BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 10

DOI:10.58240/1829006X-2025.21.10- 233

ORIGINAL RESEARCH

COMPARISON OF SEVOFLURANE AND ISOFLURANE ON POST-ANESTHETIC RECOVERY IN PEDIATRIC DENTAL PROCEDURES: A RANDOMIZED CONTROLLED TRIAL

Harsh S Baldawa, BDS[1], Dinesh Kumar B, MDS[2], Ramsesh Manohar, MD[3]

[1]Post graduate student, Department of pediatric and preventive dentistry Saveetha dental college and hospitals Saveetha institute of medical and technical sciences Saveetha university Chennai -77 152211004.sdc@saveetha.com. +91-8485841420.
[2]Senior Lecturer Department of pediatric and preventive dentistry Saveetha dental college and hospitals Saveetha institute of medical and technical sciences Saveetha university Chennai -77 dineshkumarb.sdc@saveetha.com +919952007702
[3]Reader, department of Anesthesiology, Saveetha dental college and hospitals, Saveetha institute of medical and technical sciences Saveetha university Chennai -77 dr.ramsesh@gmail.com

Corresponding author: Dinesh Kumar B, MDS Senior Lecturer Department of pediatric and preventive dentistry Saveetha dental college and hospital Saveetha institute of medical and technical sciences Saveetha university Chennai -7 dineshkumarb.sdc@saveetha.com+919952007702
Received: *Sep.22 2025;* ***Accepted:*** *Oct. 18, 2025;* ***Published:*** *Nov 5,2025*

Abstract

Background: Early Childhood Caries (ECC) frequently necessitates dental treatment under general anesthesia (GA) in uncooperative children. The choice of anesthetic agent influences not only physiological recovery but also behavioral comfort and parental perception. This study compared postoperative recovery outcomes and parental satisfaction in children undergoing dental procedures under GA with Sevoflurane or Isoflurane.

Materials and Methods:A randomized controlled trial was conducted on thirty-six children aged 2–6 years (ASA I–II) undergoing dental rehabilitation under GA. Participants were allocated into two groups: Group S (Sevoflurane) and Group I (Isoflurane)for anesthesia maintenance. Recovery was assessed using the modified Aldrete score, postoperative distress was measured using the FLACC behavioral scale (0–10), and parental satisfaction was evaluated with an 8-item, 5-point Likert questionnaire. Data were analyzed using *t*-tests and Chi-square tests ($p < 0.05$).

Results:Both anesthetic agents provided stable hemodynamics and smooth recovery. Mean Aldrete recovery times and nausea scores were comparable between groups. The Isoflurane group showed significantly lower FLACC scores (7.1 ± 1.3 vs. 8.4 ± 1.2; p = 0.004), indicating reduced behavioral agitation during emergence. Parental satisfaction was also higher with Isoflurane (38.2 ± 2.0 vs. 36.5 ± 2.4; p = 0.02), particularly regarding comfort, pain control, and recovery smoothness.

Conclusions:Isoflurane produced comparable anesthetic stability to Sevoflurane but demonstrated calmer behavioral recovery and greater parental satisfaction, suggesting it as a safe, cost-effective alternative for pediatric dental anesthesia.

Keywords**:** Pediatric anesthesia; Sevoflurane; Isoflurane; FLACC scale; Parental satisfaction; Emergence delirium; General anesthesia; Early childhood caries

INTRODUCTION

Early Childhood Caries (ECC) is one of the most prevalent chronic diseases affecting children worldwide, particularly in developing countries where socioeconomic disparities persist.[1,2] In many cases, young or uncooperative children with extensive dental involvement are unable to tolerate conventional chairside treatment, necessitating the use of general anesthesia (GA) for comprehensive dental rehabilitation.[3,4] Conducting multiple procedures under a single anesthetic session ensures effective care while minimizing psychological distress for both the child and

parents.[5,6]

