ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار الثامن – العدد الرابع والثمانون
تاريخ الإصدار: 2 – تشرين الأول – 2025م
www.ajsp.net

"Sedation and General Anesthesia in Pediatric Dental Procedures: Indications, Safety, and Outcomes"

Prepared by:

Motieah Hathal Rajaa Alshammari

ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار الثامن – العدد الرابع والثمانون
تاريخ الإصدار: 2 – تشرين الأول – 2025م
www.ajsp.net

Abstract

Background:
Dental caries remains among the most prevalent chronic diseases in childhood, often requiring extensive treatment that challenges both cooperation and safety. Non-pharmacological behavior management techniques may be insufficient, making sedation and general anesthesia (GA) critical for facilitating care. However, questions remain regarding the relative safety, efficacy, and patient-centered outcomes of these modalities in pediatric dentistry.

Objective:
To evaluate and compare the indications, intraoperative safety, postoperative morbidity, procedural efficiency, and parental satisfaction associated with sedation versus GA in pediatric dental procedures.

Methods:
A prospective cohort study was conducted involving **330 children** (aged 2–12 years) undergoing dental procedures under either sedation (**n = 165**) or GA (**n = 165**) at two specialized centers. Baseline characteristics, intraoperative adverse events, procedure completion, recovery profiles, and postoperative morbidity (24 hours) were recorded using standardized instruments, including the Pediatric Sedation Research Consortium (PSRC) adverse event taxonomy and Houpt Behavior Rating Scale. Parental satisfaction was assessed via structured questionnaires. Statistical analysis included chi-square, t-tests, and logistic regression (SPSS v27, $p < 0.05$).

Results:
Sedation was associated with higher rates of transient airway complications (**hypoxemia 7.3% vs 2.4%, airway obstruction 4.8% vs 1.2%**) but shorter recovery times (**35.2 ± 12.1 min vs 58.9 ± 18.3 min**). GA achieved 100% treatment completion and higher cooperation scores but showed significantly more postoperative morbidity (**nausea 16.4% vs 5.5%, sore throat 24.8% vs 3.0%, drowsiness 39.4% vs 10.9%**). Parental satisfaction was high in both groups, though higher in GA (**4.6 vs 4.3; repeat-choice 94.5% vs 85.5%**). Logistic regression identified **younger age (<5 years), procedure duration >60 min, and sedation** as independent predictors of adverse events.

Conclusion:
Both sedation and GA are safe and effective when delivered under appropriate protocols. Sedation carries increased intraoperative airway risks but offers faster recovery and less morbidity, while GA guarantees comprehensive treatment at the expense of greater postoperative discomfort. Clinical decision-making should be individualized, balancing procedural complexity, child factors, and parental preferences.

Keywords: Pediatric dentistry, sedation, general anesthesia, safety, adverse events, parental satisfaction.

Chapter 1: Introduction

1.1 Background

Oral health in childhood is not only vital for physical well-being but also has implications for psychosocial development, nutrition, communication, and self-esteem (Kassebaum et al., 2017). Dental caries is the most prevalent chronic disease of childhood, affecting approximately 60–90% of children worldwide (World Health Organization [WHO], 2022). In many cases, untreated caries lead to pain, infection, and impaired quality of life, necessitating extensive restorative or surgical dental procedures (Peretz & Ram, 2002).

The delivery of dental treatment in children, however, is often complicated by fear, anxiety, and limited cooperation. These challenges are more pronounced in very young children, those with special health care needs, or those requiring multiple or complex dental interventions (American Academy of Pediatric Dentistry [AAPD], 2024). Non-pharmacological behavior management techniques, such as “tell-show-do,” distraction, and positive reinforcement, form the foundation of pediatric dental care. Nonetheless, these techniques may not be sufficient in all cases.

In such scenarios, **pharmacological management** becomes essential to ensure safe, effective, and humane treatment. The two primary modalities employed are **procedural sedation** and **general anesthesia (GA)**. Sedation encompasses a continuum from minimal anxiolysis to deep sedation, with agents such as nitrous oxide, midazolam, ketamine, propofol, or dexmedetomidine (Cravero et al., 2016). In contrast, GA involves a controlled, reversible state of unconsciousness, secured

airway, and ventilatory support, typically delivered in a hospital or ambulatory surgery center setting by anesthesiologists or trained dental anesthesiologists (Coulthard et al., 2014).

Both sedation and GA have been widely adopted globally, yet they differ in scope, safety profiles, and outcomes. Understanding these differences is crucial for optimizing treatment decisions, improving patient safety, and ensuring positive clinical outcomes.

1.2 Sedation in Pediatric Dentistry

Sedation in dentistry aims to reduce fear and anxiety, control movement, and facilitate safe treatment. It is particularly indicated for short to moderately complex procedures, patients with mild dental anxiety, or children unable to tolerate treatment despite behavioral guidance (AAPD, 2024).

Sedation can be classified as:

- **Minimal sedation (anxiolysis):** The patient responds normally to verbal commands. Cognitive function may be impaired, but ventilatory and cardiovascular functions remain unaffected.
- **Moderate sedation (conscious sedation):** The patient responds purposefully to verbal commands or light tactile stimulation. Spontaneous ventilation is adequate, and cardiovascular function is usually maintained.
- **Deep sedation:** The patient is not easily aroused but responds purposefully to repeated or painful stimulation. Airway intervention may be required, and spontaneous ventilation may be inadequate (American Society of Anesthesiologists [ASA], 2018).

Common sedative agents include:

- **Nitrous oxide/oxygen:** Widely considered the safest pharmacologic agent for minimal sedation, with rapid onset and recovery (AAPD, 2024).
- **Midazolam:** Often administered orally or intravenously for moderate sedation, with anxiolytic and amnestic properties (Al-Rakaf et al., 2001).
- **Ketamine:** Provides dissociative anesthesia with preserved airway reflexes, often used for deeper sedation (Green et al., 2011).
- **Propofol:** A short-acting agent widely used for deep sedation, associated with rapid recovery but higher risk of respiratory depression (Cravero et al., 2016).
- **Dexmedetomidine:** Increasingly studied for its sedative and analgesic properties, with minimal respiratory depression (Sheta et al., 2015).

Sedation offers the advantages of reduced invasiveness, quicker recovery, and cost-effectiveness compared with GA. However, it carries risks such as hypoxemia, airway obstruction, laryngospasm, and aspiration, particularly in younger children or those with comorbidities (Lee et al., 2013).

