESIA IN FUNCTIONAL ENDOSCOPIC SINUS SURGERY AND SEPTOPLASTY: A RANDOMIZED, DOUBLE-BLIND, PLACEBO-CONTROLLED TRIAL

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Abstract

Background: Functional endoscopic sinus surgery (FESS) and septoplasty cause substantial perioperative pain owing to rich innervation of the nasal structures by the maxillary division (V2) of the trigeminal nerve. The ultrasound-guided suprazygomatic maxillary nerve block (SMB) targets V2 within the pterygopalatine fossa for focused, opioid-sparing analgesia. Objective: To compare bilateral SMB using 0.125% levobupivacaine with saline placebo for perioperative analgesia, intraoperative haemodynamics, opioid sparing, patient and surgeon satisfaction. Methods: In this prospective, randomized, double-blind, placebo-controlled trial, 60 patients (ASA I–II, 15–60 years) were randomized equally to Group SMB (0.125% levobupivacaine 5 mL per side) or Group Control (0.9% saline 5 mL per side) after induction. Outcomes were visual analogue scale (VAS) pain scores, time to first rescue analgesia, total rescue analgesic doses, intraoperative heart rate (HR) and mean arterial pressure (MAP), patient and surgeon satisfaction, and adverse events. Results: Group SMB had lower VAS at every timepoint (0 hr, 0.2 ± 0.3 vs 1.3 ± 0.79 ; 24 hr, 1.4 ± 0.5 vs 3.6 ± 0.94 ; nasal pack removal, 1.1 ± 0.5 vs 4.9 ± 1.3 ; all $P < 0.001$). Rescue analgesia was delayed (22.7 ± 1.39 vs 6.1 ± 3.8 hr) and doses fewer (0.5 ± 0.5 vs 2.7 ± 2.0 ; both $P < 0.001$). Intraoperative HR and MAP were lower in Group SMB after intubation ($P < 0.001$). Patient and surgeon satisfaction were higher (median 5 vs 2 and 5 vs 3; $P < 0.001$). No adverse events occurred. Conclusion: Ultrasound-guided bilateral SMB with 0.125% levobupivacaine significantly enhanced perioperative analgesia along with pain during nasal pack removal, reduced rescue analgesia, attenuated intraoperative haemodynamic responses, and improved patient and surgeon satisfaction, without adverse events with an excellent safety profile.

Keywords: maxillary nerve block; suprazygomatic approach; functional endoscopic sinus surgery; septoplasty; levobupivacaine.

Introduction

Functional endoscopic sinus surgery (FESS) and septoplasty are among the most frequently performed elective otorhinolaryngological procedures and are usually carried out under general anaesthesia. Despite their relatively short operative duration, both are associated with significant perioperative pain and discomfort attributable to the dense innervation of the nasal cavity, paranasal sinuses, and nasal septum by the trigeminal nerve. The maxillary division (V2), through its sphenopalatine and posterior superior alveolar branches, constitutes the principal nociceptive afferent pathway from these structures.

Conventional perioperative analgesia for nasal surgery has traditionally relied on systemic agents, particularly opioids. Opioids, however, carry well-recognised dose-dependent adverse effects—postoperative nausea and vomiting (PONV), sedation, respiratory depression, post-operative ileus, and delayed recovery—that are especially undesirable in the ambulatory ENT setting. Within the framework of Enhanced Recovery After Surgery (ERAS) and procedure-specific multimodal analgesia, locoregional techniques offering targeted, opioid-sparing analgesia are of increasing relevance.¹ A systematic review has indicated that regional techniques provide superior perioperative analgesia compared with systemic analgesia for FESS.²

The suprazygomatic maxillary nerve block (SMB) is an ultrasound-guided technique that delivers local anaesthetic into the pterygopalatine fossa (PPF), blocking the main trunk of V2 and its ganglionic branches. The approach was originally described for paediatric cleft palate surgery by Picard et al.³ and has since been adapted for children and adults undergoing nasal and mid-facial procedures.⁴ By targeting V2 along its proximal course within the PPF, SMB provides broad anaesthetic coverage of the nasal cavity, paranasal sinuses, hard palate, mid-face, and upper gingiva—territory that corresponds closely to the surgical field of FESS and septoplasty.