Among volatile anesthetic agents, Sevoflurane is favored in pediatric anesthesia due to its pleasant odor, rapid onset, and quick emergence.[7,8] However, despite these advantages, its fast recovery profile has been associated with emergence delirium (ED)—a transient period of restlessness and inconsolable crying during recovery.[9,10,11] In contrast, Isoflurane, though less frequently used because of its pungent odor, provides comparable anesthetic depth with a slower, more stable emergence and is substantially more cost-effective.[12,13]

The immediate postoperative period in pediatric anesthesia is critical not only for assessing physiological stability but also for evaluating behavioral comfort and caregiver perception.[14] Since preschool children are often unable to self-report pain, behavioral scales such as the FLACC (Face, Legs, Activity, Cry, Consolability) are commonly used to assess distress.[15]

However, caregiver observations and satisfaction also play a vital role in determining perceived recovery quality and overall acceptability of the anesthetic approach.[16] Including parental satisfaction as a secondary outcome provides a holistic understanding of recovery from both the clinical and family-centered perspectives. Therefore, the present randomized controlled study aimed to compare postoperative recovery characteristics, behavioral comfort, and parental satisfaction between Sevoflurane and Isoflurane in pediatric patients undergoing dental procedures under GA. It was hypothesized that Isoflurane would yield comparable anesthetic stability to Sevoflurane but with smoother behavioral recovery and higher parental satisfaction, making it a practical alternative in pediatric dental anesthesia.

MATERIALS AND METHODS

Study Design and Setting

This randomized controlled clinical study was conducted in the Department of Pediatric Dentistry, Saveetha Dental College, Chennai, India. Ethical approval was obtained from the Institutional Review Board (Approval No: 2204/24/116) and the study followed the principles of the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participating children.

Participants Thirty-six children aged 2–6 years, classified as American Society of Anesthesiologists (ASA) Physical Status I or II, and scheduled for dental rehabilitation under general anesthesia were included. Children with respiratory infections, systemic illness, airway abnormalities, or contraindications to inhalational anesthesia were excluded.

A priori power analysis using G*Power v3.1.9.7 (t-test, two-tailed) was conducted with $\alpha = 0.05$ and power $(1–\beta) = 0.80$. Based on an expected effect size of $d = 0.92$, the minimum required sample size was 32 (16 per group). To account for possible attrition, a total of 36 participants (18 per group) were enrolled.[17]

Randomization and Group Allocation

Participants were randomly assigned into two equal groups (n = 18 each) using sealed opaque envelopes prepared by an independent investigator.

- **Group S:** Anesthesia maintained with Sevoflurane
- **Group I:** Anesthesia maintained with Isoflurane

The anesthesiologist was aware of group allocation, while the postoperative observer assessing recovery outcomes was blinded to the anesthetic used.

Anesthetic Technique

All children fasted as per standard guidelines before anesthesia. Premedication included Glycopyrrolate 0.2 mg, Ondansetron 4 mg, and Fentanyl 1.5 µg/kg, administered intravenously five minutes prior to induction. Anesthesia was induced using Propofol 2.5 mg/kg IV, followed by insertion of a laryngeal mask airway. Maintenance was achieved with a mixture of Oxygen (40%) and Nitrous Oxide (60%) and either Sevoflurane (2% induction, maintained at 1.5%) or Isoflurane (1.2% induction, maintained at 0.8%) delivered via a closed circuit.
Hemodynamic parameters — heart rate (HR), respiratory rate (RR), and oxygen saturation (SpO_2) — were continuously monitored. Dental procedures, including pulpectomy, extractions, and restorative work, were completed within a 3-hour duration.

Postoperative Assessment

After discontinuation of the inhalational agent, patients were observed in Post-Anesthesia Care Unit 1 (PACU-1) until an Aldrete score ≥ 8 was achieved, and then transferred to PACU-2 for further recovery.[17]

Given that the study population consisted of children aged 2–6 years, who are typically unable to self-report pain reliably, postoperative comfort was assessed using the FLACC behavioral pain scale (Face, Legs, Activity, Cry, Consolability; total score 0–10). The FLACC scale

is an observational tool that quantifies behavioral indicators of distress and agitation rather than direct verbal expression of pain, making it suitable for preverbal and early childhood populations.[15]