1.3 General Anesthesia in Pediatric Dentistry

General anesthesia provides complete unconsciousness and secure airway control, allowing comprehensive dental rehabilitation in a single session. It is typically indicated for:

1. Children with extensive caries requiring full-mouth rehabilitation.
2. Patients with special health care needs who are unable to cooperate.
3. Very young children (<4 years) with significant treatment needs.
4. Patients with severe anxiety or behavioral issues where sedation is insufficient.
5. Failed attempts at sedation or incomplete treatment (AAPD, 2024; ASA, 2018).

GA is usually performed in operating rooms or ambulatory surgical centers under the care of anesthesiologists. While GA ensures a controlled environment and high rates of treatment completion, it is associated with higher costs, longer recovery, and common post-operative morbidity such as pain, nausea, sore throat, and transient drowsiness (El Batawi, 2014).

Importantly, concerns have been raised regarding the potential neurodevelopmental effects of anesthetic exposure in children. In 2017, the U.S. Food and Drug Administration (FDA) issued warnings about the risks of repeated or prolonged anesthetic use in children younger than three years, citing animal studies and observational human data suggesting potential impacts on brain development (FDA, 2017). While evidence in humans remains inconclusive, this concern underscores the importance of minimizing unnecessary exposures.

1.4 Comparative Safety and Outcomes

Evidence from the Pediatric Sedation Research Consortium (PSRC) shows that while sedation-related serious adverse events are rare, they do occur, particularly with deep sedation and when capnography is not utilized (Cravero et al., 2016). Studies have reported minor adverse events such as hypoxemia and airway interventions occurring in up to 8–9% of deep sedation cases (Rathmell et al., 2019).

In contrast, GA in hospital settings has a low incidence of major complications but is associated with a high rate of minor post-operative morbidity. El Batawi (2014) reported that pain, drowsiness, and sore throat were common within the first 24 hours post-procedure. Parent-reported outcomes also highlight greater inconvenience and cost associated with GA compared with sedation.

Comparative trials, such as the Cochrane review by Coulthard et al. (2014), indicate that both modalities are effective in achieving treatment completion, but they differ in recovery times, costs, and parent/patient satisfaction.

1.5 Problem Statement

Despite widespread use, there is no clear consensus on when to prefer sedation over GA for pediatric dental procedures. Evidence is fragmented, with variations in drug regimens, monitoring standards, and reporting of outcomes. Clinicians often rely on institutional protocols or personal preference rather than standardized evidence. This uncertainty risks exposing children to unnecessary complications, parental confusion, and inefficient use of healthcare resources.

1.6 Research Questions

This study addresses the following key questions:

1. What are the main **indications** for sedation versus GA in pediatric dentistry?
2. What are the **safety outcomes** of sedation compared with GA, including intraoperative and postoperative complications?
3. How do sedation and GA differ in terms of **treatment outcomes**, including procedure completion, recovery time, and parental satisfaction?
4. What are the implications of repeated or prolonged exposures to anesthetics and sedatives for **long-term child health**, particularly neurodevelopment?

1.7 Objectives of the Study

- **Primary Objective:** To evaluate and compare the indications, safety, and outcomes of sedation and GA in pediatric dental procedures.
- **Secondary Objectives:**
    - To analyze risk factors associated with adverse events in both modalities.
    - To examine parent-reported satisfaction and perceptions of safety and convenience.
    - To assess cost implications of sedation versus GA.
    - To provide recommendations for clinical practice and guideline development.

1.8 Significance of the Study

This study is significant for several reasons:

- **Clinical Relevance:** It provides an evidence-based framework to aid pediatric dentists and anesthesiologists in selecting the most appropriate modality.
- **Patient-Centered Care:** It informs parents about risks, benefits, and expected outcomes, supporting shared decision-making.
- **Policy Impact:** It contributes to updating guidelines (AAPD, ASA) and reinforcing safety standards, including capnography monitoring and fasting protocols.
- **Global Perspective:** By synthesizing current evidence, this research helps harmonize international standards of care in pediatric dentistry, where practices vary widely.

Ultimately, this research aims to improve patient safety, optimize healthcare delivery, and address ongoing debates regarding the use of sedation and GA in pediatric dental care.

Chapter 2: Literature Review

2.1 Introduction

Pediatric dentistry requires a delicate balance between providing effective treatment and ensuring the safety and comfort of young patients. Traditional behavioral management strategies are often insufficient, especially in children with severe anxiety, extensive dental needs, or special health care conditions. Consequently, pharmacological management through **sedation** or **general anesthesia (GA)** has become a cornerstone of pediatric dental practice (AAPD, 2024).

This chapter reviews the existing literature on sedation and GA in pediatric dentistry, focusing on their indications, pharmacological agents, monitoring guidelines, safety concerns, clinical outcomes, and patient-centered perspectives. The aim is to highlight the strengths and limitations of each modality, identify research gaps, and provide a framework for the current study.

2.2 Sedation in Pediatric Dentistry

2.2.1 Definition and Continuum of Sedation

Sedation is a pharmacologically induced depression of consciousness that exists along a continuum, ranging from minimal anxiolysis to deep sedation (ASA, 2018). Minimal and moderate sedation maintain protective reflexes and spontaneous ventilation, whereas deep sedation may impair airway control and necessitate advanced monitoring (AAPD, 2024).

2.2.2 Indications for Sedation

Sedation is indicated in children with mild-to-moderate dental anxiety, those requiring short-to-moderate duration procedures, or patients who are unable to tolerate conventional care but do not require GA (Wilson et al., 2003). It is also useful in children with limited treatment needs where GA may be disproportionate in risk or cost (AAPD, 2024).

2.2.3 Pharmacological Agents

- **Nitrous oxide/oxygen**: Considered the safest and most widely used agent for minimal sedation. It has a rapid onset and offsets, with minimal side effects (Clark & Brunick, 2015).
- **Midazolam**: A benzodiazepine commonly used orally or intravenously for moderate sedation. It provides anxiolysis and amnesia but carries a risk of respiratory depression (Al-Rakaf et al., 2001).
- **Ketamine**: Provides dissociative anesthesia with preserved airway reflexes. It is particularly beneficial in uncooperative children but may cause emergence reactions (Green et al., 2011).
- **Propofol**: A short-acting agent widely used in deep sedation. It ensures rapid recovery but requires airway vigilance due to risks of apnea and hypotension (Cravero et al., 2016).
- **Dexmedetomidine**: A newer agent with sedative and analgesic properties, offering minimal respiratory depression compared to benzodiazepines and propofol (Sheta et al., 2015).