Levobupivacaine, the S(–)-enantiomer of racemic bupivacaine, is a long-acting amide local anaesthetic with a more favourable cardiovascular and central nervous system safety profile than the racemate.⁵ Its prolonged duration of action makes it suitable for deep regional blocks, which are placed in proximity to major vascular structures such as the maxillary artery within the PPF. At a concentration of 0.125%, levobupivacaine produces predominantly sensory blockade at low systemic-toxicity risk—a profile well suited to perioperative analgesia in nasal surgery, where intense and prolonged sensory block is the relevant therapeutic aim.

Despite growing interest in SMB as an analgesic adjunct for nasal surgery, relatively few randomized, double-blind, placebo-controlled studies have evaluated SMB with levobupivacaine across both FESS and septoplasty within a single design, or extended analgesic assessment to the clinically important interval of nasal pack removal. This trial was therefore designed to evaluate the efficacy of ultrasound-guided bilateral SMB with 0.125% levobupivacaine on perioperative analgesia, intraoperative haemodynamics, and opioid consumption, along with patient and surgeon satisfaction scores in patients undergoing FESS or septoplasty under general anaesthesia.

Methods

Ethics approval

The study was approved by the Institutional Ethics Committee, Narayana Medical College and Hospital, Nellore (Ref. No. IEC/NMC/07), Written informed consent was obtained from all participants prior to enrolment.

Study design and setting

This was a prospective, randomized, double-blind, placebo-controlled, parallel-group clinical trial conducted over a three-month period in the Department of Anaesthesiology, Narayana Medical College and Hospital, Nellore, Andhra Pradesh, India.

Participants

Patients of either sex aged 15–60 years, with ASA physical status I or II, scheduled for elective FESS or septoplasty under general anaesthesia, were eligible. Exclusion criteria were patient refusal; ASA grade III or IV; known allergy to local anaesthetics; local skin infection at the injection site; bleeding diathesis or use of anticoagulants; and inability to comprehend or use the Visual Analogue Scale.

Sample size

The sample size was calculated to detect a clinically meaningful between-group difference in postoperative VAS pain scores—the primary outcome—using the formula for comparison of two independent means, $n = 2 \times (Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma^2 / \Delta^2$, where σ is the assumed common standard deviation of VAS and Δ the minimum clinically important difference. Assuming a two-sided α of 0.05 and 80% power, and adopting the effect size observed in a previous comparable study of SMB in nasal surgery, a minimum of 30 patients per group was required. Sixty patients (30 per group) were therefore enrolled.

Randomization, allocation concealment, and blinding

Participants were randomly allocated in a 1:1 ratio using a computer-generated random-number sequence. Allocation concealment was maintained with sequentially numbered, opaque, sealed envelopes opened only after enrolment by an anaesthesiologist not involved in outcome assessment. The trial was double-blind: patients, the operating surgeons, and the outcome assessors recording VAS scores, haemodynamic parameters, and satisfaction scores were all unaware of group assignment. Because both groups underwent an identical procedure differing only in the injectate, procedural blinding was preserved.

Anaesthetic protocol

After thorough preoperative assessment, all patients were informed about the purpose of the study and its possible complications and benefits, and written informed consent was obtained. On the day of surgery, patients were transferred to the operating theatre, a large-bore intravenous cannula was secured, and balanced crystalloid was administered. Standard ASA monitoring—electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography—was attached. All patients received a standardized general anaesthetic technique consistent with institutional practice.

Premedication comprised intravenous glycopyrrolate 10 µg/kg, midazolam 0.05 mg/kg, and fentanyl 1–2 µg/kg. After premedication, anaesthesia was induced with intravenous propofol 2 mg/kg and cisatracurium 0.2 mg/kg. Following endotracheal intubation, anaesthesia was maintained with sevoflurane and intermittent boluses of cisatracurium 0.02 mg/kg for muscle relaxation. At the end of surgery, residual neuromuscular blockade was reversed with intravenous neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg. Tracheal extubation was performed using standard criteria.