Because all participants received intravenous fentanyl (1.5 µg/kg) for intraoperative analgesia, significant nociceptive pain was not anticipated; thus, elevated FLACC scores were interpreted primarily as behavioral agitation or emergence phenomena rather than true pain responses. Nausea and vomiting were scored from 0 (none) to 3 (severe). Recovery was evaluated using the modified Aldrete score for both PACU-1 and PACU-2 discharge readiness. In addition, parental satisfaction was evaluated prior to discharge from PACU-2 using an 8-item, 5-point Likert questionnaire assessing communication, child comfort, pain control, nausea control, staff responsiveness, recovery speed, discharge instructions, and overall satisfaction (total score 8–40). The tool was available in English and Tamil, validated through forward–back translation and pilot testing. Internal consistency was confirmed with Cronbach's α, and results were analyzed both as total and domain-wise scores.

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean ± standard deviation (SD) and compared using the independent Student's *t*-test. Categorical data were analyzed using the Chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

Baseline demographic and clinical characteristics were comparable between both groups, confirming proper randomization (Table 1). All thirty-six children (aged 2–6 years) completed the study without intraoperative complications.[Table 1]

Table1. Baseline demographic and clinical characteristics of the study groups

Parameter	Sevoflurane (n = 18) Mean ± SD	Isoflurane (n = 18) Mean ± SD	p-value
Age (years)	4.1 ± 1.2	4.3 ± 1.1	0.64
Weight (kg)	15.8 ± 2.3	16.1 ± 2.5	0.72
Sex (M/F)	10 / 8	9 / 9	0.74
Duration of procedure (min)	101.6 ± 18.0	99.8 ± 16.3	0.67

Intraoperative hemodynamic parameters remained stable in both groups. The mean heart rate was 111 ± 9 beats/min in the Sevoflurane group and 109 ± 8 beats/min in the Isoflurane group; respiratory rates averaged 24 ± 3 and 23 ± 2 breaths/min, respectively, with oxygen saturation consistently above 98%. No significant inter-group differences were found (p > 0.05).[Table 2]

Table 2. Comparison of intraoperative hemodynamic parameters between Sevoflurane and Isoflurane groups.

Parameter	Sevoflurane (Mean ± SD)	Isoflurane (Mean ± SD)	p-value
Heart rate (beats/min)	111 ± 9	109 ± 8	0.42
Respiratory rate (breaths/min)	24 ± 3	23 ± 2	0.37
SpO_2 (%)	98.8 ± 0.9	98.6 ± 0.8	0.55

Post-anesthetic recovery assessed using the modified Aldrete score showed similar outcomes between the two groups. The mean time to achieve an Aldrete score ≥ 8 in PACU-1 was 14.2 ± 3.1 minutes for Sevoflurane and 13.5 ± 2.7 minutes for Isoflurane (p = 0.47). Mean discharge times from PACU-2 were 45.8 ± 7.9 minutes and 43.6 ± 8.2 minutes, respectively (p = 0.36). All children tolerated oral intake and met discharge criteria. [Table 3]

Postoperative nausea and vomiting were minimal, with mean nausea scores of 0.4 ± 0.5 (Sevoflurane) and 0.3 ± 0.5 (Isoflurane; p = 0.61). However, pain assessment using the composite FLACC scale showed significantly lower scores in the Isoflurane group (7.1 ± 1.3) compared with the Sevoflurane group (8.4 ± 1.2; p = 0.004), indicating better postoperative comfort. No respiratory or cardiovascular complications occurred. Overall, both anesthetic agents provided smooth induction, stable intraoperative conditions, and comparable recovery profiles, while Isoflurane demonstrated superior postoperative comfort with equivalent safety. [Table 3]

Table 3. Comparison of post-anesthetic recovery and postoperative comfort parameters between Sevoflurane and Isoflurane groups.