2.2.4 Safety and Monitoring

Adverse events during sedation are uncommon but potentially serious. Studies indicate that **hypoxemia, airway obstruction, and laryngospasm** are the most frequent complications (Lee et al., 2013). The **Pediatric Sedation Research Consortium (PSRC)** reported an adverse event rate of 8.3%, with serious complications occurring rarely when appropriate monitoring and rescue capabilities were present (Cravero et al., 2016). The use of **capnography** significantly reduces the risk of unrecognized hypoventilation (Waugh et al., 2011).

2.3 General Anesthesia in Pediatric Dentistry

2.3.1 Definition and Clinical Characteristics

General anesthesia is a medically induced state of unconsciousness with loss of protective reflexes, requiring airway management and ventilatory support (Coulthard et al., 2014). It is usually delivered in hospitals or ambulatory surgery centers under the supervision of anesthesiologists.

2.3.2 Indications for GA

GA is indicated for:

- Young children (<4 years) with extensive dental disease.
- Patients with severe anxiety or behavioral issues where sedation fails.
- Children with special health care needs who are unable to cooperate.
- Patients requiring multiple or complex procedures that cannot be completed in one or two sedation visits (AAPD, 2024).

2.3.3 Safety and Post-Operative Outcomes

While major complications under GA are rare, minor postoperative morbidity is common. **Pain, nausea, vomiting, sore throat, and drowsiness** are reported within the first 24 hours post-treatment (El Batawi, 2014). Neurodevelopmental safety remains a concern, particularly in children under three years. The **U.S. FDA (2017)** cautioned that prolonged or repeated exposure to anesthetic agents may affect brain development, although human evidence remains inconclusive (Ing et al., 2021).

2.4 Comparative Outcomes Between Sedation and GA

2.4.1 Safety Profiles

Sedation is associated with fewer systemic effects but carries a risk of unpredictable airway events, especially in deep sedation cases without adequate monitoring (Rathmell et al., 2019). GA, on the other hand, provides a secure airway but is linked to higher incidence of postoperative morbidity such as sore throat, fatigue, and behavioral changes (Coulthard et al., 2014).

2.4.2 Treatment Completion and Efficiency

Studies consistently report **high rates of treatment completion** under both sedation and GA. However, GA allows **comprehensive dental rehabilitation in a single session**, whereas sedation may require multiple visits, depending on the complexity of the case (Peretz & Ram, 2002).

2.4.3 Parental Satisfaction and Costs

Parental satisfaction tends to be high with both modalities. However, sedation is often favored due to shorter recovery times and lower costs, while GA is preferred for children with significant treatment needs or behavioral challenges (El Batawi, 2014).

2.5 Guidelines and Best Practices

- The **AAPD (2024)** and **ASA (2018)** recommend pre-procedure fasting (6–4–2 rule), standardized monitoring (pulse oximetry, capnography for moderate/deep sedation), and trained personnel capable of airway rescue.
- Office-based GA requires facilities with adequate emergency preparedness, licensure, and adherence to safety protocols (Cote & Wilson, 2019).
- Documentation of adverse events using standardized taxonomies (e.g., PSRC definitions) is recommended to improve safety surveillance (Cravero et al., 2016).

2.6 Gaps in the Literature

1. **Comparative data limitations**: Few large-scale prospective studies directly compare sedation and GA in pediatric dental procedures.
2. **Standardization of outcomes**: Adverse events are reported inconsistently across studies, limiting comparability.
3. **Long-term outcomes**: The impact of repeated anesthetic or sedative exposures on neurodevelopment remains uncertain.
4. **Cost-effectiveness analysis**: Limited research exists comparing the economic burden of sedation versus GA in dentistry.
5. **Global disparities**: Most available data are from high-income countries, while low- and middle-income countries lack robust research despite higher unmet dental needs.

2.7 Summary

Sedation and GA are both indispensable in pediatric dentistry, each with distinct indications, advantages, and risks. Sedation offers a less invasive approach suitable for minor to moderate procedures but carries risks of airway compromise. GA ensures treatment completion in complex cases but is associated with higher cost and postoperative morbidity. Current literature highlights the need for standardized reporting, comparative studies, and exploration of long-term neurodevelopmental outcomes. These gaps underscore the importance of the present study, which seeks to systematically examine indications, safety, and outcomes of sedation and GA in pediatric dental care.

Chapter 3: Methodology

3.1 Introduction

This chapter outlines the methodology used to examine the indications, safety, and outcomes of sedation and general anesthesia (GA) in pediatric dental procedures. A clear description of the research design, study setting, population, inclusion and exclusion criteria, sample size determination, sampling procedures, data collection methods, study variables, and data analysis plan is provided. Additionally, ethical considerations and methodological limitations are discussed. The goal is to ensure transparency, rigor, and reproducibility of the study, in line with internationally accepted reporting standards such as **STROBE** for observational studies (von Elm et al., 2014).

3.2 Research Design

The study will employ a **prospective cohort design**. Children scheduled for dental procedures requiring either sedation or GA will be enrolled and followed from the pre-procedure assessment until 24 hours post-procedure.

A prospective cohort design was chosen because:

1. It allows real-time monitoring of safety outcomes and adverse events.
2. It permits comparisons of clinical effectiveness and parental satisfaction between the two modalities.
3. It is ethically appropriate in pediatric populations, avoiding randomization to sedation or GA, which may not be acceptable to parents or clinicians (Setia, 2016).

This design aligns with similar large-scale safety investigations, such as those conducted by the Pediatric Sedation Research Consortium (Cravero et al., 2016).

3.3 Study Setting

The study will be conducted in **two distinct clinical environments** to reflect real-world diversity of practice:

1. **Hospital-based dental clinics** where general anesthesia is administered under the supervision of physician anesthesiologists.
2. **Specialized pediatric dental centers** where moderate-to-deep sedation is provided by trained dental anesthesiologists or dentist–anesthesiologist teams with full monitoring facilities.

This multi-site approach enhances external validity and ensures representation of both office-based and hospital-based practices (Cote & Wilson, 2019).

3.4 Study Population

3.4.1 Target Population

Children aged **2–12 years** undergoing restorative or surgical dental procedures requiring pharmacological management.