Intervention: suprazygomatic maxillary nerve block technique

Bilateral SMB was performed under ultrasound guidance immediately after induction and tracheal intubation, with the patient supine and positioned for the block. Under strict aseptic precautions, a reference line was drawn from the lateral orbital rim to the zygomatic process, and the notch superior to the zygomaticomaxillary junction was marked as the entry point. A high-frequency (10–15 MHz) linear probe was placed along the zygomatic arch, slid into the infra-zygomatic space, and tilted cranially to visualise the PPF. The maxilla, coronoid process, and pterygoid plate served as sonoanatomic landmarks. A 22-gauge, 50-mm needle was advanced via an out-of-plane suprazygomatic approach into the PPF; after negative aspiration, 0.125% levobupivacaine 5 mL was deposited adjacent to the maxillary artery with real-time visualisation of injectate spread.⁹ The procedure was repeated contralaterally. The surface landmarks, linear-probe placement, and out-of-plane needle insertion are shown in Figure 2; a representative labelled sonogram of the pterygopalatine fossa and adjacent structures is shown in Figure 3.

In Group Control, identical aseptic preparation, probe placement, needle insertion, and aspiration were carried out bilaterally, with 5 mL of 0.9% saline administered per side as an active placebo, ensuring complete procedural blinding.

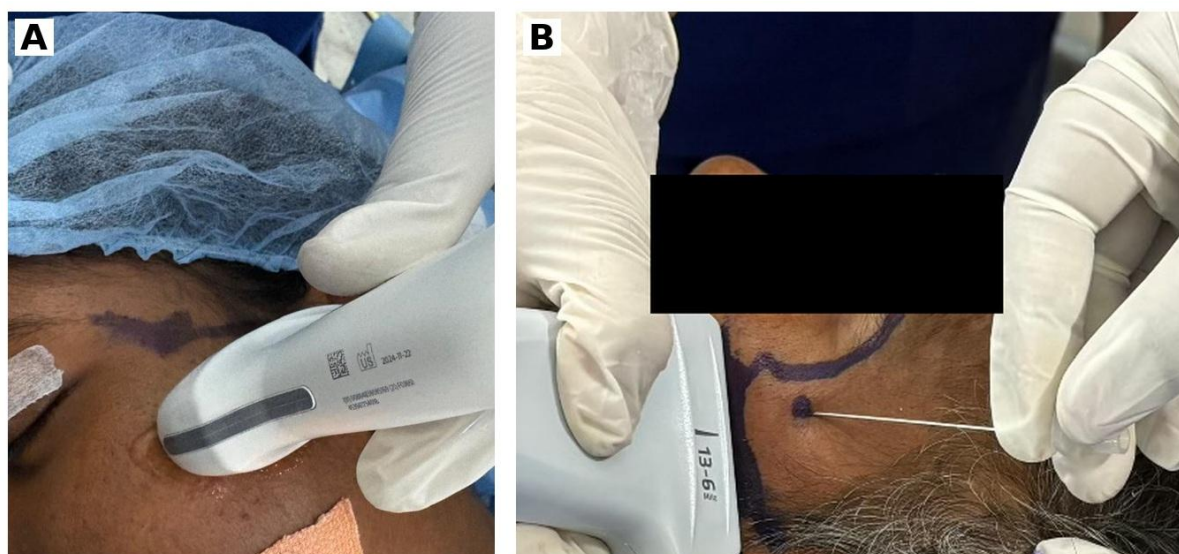


Figure 2. Ultrasound-guided bilateral suprazygomatic maxillary nerve block technique. (A) Surface reference line marked from the lateral orbital rim along the zygomatic arch, with the high-frequency linear probe positioned in the infra-zygomatic space. (B) Out-of-plane suprazygomatic needle insertion

directed toward the pterygopalatine fossa. Patient-identifying ocular features have been masked to preserve anonymity; no other feature of the images was altered.