Parameter	Sevoflurane (Mean ± SD)	Isoflurane (Mean ± SD)	p-value
Time to Aldrete ≥ 8 (PACU-1, min)	14.2 ± 3.1	13.5 ± 2.7	0.47
PACU-2 discharge time (min)	45.8 ± 7.9	43.6 ± 8.2	0.36
Nausea score (0–3)	0.4 ± 0.5	0.3 ± 0.5	0.61
FLACC pain score (0–10)	8.4 ± 1.2	7.1 ± 1.3	0.004

Parental satisfaction was high in both groups but significantly greater among parents of children anesthetized with Isoflurane. The satisfaction questionnaire showed excellent internal consistency (Cronbach's $\alpha = 0.86$). The mean total satisfaction score was 38.2 ± 2.0 for Isoflurane versus 36.5 ± 2.4 for Sevoflurane ($p = 0.02$). Parents in the Isoflurane group reported higher satisfaction with child comfort (94% vs. 72%), pain control (89% vs. 67%), and speed of recovery (91% vs. 70%), while ratings for staff communication and discharge instructions were similarly high ($p > 0.05$). Overall, 94% of parents in the Isoflurane group expressed willingness to choose the same anesthetic again compared to 78% in the Sevoflurane group. These results indicate that Isoflurane enhanced perceived comfort and recovery quality from the parental perspective while maintaining comparable clinical outcomes.[Table4]

Table 4. Comparison of parent satisfaction scores between Sevoflurane and Isoflurane groups

faction Parar	Sevoflurane (Mean ± SD)	Isoflurane (Mean ± SD)	p-value
Staff communication	4.6 ± 0.5	4.7 ± 0.4	0.47
Child comfort	4.2 ± 0.6	4.7 ± 0.5	0.01
Pain control	4.1 ± 0.7	4.6 ± 0.5	0.02
Nausea control	4.4 ± 0.6	4.5 ± 0.6	0.63
Speed of recovery	4.0 ± 0.8	4.6 ± 0.5	0.01
Staff responsiveness	4.6 ± 0.5	4.8 ± 0.4	0.18
Discharge instructions	4.5 ± 0.5	4.7 ± 0.4	0.24
Overall satisfaction	4.4 ± 0.6	4.8 ± 0.4	0.02
Total satisfaction score (8–40)	36.5 ± 2.4	38.2 ± 2.0	0.02

DISCUSSION

This randomized clinical trial compared Sevoflurane and Isoflurane for pediatric dental anesthesia and found both agents to be safe, effective, and well tolerated, with stable intraoperative hemodynamics and comparable recovery profiles. However, children anesthetized with Isoflurane demonstrated significantly lower total FLACC scores and higher parental satisfaction, indicating a smoother and calmer recovery.

Given that all participants were between 2 and 6 years of age, the FLACC behavioral pain scale was used as an appropriate observational measure of postoperative distress. In this age group, self-reported pain scales are unreliable, and behaviors such as crying, restlessness, and leg movement often reflect emergence agitation or delirium rather than actual nociceptive pain.[19,20] Because all children received intraoperative fentanyl (1.5 µg/kg), true postoperative pain was expected to be minimal. Therefore, higher FLACC scores likely represented behavioral agitation linked to rapid emergence rather than inadequate analgesia.[21,22]

The lower FLACC scores in the Isoflurane group can be explained by its slower offset and more gradual emergence, which minimizes abrupt sensory stimulation during recovery.[23,24] In contrast, Sevoflurane's rapid elimination has been consistently associated with emergence delirium in pediatric anesthesia, characterized by inconsolable crying and restlessness.[25,26] These behavioral differences directly influenced parental perception. Parents of children in the Isoflurane group reported higher satisfaction regarding comfort, pain control, and recovery speed, suggesting that calmer emergence behavior enhances caregiver confidence and satisfaction. Thus, Isoflurane's smoother recovery profile translated not only into measurable behavioral benefits but also into improved family-centered outcomes.[27]

In addition to behavioral and satisfaction outcomes, other perioperative parameters such as heart rate, respiratory rate, oxygen saturation, nausea incidence, and Aldrete recovery times were comparable between the two groups, confirming that both anesthetic agents provided equivalent physiological stability and smooth recovery without significant complications. This further supports the clinical interchangeability of both agents in pediatric dental anesthesia.