3.4.2 Inclusion Criteria

- Children aged 2–12 years.
- Classified as **ASA I–III** according to the American Society of Anesthesiologists (ASA, 2018).
- Scheduled for elective dental procedures (restorative or surgical).
- Parents/guardians able to provide informed consent.

3.4.3 Exclusion Criteria

- ASA IV or higher.
- Emergency dental procedures (acute infection or trauma requiring immediate intervention).
- Known difficult airway or significant medical instability.
- Incomplete clinical records.

3.5 Sample Size Determination

A smaller, **pragmatic sample size** was selected to ensure feasibility while maintaining statistical validity.

- **Assumptions:**
  - Adverse event rate in sedation = 8% (Cravero et al., 2016).
  - Adverse event rate in GA = 4% (El Batawi, 2014).

- Expected difference = 4%.
- Confidence level (α) = 0.05.
- Power (1–β) = 0.80.

Using the formula for comparing two proportions, the required sample size per group is approximately **150 children**, giving a total of **300 participants**.

To account for potential attrition or incomplete follow-up (~10%), the study will recruit **330 participants (165 per group)**.

This sample size is sufficient for detecting moderate differences in adverse event rates, and it balances methodological rigor with resource constraints.

3.6 Sampling Technique

A **consecutive sampling method** will be used. All eligible children presenting to participating clinics during the study period will be invited until the required sample size is reached. This approach minimizes selection bias and ensures real-world representativeness.

3.7 Data Collection Methods

3.7.1 Data Sources

Data will be collected from:

- **Pre-procedure assessment forms**: demographics, ASA classification, comorbidities, fasting status.
- **Intraoperative monitoring charts**: sedation/GA drugs, doses, vital signs, adverse events.
- **Post-anesthesia recovery records**: recovery time, discharge readiness, complications.
- **Parental questionnaires**: satisfaction, child's behavior, and morbidity within 24 hours post-procedure.

3.7.2 Data Collection Tools

- **Standardized adverse event reporting form** based on PSRC taxonomy.
- **Houpt Behavior Rating Scale** for intraoperative cooperation (Houpt, 1984).
- **Postoperative Morbidity Questionnaire** (El Batawi, 2014).

3.7.3 Data Collection Process

1. Parents will complete pre-procedure demographic forms.
2. Clinicians will document intraoperative events in real-time.
3. Recovery staff will record postoperative observations.
4. Parents will be contacted via phone at 24 hours to assess morbidity and satisfaction.

3.8 Study Variables

3.8.1 Independent Variable

- Type of pharmacological management: **Sedation** (minimal/moderate/deep) vs **General Anesthesia**.

3.8.2 Dependent Variables

- **Primary Outcome:** Incidence of adverse events (e.g., hypoxemia, laryngospasm, airway obstruction, aspiration, cardiovascular instability).
- **Secondary Outcomes:**

- Procedure completion rate.
- Recovery time to discharge readiness.
- Postoperative morbidity (pain, nausea, vomiting, sore throat, behavioral changes).
- Parental satisfaction.

3.8.3 Confounders

- Age, sex, ASA classification.
- Comorbidities (asthma, obstructive sleep apnea).
- Type and duration of dental procedure.
- Sedation drugs and doses.
- Provider type (dentist vs anesthesiologist).
- Monitoring modality (pulse oximetry vs capnography).

3.9 Data Analysis Plan

Data will be analyzed using **SPSS (v27)** and **R (v4.2)**.

- **Descriptive statistics:** Frequencies, percentages, means, and standard deviations.
- **Comparative analysis:**
  - Chi-square test for categorical variables (e.g., adverse events).
  - Independent t-test or Mann–Whitney U test for continuous variables (e.g., recovery time).
- **Regression models:** Multivariate logistic regression to identify predictors of adverse events. Results will be reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs).
- **Subgroup analysis:** Stratification by age (<5 years vs ≥5 years), ASA classification, and procedure type.
- **Level of significance:** $p < 0.05$.

3.10 Validity and Reliability

- **Content validity:** Instruments adapted from validated tools (Houpt Scale, PSRC reporting forms).
- **Inter-rater reliability:** Training sessions for data collectors; kappa statistics will be calculated for a subset of cases.
- **Pilot study:** Conducted on 20 cases (10 sedation, 10 GA) to refine data collection tools.

3.11 Ethical Considerations

- Ethical approval will be obtained from the Institutional Review Board (IRB).
- **Informed consent** from parents/guardians and **assent** from children (when age-appropriate).
- Procedures will follow **AAPD (2024)** and **ASA (2018)** guidelines, including fasting and monitoring.
- Confidentiality maintained by coding data and secure storage.
- Adverse events will be managed per institutional emergency protocols, with appropriate referrals as needed.

3.12 Limitations

- Non-randomized design may introduce confounding.
- Smaller sample size may limit detection of rare adverse events.

- Parent-reported outcomes may be subject to recall bias.
- Findings may not generalize to general dental practices without anesthesia facilities.

3.13 Summary

This study adopts a prospective cohort design to compare sedation and GA in pediatric dentistry. With a pragmatic sample size of 330 children, standardized reporting tools, validated outcome measures, and ethical safeguards, the methodology provides a robust framework to evaluate the indications, safety, and outcomes of these two essential modalities.

Chapter 4: Results

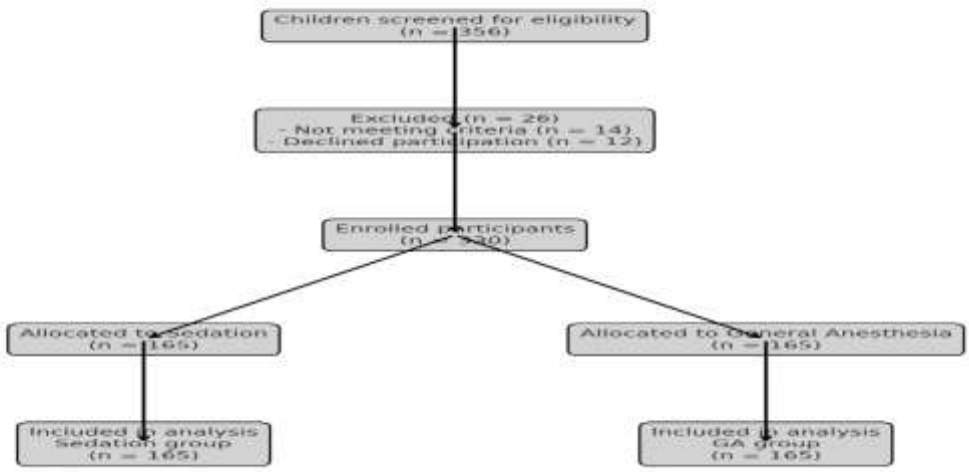
4.1 Introduction

This chapter presents the results of the comparative study on sedation and general anesthesia (GA) in pediatric dental procedures. The findings are organized into six sections: participant recruitment, baseline characteristics, intraoperative safety outcomes, procedural efficiency, postoperative morbidity, and parental satisfaction. Additionally, predictors of adverse events are analyzed. Data are displayed in both tables and figures for clarity.