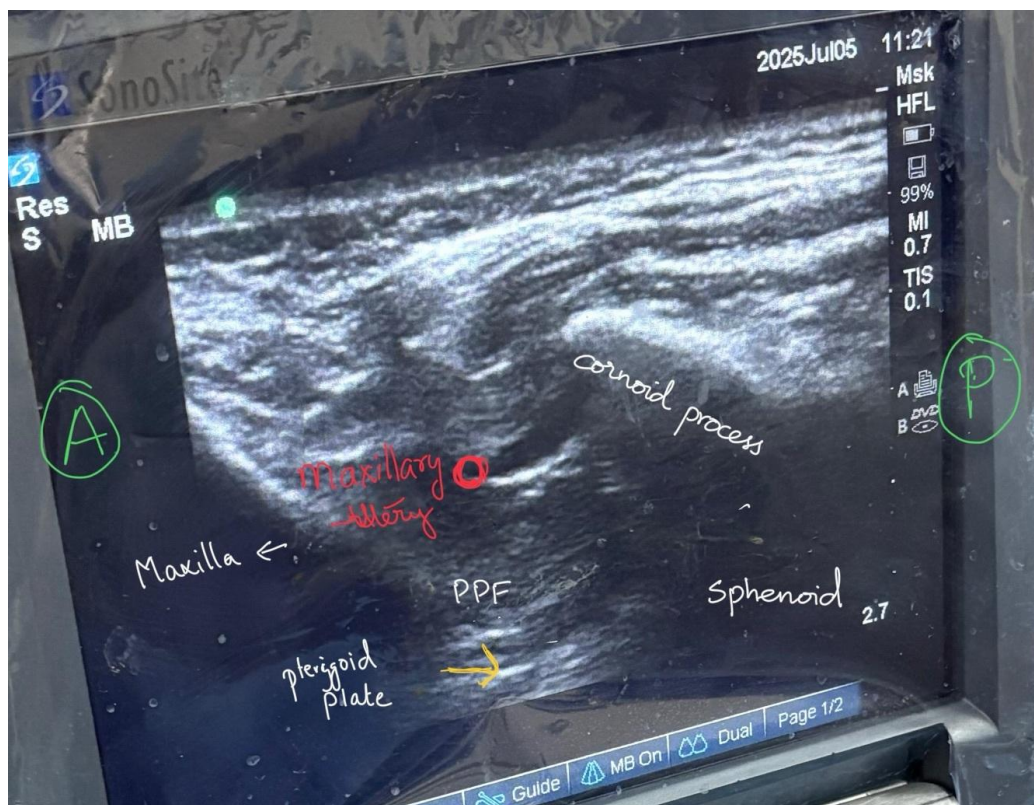


Figure 3. Labelled sonogram of the pterygopalatine fossa (PPF) obtained during the suprazygomatic approach, showing the maxilla, coronoid process, pterygoid plate, maxillary artery, and sphenoid. A, anterior; P, posterior.

Outcome measures

Primary outcomes were VAS pain scores (0 = no pain, 10 = worst pain) at 0, 2, 8, 12, and 24 hours after extubation and at nasal pack removal (≈ 36 hours); time to first rescue analgesia (hours from extubation to VAS ≥ 4); and total rescue analgesic doses within 24 hours (intravenous tramadol 100 mg when VAS ≥ 4).

Secondary outcomes were intraoperative heart rate (HR, bpm) and mean arterial pressure (MAP, mmHg) at baseline, 5 minutes after intubation, and at 15 minutes, 30 minutes, and the end of surgery; patient satisfaction at 24 hours and surgeon satisfaction at the end of surgery (Likert 1–5); and adverse events including haematoma, nasal bleeding, headache, PONV, facial oedema, paraesthesia, numbness of the jaw, or any features of local anaesthetic systemic toxicity (LAST).

Statistical analysis

Data were analysed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean $\pm$ standard deviation; ordinal and non-normally distributed data as median

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[interquartile range, IQR]; and categorical variables as n (%). Normally distributed continuous data were compared with the unpaired Student t-test, non-normally distributed and ordinal data with the Mann–Whitney U test, and categorical data with the chi-square or Fisher exact test. A two-tailed P value <0.05 was considered statistically significant.

Results

Sixty patients were assessed for eligibility; all met the inclusion criteria, and 30 were randomized to each group. All 60 participants completed the protocol with no dropouts or protocol deviations (Figure 1).