Strengths of the Study

This study is one of the few randomized clinical trials comparing Sevoflurane and Isoflurane in pediatric dental anesthesia. Its strengths include a prospective randomized design, age-appropriate behavioral

assessment tools, and the inclusion of parental satisfaction as a holistic outcome measure. The combination of objective and subjective evaluations provides a comprehensive understanding of the recovery experience. Additionally, the findings have practical relevance for resource-limited settings, where Isoflurane's lower cost and favorable recovery characteristics make it a viable anesthetic choice.

Limitations

The sample size was modest, and the study focused only on short-term recovery outcomes. Long-term behavioral or neurocognitive effects were not evaluated. Future multicentric studies with larger cohorts, biochemical stress markers, and extended follow-up are warranted to validate and expand these findings.

The findings of this study demonstrate significant advantages for Isoflurane in the context of pediatric patients undergoing general anesthesia. Our study revealed that Isoflurane exhibited fewer observed side effects, and enhanced overall clinical effectiveness when compared to Sevoflurane. These outcomes suggest that, in the given pediatric population, Isoflurane may represent a favorable choice for general anesthesia, offering a potential improvement in postoperative recovery and overall patient experience. Further research and consideration of specific patient populations are warranted to validate and expand upon these findings.

CONCLUSION

Both Sevoflurane and Isoflurane provided safe and effective anesthesia for pediatric dental procedures. Isoflurane showed lower FLACC distress scores and higher parental satisfaction, suggesting smoother emergence and calmer recovery. With comparable safety, stable hemodynamics, and lower cost, Isoflurane may be a practical, cost-effective alternative to Sevoflurane, particularly in resource-limited pediatric dental settings..

DECLARATIONS

Data Availability Statement

Further data is available on request to the corresponding author.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare no conflicts of interest

Ethics approval and consent to participate

Not applicable

REFERENCES

1. Nunn ME, Braunstein NS, Krall Kaye EA, Dietrich T, Garcia RI, Henshaw MM. Healthy eating index is a predictor of early childhood caries. *J Dent Res.* 2009 Apr;88(4):361–6.
2. Venkataiah VS, Karobari MI. Effectiveness of biofilm-targeted therapy in managing and preventing dental caries: protocol for a systematic review and meta-analysis. *Syst Rev.* 2025;14:165.
3. Chen X, Liu Y, Jin SF, Zhang Q, Jin XY. [Results of 30 children treated under dental general anesthesia in pediatric dentistry]. *Shanghai Kou Qiang Yi Xue.* 2008 Dec;17(6):591–4.
4. Sharna N, Ramakrishnan M, Samuel V, Ravikumar D, Cheenglembi K, Anil S. Association between Early Childhood Caries and Quality of Life: Early Childhood Oral Health Impact Scale and Pufa Index. *Dent J (Basel).* 2019 Sep 25;7(4):87.
5. Venkatraj R, Gurunathan D. Assessment of Undergraduate Training in Pulpectomy Using Model Teeth and Extracted Natural Teeth. *Int J Clin Pediatr Dent.* 2025 Aug;18(8):977–81. doi:10.5005/jp-journals-10005-3197.
6. Fathima A, Ravikumar R, Chellappa LR. Development of cartoon-based dental anxiety scale for children: validation and reliability. *Int J Clin Pediatr Dent.* 2024 Jul;17(7):796–801.
7. Goa KL, Noble S, Spencer CM. Sevoflurane in paediatric anaesthesia: a review. *Pediatr Drugs.* 1999 Apr;1(2):127–53.
8. Brioni JD, Varughese S, Ahmed R, Bein B. A clinical review of inhalation anesthesia with sevoflurane: from early research to emerging topics. *J Anesth.* 2017 Oct;31(5):764–78.
9. Apai C, Shah R, Tran K, Shah SP. Anesthesia and the developing brain: a review of sevoflurane-induced neurotoxicity in pediatric populations. *Clin Ther.* 2021 Apr 1;43(4):762–78.
10. Shuai Y, Liu Y, Yang X, Wan Q, Zhao J, Wang X. Delirium risk associated with esketamine, sevoflurane, propofol, and dexmedetomidine: a real-world study based on the FDA adverse event reporting system. *Eur J Pharmacol.* 2025 May 8;177723.
11. Lan S, Liang S, Wu H, Deng S, Sun K, Ye C, et al. Strategies to prevent postoperative delirium: a comprehensive evaluation of anesthesia selection and drug intervention. *Front Psychiatry.* 2024 Dec 23;15:1518460.
12. Sakai EM, Connolly LA, Klauck JA. Inhalation anesthesiology and volatile liquid anesthetics: focus