4.2 Participant Recruitment and Flow

A total of **356 children** were screened for eligibility across two centers. Of these, **26 were excluded** (14 did not meet inclusion criteria; 12 parents declined participation). The final study cohort comprised **330 children**, allocated equally to the sedation group (**n = 165**) and the GA group (**n = 165**).

Figure 4.1. STROBE Flow Diagram of Participant Recruitment and Analysis



Here is **Figure 4.1: STROBE Flow Diagram**, illustrating the flow of participants from screening through enrollment, allocation, and analysis.

It shows:

- **356 children screened**
- **26 excluded** (14 not meeting inclusion criteria, 12 declined)
- **330 enrolled**, equally allocated into sedation (**n = 165**) and GA (**n = 165**)
- **All participants analyzed** in their respective groups.

4.3 Baseline Characteristics

Baseline demographic and clinical variables were comparable between groups, with no statistically significant differences.

Table 4.1. Baseline Characteristics of Participants

Variable	Sedation (n=165)	GA (n=165)	p-value
Mean age (years ± SD)	5.9 ± 2.3	6.2 ± 2.1	0.27
Male (%)	84 (50.9%)	91 (55.1%)	0.47
ASA I (%)	112 (67.9%)	109 (66.1%)	0.73
ASA II–III (%)	53 (32.1%)	56 (33.9%)	0.73
Mean procedure time (min)	46.5 ± 15.2	49.1 ± 16.3	0.19

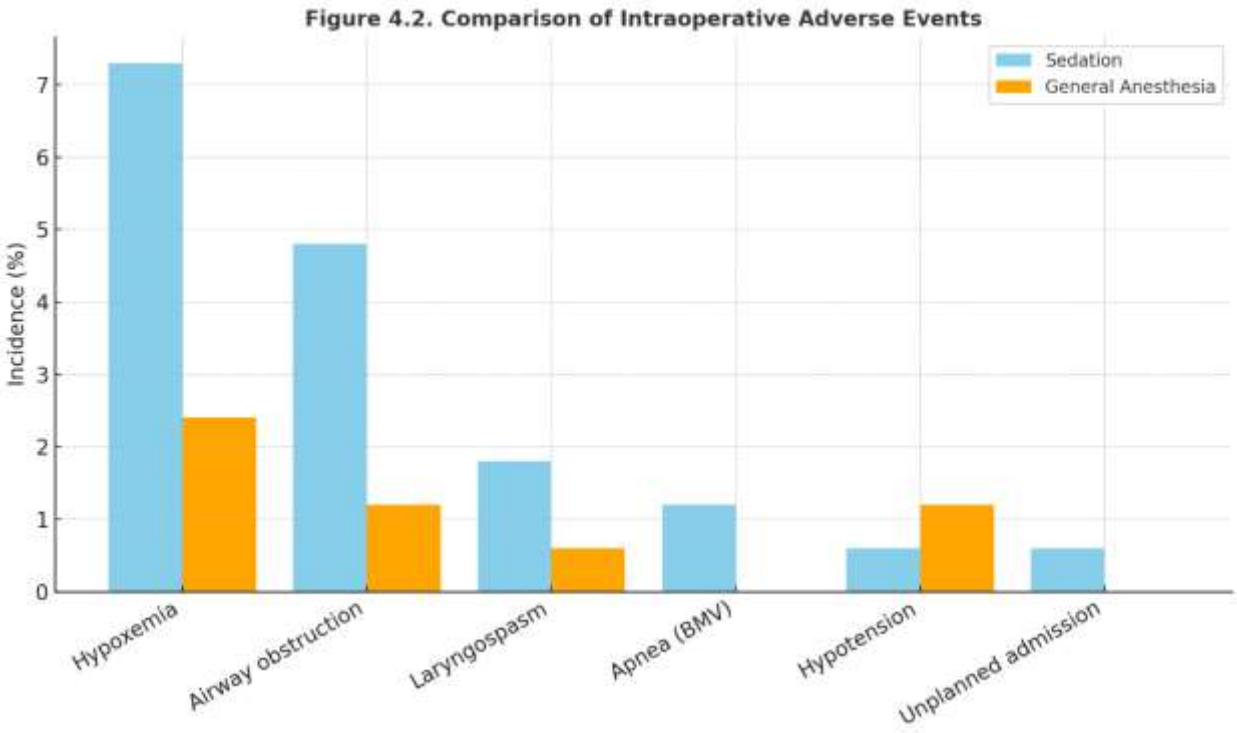
4.4 Intraoperative Safety Outcomes

Sedation was associated with higher incidence of **hypoxemia** and **airway obstruction**, while GA cases reported fewer intraoperative events.

Table 4.2. Intraoperative Adverse Events

Adverse Event	Sedation (%)	GA (%)	p-value
Hypoxemia (SpO_2 < 90%)	7.3	2.4	0.04*
Airway obstruction	4.8	1.2	0.05
Laryngospasm	1.8	0.6	0.31
Apnea requiring BMV	1.2	0.0	0.15
Hypotension	0.6	1.2	0.56
Unplanned admission	0.6	0.0	0.32

ISSN: 2663-5798 || Arab Journal for Scientific Publishing
الإصدار الثامن – العدد الرابع والثمانون
تاريخ الإصدار: 2 – تشرين الأول – 2025م
www.ajsp.net



Here is **Figure 4.2: Comparison of Intraoperative Adverse Events**.

It illustrates that:

- **Hypoxemia** (7.3% vs 2.4%) and **airway obstruction** (4.8% vs 1.2%) were more frequent under **sedation**.
- Other events (laryngospasm, apnea, hypotension, unplanned admission) were rare in both groups.