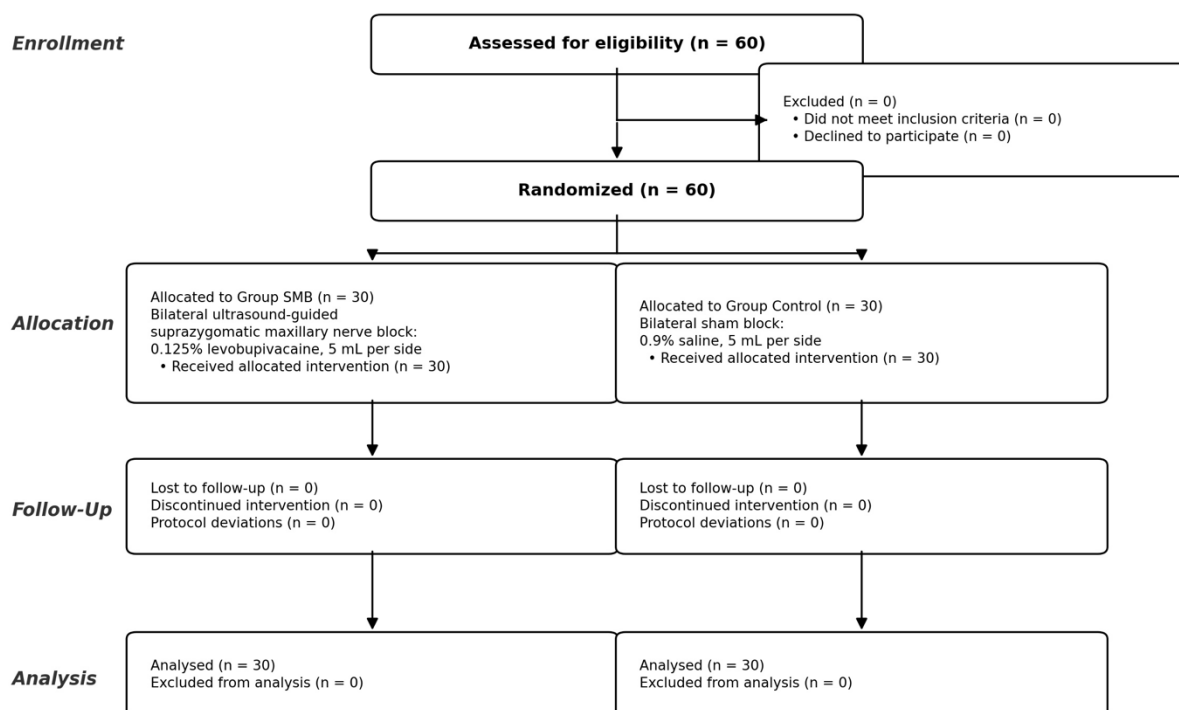


Figure 1. CONSORT 2010 flow diagram of participant enrolment, randomization, allocation, follow-up, and analysis. All 60 enrolled participants completed the protocol; no exclusions, dropouts, or protocol deviations occurred. SMB, suprazygomatic maxillary nerve block.

Baseline characteristics

The two groups were comparable for all baseline parameters. Mean age was 32.4 ± 10.2 years in Group SMB and 33.1 ± 9.8 years in Group Control ($P=0.76$). Sex distribution (66.7% vs 63.3% male, $P=0.79$), body weight (62.3 ± 8.4 vs 63.1 ± 9.2 kg, $P=0.71$), ASA grade ($P=0.78$), surgical procedure ($P=0.81$), and duration of surgery (68.4 ± 14.2 vs 70.1 ± 15.8 min, $P=0.66$) did not differ significantly (Table 1).