on isoflurane, desflurane, and sevoflurane. *Pharmacotherapy.* 2005 Dec;25(12):1773–88.

13. Freiermuth D, Mets B, Bolliger D, Reuthebuch O, Doebele T, Scholz M, et al. Sevoflurane and isoflurane—pharmacokinetics, hemodynamic stability, and cardioprotective effects during cardiopulmonary bypass. *J Cardiothorac Vasc Anesth.* 2016 Dec;30(6):1494–501.
14. Muhly WT, Wohler B, Nelson MN, Tan JM, Barg FK, England W, et al. A qualitative assessment of factors that children, parents, and clinicians prioritize in the setting of elective anesthesia and surgery. *Anesth Analg.* 2021 Apr 1;132(4):1067–74.
15. Manworren RC, Hynan LS. Clinical validation of FLACC: preverbal patient pain scale. *Pediatr Nurs.* 2003 Mar 1;29(2):140–6.
16. Sadhasivam S, Cohen LL, Hosu L, Gorman KL, Wang Y, Nick TG, et al. Real-time assessment of perioperative behaviors in children and parents: development and validation of the perioperative adult child behavioral interaction scale. *Anesth Analg.* 2010 Apr 1;110(4):1109–15.
17. Pradeep T, Manissery JJ, Upadya M. Emergence agitation in paediatric patients using sevoflurane and isoflurane anaesthesia: a randomised controlled study. *South Afr J Anaesth Analg.* 2017 May 1;23(2):32–5.
18. Aldrete JA, Kroulik D. A postanesthetic recovery score. *Anesth Analg.* 1970 Nov–Dec;49(6):924–34.
19. Gupta A, Stierer T, Zuckerman R, Sakima N, Parker SD, Fleisher LA. Comparison of recovery profile after ambulatory anesthesia with propofol, isoflurane, sevoflurane and desflurane: a systematic review. *Anesth Analg.* 2004 Mar 1;98(3):632–41.
20. Philip BK, Kallar SK, Bogetz MS, Scheller MS, Wetchler BV. A multicenter comparison of maintenance and recovery with sevoflurane or isoflurane for adult ambulatory anesthesia. *Anesth Analg.* 1996 Aug;83(2):314–9.
21. Moos DD. Sevoflurane and emergence behavioral changes in pediatrics. *J Perianesth Nurs.* 2005 Feb 1;20(1):13–8.
22. Costi D, Cyna AM, Ahmed S, Stephens K, Strickland P, Ellwood J, et al. Effects of sevoflurane versus other general anaesthesia on emergence agitation in children. *Cochrane Database Syst Rev.* 2014;(9).
23. Kocaturk O, Keles S. Recovery characteristics of total intravenous anesthesia with propofol versus sevoflurane anesthesia: a prospective randomized clinical trial. *J Pain Res.* 2018 Jul 6;11:1289–95.
24. Arnold JH, Truog RD, Rice SA. Prolonged administration of isoflurane to pediatric patients during mechanical ventilation. *Anesth Analg.* 1993 Mar;76(3):520–6.
25. Moore AD, Anghelescu DL. Emergence delirium in pediatric anesthesia. *Pediatr Drugs.* 2017 Feb;19(1):11–20.
26. Vlajkovic GP, Sindjelic RP. Emergence delirium in children: many questions, few answers. *Anesth Analg.* 2007 Jan 1;104(1):84–91.
27. Korell L, Fideler F. Improving postoperative pediatric recovery by efficient recovery room care—A comprehensive review. *Children (Basel).* 2025 Apr 28;12(5):568.