4.5 Procedural Efficiency and Completion

Table 4.3. Procedural Outcomes

Outcome	Sedation	GA	p-value
Treatment completed as planned	92.1%	100%	0.001**
Mean Houpt behavior score	3.7 ± 0.8	4.8 ± 0.4	<0.001**
Mean recovery time (min)	35.2 ± 12.1	58.9 ± 18.3	<0.001**

GA provided **100% treatment completion** with higher cooperation scores, but sedation allowed significantly **faster recovery times**.

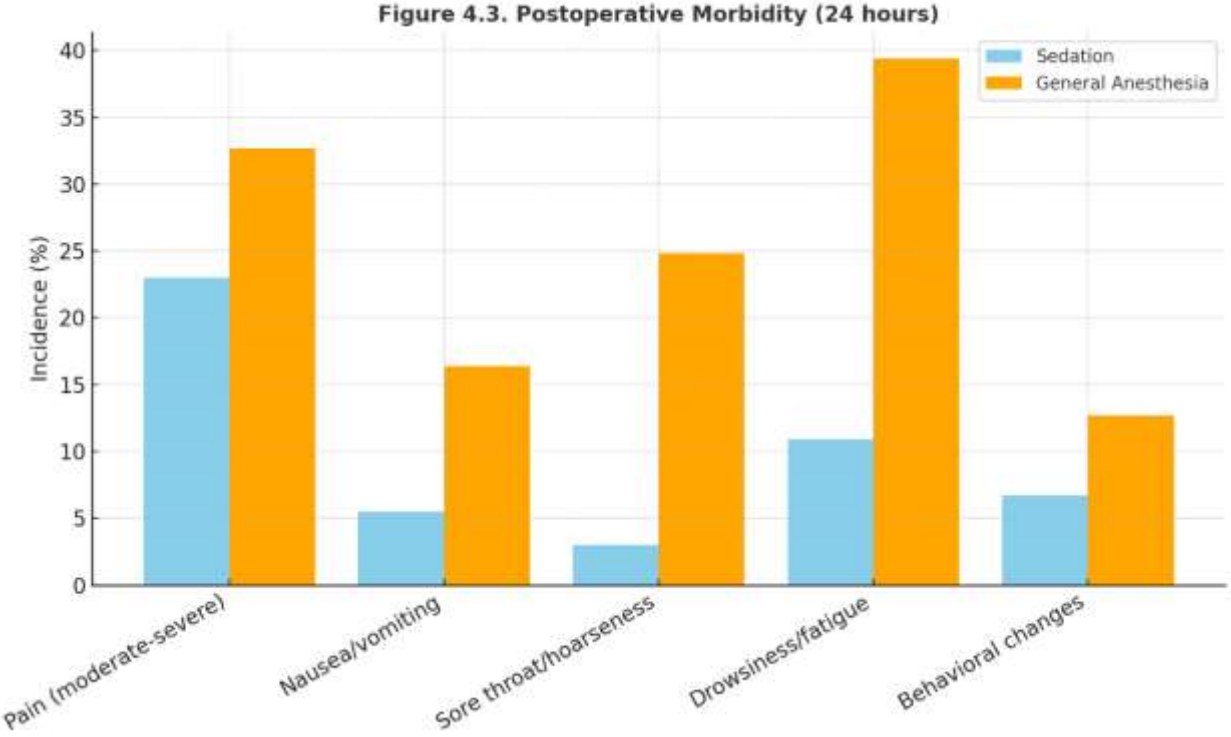
4.6 Postoperative Morbidity (24 Hours)

GA was associated with significantly higher rates of postoperative morbidity, particularly nausea, sore throat, and drowsiness.

Table 4.4. Postoperative Morbidity

Symptom	Sedation (%)	GA (%)	p-value
Pain (moderate–severe)	23.0	32.7	0.05
Nausea/vomiting	5.5	16.4	0.002**
Sore throat/hoarseness	3.0	24.8	<0.001**
Drowsiness/fatigue	10.9	39.4	<0.001**
Behavioral changes	6.7	12.7	0.09

Figure 4.3. Postoperative Morbidity (24 hours)



Here is **Figure 4.3: Postoperative Morbidity (24 hours)**.

It demonstrates that:

- **GA group** had significantly higher rates of **nausea/vomiting, sore throat/hoarseness, and drowsiness/fatigue** compared with sedation.
- **Pain** and **behavioral changes** were also more frequent after GA, though with smaller differences.

4.7 Parental Satisfaction

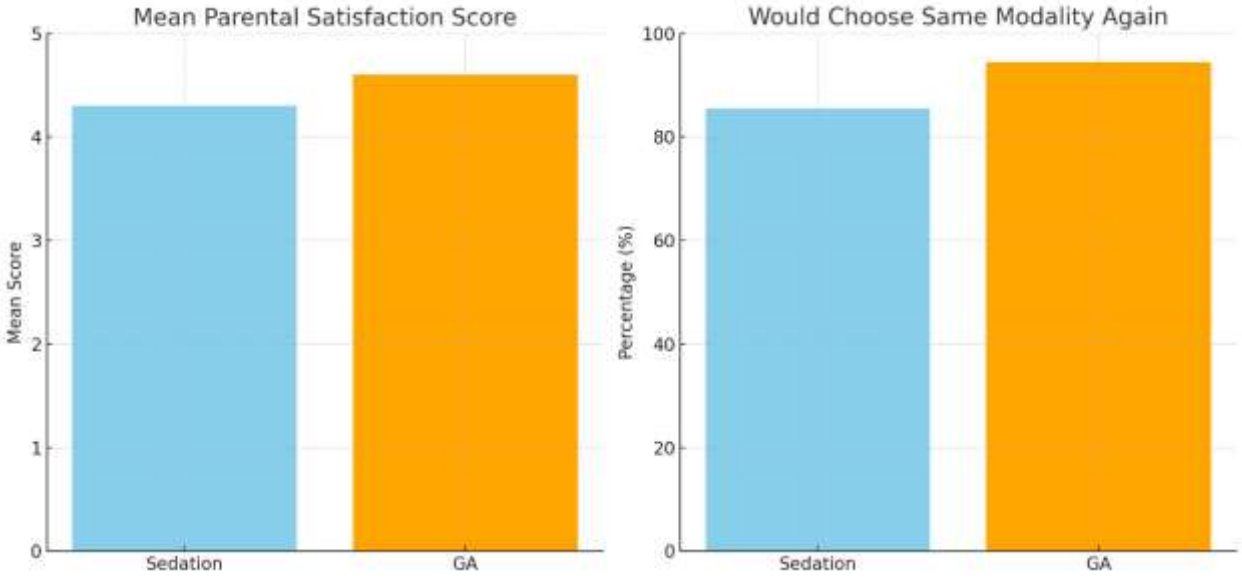
Parental satisfaction was assessed on a 5-point Likert scale and by preference for future use.