Table 1. Demographic and baseline clinical characteristics of study participants

Variable	Group SMB (n=30)	Group Control (n=30)	P value
Age (years), mean $\pm$ SD	32.4 $\pm$ 10.2	33.1 $\pm$ 9.8	0.76
Sex – Male, n (%)	20 (66.7)	19 (63.3)	0.79
Sex – Female, n (%)	10 (33.3)	11 (36.7)	0.79
Weight (kg), mean $\pm$ SD	62.3 $\pm$ 8.4	63.1 $\pm$ 9.2	0.71
ASA grade I, n (%)	20 (66.7)	21 (70.0)	0.78
ASA grade II, n (%)	10 (33.3)	9 (30.0)	0.78
Surgery – FESS, n (%)	16 (53.3)	15 (50.0)	0.81
Surgery – Septoplasty, n (%)	14 (46.7)	15 (50.0)	0.81
Duration of surgery (min), mean $\pm$ SD	68.4 $\pm$ 14.2	70.1 $\pm$ 15.8	0.66

Values are mean $\pm$ SD or n (%). SD, standard deviation; ASA, American Society of Anesthesiologists; FESS, functional endoscopic sinus surgery; SMB, suprazygomatic maxillary nerve block. Between-group comparisons by unpaired t-test or chi-square/Fisher exact test; $P < 0.05$ considered significant.

Primary outcomes: pain scores and rescue analgesia

Group SMB had significantly lower VAS scores than Group Control at every assessment point (Table 2): 0.2 ± 0.3 vs 1.3 ± 0.79 at 0 hr; 0.2 ± 0.34 vs 1.4 ± 0.8 at 2 hr; 0.3 ± 0.4 vs 1.9 ± 0.8 at 8 hr; 1.1 ± 0.5 vs 2.5 ± 0.5 at 12 hr; and 1.4 ± 0.5 vs 3.6 ± 0.94 at 24 hr (all $P < 0.001$). At nasal pack removal (≈ 36 hr), the VAS was 1.1 ± 0.5 in Group SMB versus 4.9 ± 1.3 in Group Control ($P < 0.001$).

Time to first rescue analgesia was prolonged in Group SMB (22.7 ± 1.39 vs 6.1 ± 3.8 hr; $P < 0.001$), and total rescue analgesic doses in the first 24 hours were fewer (0.5 ± 0.5 vs 2.7 ± 2.0 ; $P < 0.001$), consistent with an opioid-sparing effect.

Secondary outcomes: intraoperative haemodynamics

Baseline (pre-block) HR and MAP were comparable between groups (HR 81.6 ± 6.8 vs 82.2 ± 7.1 bpm, $P = 0.72$; MAP 93.2 ± 8.4 vs 94.1 ± 8.9 mmHg, $P = 0.68$). From 5 minutes after intubation through to the end of surgery, Group SMB showed significantly lower HR and MAP at all intraoperative timepoints ($P < 0.001$). At the end of surgery, mean HR was 74.8 ± 5.4 vs 82.1 ± 7.6 bpm and mean MAP 83.7 ± 6.1 vs 89.6 ± 7.8 mmHg (both $P < 0.001$).

Secondary outcomes: satisfaction and safety

Patient satisfaction at 24 hours was higher in Group SMB (median 5 [IQR 0] vs 2 [IQR 1]; $P < 0.001$), as was surgeon satisfaction at the end of surgery (median 5 [IQR 0] vs 3 [IQR 1]; $P < 0.001$) likely reflecting the improved operative field conditions associated with hemodynamic stability. No adverse events were recorded in either group throughout the study period, specifically haematoma, excessive nasal bleeding, headache, facial oedema, PONV attributable to the block, or any features of LAST.