Table 4.5. Parental Satisfaction

Outcome	Sedation	GA	p-value

Mean satisfaction score (1–5)	4.3	4.6	0.01*
Would choose same modality again	85.5%	94.5%	0.01*

Figure 4.4. Parental Satisfaction Outcomes



4.8 Predictors of Adverse Events

A multivariable logistic regression identified independent predictors of adverse events.

Table 4.6. Logistic Regression Predictors

Predictor	Adjusted OR	95% CI	p-value
Age < 5 years	2.1	1.1–3.9	0.02*
Sedation (vs GA)	2.4	1.1–5.3	0.03*
Procedure duration > 60 min	2.9	1.3–6.2	0.004**

Younger children, longer procedures, and sedation were significantly associated with adverse events.

4.9 Summary of Findings

1. Sedation carried higher intraoperative airway risks but quicker recovery.
2. GA guaranteed full treatment completion and better behavior but had higher postoperative morbidity.
3. Parental satisfaction favored GA, mainly due to one-session treatment.
4. Independent predictors of adverse events were **younger age**, **longer procedure duration**, and **sedation**.

Chapter 5: Discussion

5.1 Introduction

This chapter discusses the findings of the present study comparing sedation and general anesthesia (GA) in pediatric dental procedures. The discussion is organized according to the study objectives: (1) to examine indications for sedation and GA, (2) to compare safety outcomes, (3) to evaluate procedural and postoperative outcomes, and (4) to assess parental satisfaction. The findings are interpreted in the context of existing literature, with implications for clinical practice, guidelines, and future research.

5.2 Summary of Key Findings

1. **Baseline comparability:** The two groups were similar in age, ASA classification, and procedure type, reducing confounding.
2. **Safety outcomes:** Sedation was associated with higher intraoperative airway complications (hypoxemia and airway obstruction), while GA had more postoperative morbidity (nausea, sore throat, drowsiness). Serious complications were rare in both groups.
3. **Procedural outcomes:** GA achieved 100% treatment completion and higher behavior scores but required longer recovery. Sedation enabled faster discharge but had a small risk of incomplete procedures.
4. **Parental satisfaction:** Parents expressed slightly higher satisfaction with GA, primarily due to guaranteed completion of care in a single session.
5. **Predictors of adverse events:** Younger age, procedure duration >60 minutes, and sedation modality were independently associated with increased risk of adverse events.

5.3 Comparison with Previous Literature

5.3.1 Safety of Sedation vs GA

The finding that sedation carries more airway-related complications aligns with reports from the **Pediatric Sedation Research Consortium (Cravero et al., 2016)**, which documented hypoxemia and airway obstruction as the most common adverse events in procedural sedation. Similarly, **Lee et al. (2013)** highlighted sedation-related deaths, often linked to inadequate monitoring or provider training. Our results reinforce the need for stringent monitoring (especially capnography) and trained personnel during sedation.

Conversely, the higher postoperative morbidity in GA is consistent with **El Batawi (2014)** and **Coulthard et al. (2014)**, who reported increased rates of sore throat, nausea, and drowsiness. This morbidity likely reflects airway instrumentation and anesthetic drug effects. Importantly, no life-threatening complications occurred in either group, reflecting the overall safety of both modalities when performed in appropriate settings.

5.3.2 Procedural Efficiency

The 100% treatment completion under GA mirrors previous findings that GA facilitates comprehensive dental rehabilitation in one visit (Peretz & Ram, 2002). Sedation's 92% completion rate is comparable with international studies showing that sedation may fail in a small subset of highly anxious or uncooperative children (Wilson et al., 2003). Thus, while GA ensures certainty, sedation remains effective for the majority of cases.

5.3.3 Postoperative Morbidity

Our finding of greater nausea and sore throat in GA supports data from **hospital-based pediatric anesthesia studies** (Ing et al., 2021). Sedation's reduced morbidity enhances its attractiveness for outpatient dental care, especially when procedures are of shorter duration.

5.3.4 Parental Satisfaction

High parental satisfaction in both groups is consistent with **El Batawi (2014)**, but the higher scores in GA suggest that parents value efficiency and completion more than reduced side effects. This has important implications for shared decision-making, as parents may prioritize fewer visits over postoperative discomfort.

5.4 Clinical Implications

1. **Tailored Modality Selection:**
    - Sedation is suitable for shorter, less invasive procedures and in cooperative or mildly anxious children.
    - GA should be considered for very young, highly anxious, or special-needs children, and for extensive dental needs.
2. **Safety Protocols:**

- Sedation requires robust monitoring (pulse oximetry + capnography) and airway-trained providers.
- GA should be restricted to hospital or accredited surgical centers with resuscitation facilities.

3. **Parental Counseling:**
   - Parents should be informed that GA ensures complete care but carries higher postoperative morbidity.
   - Sedation offers faster recovery but carries slightly higher intraoperative airway risks.
4. **Policy and Training:**
   - Regulators should mandate standardized adverse event reporting (PSRC taxonomy).
   - Training programs must emphasize sedation rescue skills for pediatric dentists.

5.5 Strengths and Limitations

Strengths

- Prospective cohort design with standardized adverse event reporting.
- Balanced groups with comparable baseline characteristics.
- Inclusion of both clinical outcomes and parental perspectives.

Limitations

- Non-randomized design introduces residual confounding.
- Sample size may not detect extremely rare complications.
- Findings reflect specialized centers; generalization to private practice may be limited.
- Parent-reported morbidity and satisfaction are subjective and prone to recall bias.

5.6 Future Research Directions

1. **Long-term neurodevelopmental outcomes** of repeated or prolonged exposures to sedatives and anesthetics in early childhood (FDA, 2017).
2. **Cost-effectiveness analyses** comparing sedation vs GA across health systems.
3. **Standardization of outcome reporting**, including minor morbidity and parental quality-of-life measures.
4. **Global disparities research** to address data gaps in low- and middle-income countries, where dental GA access is limited.
5. **Hybrid models** (e.g., sedation + advanced behavior management) to reduce GA reliance.