Table 2. Comparison of outcome measures between Group SMB and Group Control

Outcome / Variable	Group SMB (n=30)	Group Control (n=30)	P value
VAS pain scores (0–10 scale), mean $\pm$ SD			
VAS – 0 hr (post-extubation)	0.2 $\pm$ 0.30	1.3 $\pm$ 0.79	<0.001
VAS – 2 hr	0.2 $\pm$ 0.34	1.4 $\pm$ 0.80	<0.001
VAS – 8 hr	0.3 $\pm$ 0.40	1.9 $\pm$ 0.80	<0.001
VAS – 12 hr	1.1 $\pm$ 0.50	2.5 $\pm$ 0.50	<0.001
VAS – 24 hr	1.4 $\pm$ 0.50	3.6 $\pm$ 0.94	<0.001
VAS – Nasal pack removal ($\approx$ 36 hr)	1.1 $\pm$ 0.50	4.9 $\pm$ 1.30	<0.001
Rescue analgesia			
Time to first rescue analgesia (hr), mean $\pm$ SD	22.7 $\pm$ 1.39	6.1 $\pm$ 3.80	<0.001
Total rescue doses in 24 hr, mean $\pm$ SD	0.5 $\pm$ 0.50	2.7 $\pm$ 2.00	<0.001
Intraoperative heart rate (bpm), mean $\pm$ SD			
HR – Baseline (pre-block)	81.6 $\pm$ 6.8	82.2 $\pm$ 7.1	0.72
HR – 5 min after intubation	78.4 $\pm$ 6.2	91.3 $\pm$ 7.8	<0.001
HR – 15 min intraoperative	76.1 $\pm$ 5.9	88.7 $\pm$ 7.4	<0.001
HR – 30 min intraoperative	75.3 $\pm$ 5.6	86.4 $\pm$ 8.2	<0.001
HR – End of surgery	74.8 $\pm$ 5.4	82.1 $\pm$ 7.6	<0.001
Intraoperative mean arterial pressure (mmHg), mean $\pm$ SD			
MAP – Baseline (pre-block)	93.2 $\pm$ 8.4	94.1 $\pm$ 8.9	0.68
MAP – 5 min after intubation	88.6 $\pm$ 7.3	101.4 $\pm$ 9.2	<0.001
MAP – 15 min intraoperative	85.4 $\pm$ 6.8	97.8 $\pm$ 8.6	<0.001
MAP – 30 min intraoperative	84.2 $\pm$ 6.5	94.3 $\pm$ 8.1	<0.001
MAP – End of surgery	83.7 $\pm$ 6.1	89.6 $\pm$ 7.8	<0.001
Satisfaction and safety			
Patient satisfaction (Likert 1–5), median [IQR]	5 [0]	2 [1]	<0.001
Surgeon satisfaction (Likert 1–5), median [IQR]	5 [0]	3 [1]	<0.001
Adverse events, n	0	0	—

Values are mean $\pm$ SD or median [IQR]. VAS, Visual Analogue Scale (0–10); SMB, suprazygomatic maxillary nerve block; HR, heart rate; MAP, mean arterial pressure; IQR, interquartile range. Rescue analgesia: intravenous tramadol 100 mg when VAS $\geq$ 4. Continuous data compared by unpaired t-test; ordinal data by Mann–Whitney U test.

Discussion

In this randomized, double-blind, placebo-controlled trial, bilateral ultrasound-guided SMB with 0.125% levobupivacaine (5 mL per side) provided significantly better perioperative analgesia than saline placebo in patients undergoing FESS or septoplasty. The block lowered postoperative VAS scores at all timepoints up to nasal pack removal, prolonged the interval to first rescue analgesia, reduced total analgesic consumption, was associated with more stable intraoperative haemodynamics, and improved patient and surgeon satisfaction, with no observed adverse events.

The PPF is a pyramidal osseous space bounded anteriorly by the maxilla, posteriorly by the pterygoid process of the sphenoid, and medially by the perpendicular plate of the palatine bone. It contains the main trunk of V2, the pterygopalatine ganglion, the maxillary artery, and their branches, which collectively supply the nasal cavity, paranasal sinuses, hard palate, nasopharynx, and mid-face.¹⁰ Depositing local anaesthetic within the PPF via the suprazygomatic approach achieves broad, predictable blockade of these structures, making it anatomically well suited to analgesia for FESS and septoplasty; the sonographic anatomy relevant to the block is shown in Figure 3.

Our findings are consistent with those of Neupane et al., who evaluated ultrasound-guided SMB in FESS and reported lower postoperative pain scores and reduced analgesic consumption in the block group up to 24 hours.⁶ The present study adds a combined FESS-and-septoplasty cohort and reports analgesia specifically at nasal pack removal—an event widely regarded as one of the most painful in the postoperative course of nasal surgery, yet seldom assessed in earlier work. The VAS at pack removal was markedly lower in Group SMB (1.1 ± 0.5 vs 4.9 ± 1.3 ; $P < 0.001$), which has direct implications for patient comfort and discharge readiness.

In septoplasty, Yılmaz and Çilingir reported that a maxillary nerve block lowered pain scores and improved quality of recovery compared with controls undergoing septoplasty.⁷ Our results are concordant and extend the observation to a mixed nasal-surgery population, suggesting that the benefit of bilateral SMB applies across both procedures. Afandy et al. additionally reported reduced emergence agitation with SMB in septorhinoplasty;⁸ although emergence agitation was not a formal endpoint here, the low VAS at extubation in Group SMB (0.2 vs 1.3 ; $P < 0.001$) is compatible with a smoother, less pain-driven emergence.

The intraoperative haemodynamic findings warrant careful interpretation. Baseline HR and MAP were comparable ($P = 0.72$ and $P = 0.68$), and Group SMB showed lower HR and MAP from 5 minutes after intubation onward (all $P < 0.001$). Because the block was placed after induction and tracheal intubation, this pattern is best attributed to attenuation of the sympathoadrenal response to surgical stimulation within the trigeminal territory, rather than to blunting of the laryngoscopy or intubation response. In FESS, where controlled hypotension is often used to improve the endoscopic field, this haemodynamic stability is of operative value and is reflected in the higher surgeon-satisfaction scores.

The use of 0.125% levobupivacaine offers a favourable balance of effective, prolonged sensory analgesia and a low systemic-toxicity risk. The extended interval to first rescue analgesia (mean 22.7 hours) is consistent with the agent's long duration of action. The S(–)-configuration of levobupivacaine confers lower cardiotoxicity and neurotoxicity than racemic bupivacaine,⁵ an advantage for deep injections near vascular structures such as the maxillary artery, and the absence of LAST in this cohort supports the safety of this agent–concentration combination for bilateral SMB.

Strengths

Methodological strengths include the use of normal saline as an active (sham) placebo, which preserved genuine procedural blinding of patients, surgeons, and assessors and reduced the risk of a non-specific procedural placebo effect confounding the results. Real-time ultrasound guidance, a standardized anaesthetic protocol, and complete follow-up of all 60 participants further strengthen internal validity.

Limitations

Several limitations should be acknowledged. First, this was a single-centre trial with a three-month recruitment window, which may limit generalizability. Second, follow-up beyond nasal pack removal (≈ 36 hours) was not performed. Third, the lower age limit of 15 years includes adolescents, for whom a separate subgroup analysis would be informative. Fourth, intraoperative haemodynamics can be influenced by coexisting conditions such as hypertension and diabetes mellitus and by concurrent medications; whether such patients were included or excluded was not separately recorded, and the haemodynamic comparison should be interpreted with this in mind.

Future directions

Future multicentre trials with longer follow-up, dedicated adolescent subgroups, pre-specified analysis of comorbidities affecting haemodynamics, and comparison of SMB with alternative regional techniques would help define its place within multimodal analgesic pathways for nasal surgery.

Conclusion

Bilateral ultrasound-guided suprazygomatic maxillary nerve block with 0.125% levobupivacaine provided superior perioperative analgesia compared with saline placebo in patients undergoing FESS and septoplasty. The block reduced VAS pain scores through to nasal pack removal at ≈ 36 hours, prolonged the time to first rescue analgesia approximately 3.7-fold, reduced rescue analgesic requirements, was associated with more stable intraoperative haemodynamics, and improved patient and surgeon satisfaction, with no adverse events observed. These findings support consideration of bilateral SMB as a component of multimodal analgesia for nasal surgery. Confirmation in larger, multicentre trials with longer follow-up and effect-size reporting is warranted before broad recommendations are made.

Declarations

Ethics approval and consent to participate: Approved by the Institutional Ethics Committee, Narayana Medical College and Hospital, Nellore (Ref. No. IEC/NMC/07). Written informed consent was obtained from all participants.

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Conflict of interest: The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Author contributions: Study concept and design: Krishnachaithanya K and Sammana Vijaya. Data acquisition: Panwale Nishat Fatima. Analysis and interpretation of data: Panwale Nishat Fatima and Sammana Vijaya. Drafting of the manuscript: Panwale Nishat Fatima. Critical revision of the manuscript for important intellectual content: Krishnachaithanya K, Sammana Vijaya, and Haritha Damarla. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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