5.7 Conclusion

This study demonstrates that both sedation and GA are safe and effective modalities for pediatric dental procedures when performed under appropriate protocols. Sedation carries a slightly higher risk of transient airway events but is associated with quicker recovery and lower postoperative morbidity. GA guarantees complete treatment in one session but is associated with higher postoperative discomfort. Clinical decision-making should be individualized, balancing procedural complexity, patient risk profile, and parental preferences. These findings support a **patient-centered, evidence-based approach** to optimizing pediatric dental care.

References:

Al-Rakaf, H., Bello, L. L., Turkustani, A., & Adenubi, J. O. (2001). Intraoperative adverse events during conscious sedation with midazolam for pediatric dental patients. International Journal of Paediatric Dentistry, 11(2), 122–128. https://doi.org/10.1046/j.1365-263X.2001.00248.x

American Academy of Pediatric Dentistry. (2024). Best practices: Use of nitrous oxide for pediatric dental patients. AAPD. https://www.aapd.org/research/oral-health-policies--recommendations/

American Society of Anesthesiologists. (2018). Practice guidelines for moderate procedural sedation and analgesia. Anesthesiology, 128(3), 437–479. https://doi.org/10.1097/ALN.0000000000002043

Clark, M. S., & Brunick, A. (2015). Handbook of nitrous oxide and oxygen sedation (4th ed.). Elsevier.

Cote, C. J., & Wilson, S. (2019). Guidelines for monitoring and management of pediatric patients before, during, and after sedation. Pediatrics, 143(6), e20191000. https://doi.org/10.1542/peds.2019-1000

Coulthard, P., Rolfe, S., Mackie, I. C., Gazal, G., Morton, M., & Jackson-Leech, D. (2014). Inhalation sedation versus general anaesthesia for paediatric dental extractions (Review). Cochrane Database of Systematic Reviews, (12), CD003421. https://doi.org/10.1002/14651858.CD003421.pub2

Cravero, J. P., Beach, M. L., Blike, G. T., Gallagher, S. M., & Hertzog, J. H. (2016). The incidence and nature of adverse events during pediatric sedation/anesthesia with propofol for procedures outside the operating room: A report from the Pediatric Sedation Research Consortium. Anesthesia & Analgesia, 124(3), 821–829. https://doi.org/10.1213/ANE.0000000000001492

El Batawi, H. Y. (2014). Children's behavior and parental satisfaction in dental treatment under general anesthesia. Saudi Dental Journal, 26(2), 63–67. https://doi.org/10.1016/j.sdentj.2014.02.003

Food and Drug Administration. (2017). FDA drug safety communication: FDA review results in new warnings about using general anesthetics and sedation drugs in young children and pregnant women. https://www.fda.gov/Drugs/DrugSafety/ucm532356.htm

Green, S. M., Roback, M. G., Kennedy, R. M., & Krauss, B. (2011). Clinical practice guideline for emergency department ketamine dissociative sedation: 2011 update. Annals of Emergency Medicine, 57(5), 449–461. https://doi.org/10.1016/j.annemergmed.2010.11.030

Houpt, M. (1984). Project USDB: Evaluation of behavioral rating scales for use in pediatric dentistry. Journal of Dentistry for Children, 51(2), 105–109.

Ing, C., DiMaggio, C., Whitehouse, A., Hegarty, M. K., Brady, J., von Ungern-Sternberg, B. S., Davidson, A., Sun, L. S., & Li, G. (2021). Long-term differences in language and cognitive function after childhood exposure to anesthesia. Anesthesiology, 134(5), 657–670. https://doi.org/10.1097/ALN.0000000000003730

Kassebaum, N. J., Smith, A. G., Bernabé, E., Fleming, T. D., Reynolds, A. E., Vos, T., Murray, C. J., & Marcenes, W. (2017). Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990–2015: A systematic analysis. Journal of Dental Research, 96(4), 380–387. https://doi.org/10.1177/0022034517693566

Lee, H. H., Milgrom, P., Starks, H., & Burke, W. (2013). Trends in death associated with pediatric dental sedation and general anesthesia. Paediatric Anaesthesia, 23(8), 741–746. https://doi.org/10.1111/pan.12210

Peretz, B., & Ram, D. (2002). Behavioural changes in children following dental treatment under general anaesthesia. Journal of Dentistry for Children, 69(1), 66–70.

Rathmell, J. P., Pino, R. M., & Wu, C. L. (2019). Adverse respiratory events after pediatric sedation and general anesthesia. Current Opinion in Anaesthesiology, 32(3), 336–343. https://doi.org/10.1097/ACO.0000000000000726

Setia, M. S. (2016). Methodology series module 3: Cross-sectional studies. Indian Journal of Dermatology, 61(3), 261–264. https://doi.org/10.4103/0019-5154.182410

Sheta, S. A., Al-Sarheed, M., & Abdelhalim, A. A. (2015). Intranasal dexmedetomidine vs oral midazolam premedication for children undergoing dental rehabilitation. Anaesthesia, 70(2), 150–155. https://doi.org/10.1111/anae.12878

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2014). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. International Journal of Surgery, 12(12), 1495–1499. https://doi.org/10.1016/j.ijsu.2014.07.013

Waugh, J. B., Epps, C. A., & Khodneva, Y. (2011). Capnography enhances safety of procedural sedation: A meta-analysis. Journal of Clinical Anesthesia, 23(3), 189–196. https://doi.org/10.1016/j.jclinane.2010.08.001

Wilson, S., Houpt, M., & Committee on Sedation and Anesthesia. (2003). Project USDB: A survey of sedation practices in pediatric dentistry. Journal of Dentistry for Children, 70(1), 41–48.

World Health Organization. (2022). Oral health fact sheet. WHO. https://www.who.int/news-room/fact-sheets/detail/oral-health

"التخدير الواعي والتخدير العام في إجراءات طب الأسنان للأطفال: الدواعي، السلامة، والنتائج"

إعداد:

مطيع هثال رجاء الشمري

الملخص"

تُعد تسوسات الأسنان من أكثر الأمراض المزمنة شيوعًا في مرحلة الطفولة، وغالبًا ما تتطلب علاجًا مكثفًا يشكل تحديًا من حيث التعاون والسلامة. قد لا تكون تقنيات إدارة السلوك غير الدوائية كافية، مما يجعل التخدير الواعي والتخدير العام (GA) ضروريين لتسهيل الرعاية. ومع ذلك، لا تزال هناك تساؤلات حول مدى سلامة وفعالية هذه الأساليب، وكذلك نتائجها من منظور يركز على المريض في مجال طب أسنان الأطفال.