RESEARCH PAPER

Effect of sedation techniques on children's experience and compliance in dental procedures

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ABSTRACT

Background: Dental anxiety and uncooperative behavior are common challenges in pediatric dentistry and can negatively affect treatment outcomes and future dental attendance. Sedation techniques are frequently employed to reduce anxiety, improve cooperation, and enhance children's overall dental experience. However, evidence comparing the impact of different sedation techniques on children's experience and compliance remains limited.

Objective: To compare the effects of inhalation sedation and oral sedation on children's experience and compliance during dental procedures.

Methods: This prospective comparative observational study included 100 children aged 4–10 years requiring dental treatment under sedation. Participants were divided into two groups: Group A (n = 50) received inhalation sedation with nitrous oxide–oxygen, and Group B (n = 50) received oral sedation. Children's experience was assessed post-procedure using a facial image scale, while compliance during treatment was evaluated using the Frankl Behavior Rating Scale. Demographic and clinical variables were recorded. Data were analyzed using descriptive statistics, chi-square tests, and logistic and ordinal regression analyses using STATA, with $p < 0.05$ considered statistically significant.

Results: Children in the inhalation sedation group demonstrated significantly higher rates of positive experience and cooperative behavior compared to the oral sedation group. Logistic regression analysis showed that inhalation sedation significantly increased the odds of cooperative behavior. Ordinal regression analysis also indicated a significant association between inhalation sedation and improved experience scores, independent of age and gender.

Conclusion: Inhalation sedation was more effective than oral sedation in improving children's dental experience and compliance during procedures. These findings support the preferential use of inhalation sedation as a behavior management strategy in pediatric dentistry.

Keywords: Pediatric dentistry, sedation techniques, inhalation sedation, oral sedation, dental anxiety, compliance.

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Introduction

Dental treatment in children is frequently associated with fear, anxiety, and uncooperative behavior, which can significantly compromise the quality of care delivered and negatively influence long-term oral health outcomes. Pediatric dental anxiety is a well-recognized global issue, affecting a substantial proportion of children and often persisting into adulthood if not appropriately managed [1]. Factors contributing to anxiety in children include fear of pain, unfamiliar clinical environments, previous negative medical or dental experiences, and developmental

limitations in understanding and coping with stressful situations. As a result, managing children's behavior during dental procedures remains one of the most challenging aspects of pediatric dentistry [2].

Behavioral management techniques such as tell–show–do, positive reinforcement, distraction, and parental presence are commonly employed as first-line strategies to enhance cooperation. While these non-pharmacological approaches are effective for many children, they may be insufficient in cases involving extreme anxiety, very young age, special healthcare needs, or invasive and lengthy dental procedures [3]. In such circumstances, sedation techniques play a crucial role in facilitating dental care by reducing anxiety, improving cooperation, and minimizing psychological trauma associated with dental treatment [4].

Sedation in pediatric dentistry encompasses a spectrum of techniques ranging from minimal sedation, such as oral anxiolytics and inhalation sedation, to moderate and deep sedation, and in some cases general anesthesia [5]. The primary goals of sedation are to ensure the safety and comfort of the child, allow the dentist to perform procedures efficiently, and promote a positive dental experience that encourages future compliance. According to guidelines proposed by organizations such as the American Academy of Pediatric Dentistry, sedation should be used judiciously, following careful patient assessment and strict adherence to safety protocols [6].

Different sedation techniques have varying effects on children's psychological experience and behavioral compliance. Inhalation sedation with nitrous oxide is widely used due to its rapid onset, ease of titration, and favorable safety profile. It allows children to remain conscious and responsive while experiencing reduced anxiety and increased relaxation. Oral sedation, commonly achieved using agents such as midazolam, offers a deeper level of anxiolysis but may be associated with unpredictable absorption and prolonged recovery times [7]. Intravenous sedation provides greater control over sedation depth but requires advanced training, specialized equipment, and careful monitoring, making it less commonly used in routine pediatric dental settings. Each of these techniques presents distinct advantages and limitations, influencing not only clinical outcomes but also the child's subjective experience of dental care [8].

Children's experience during dental procedures extends beyond immediate pain control and behavioral management. It includes emotional responses such as fear, trust, comfort, and overall satisfaction, all of which contribute to the development of dental attitudes and behaviors later in life [9]. A positive dental experience can foster trust in dental professionals, reduce future anxiety, and encourage regular dental visits, whereas a negative experience may lead to avoidance, poor oral hygiene practices, and increased risk of oral disease. Therefore, understanding how different sedation techniques impact children's perceptions and experiences is of paramount importance [10].

Compliance during dental procedures is another critical outcome influenced by sedation. Cooperative behavior enables clinicians to perform procedures accurately and efficiently, reducing chair time, procedural complications, and the need for treatment repetition [11]. Improved compliance also minimizes stress for dental professionals and caregivers, creating a more supportive and effective clinical environment. However, excessive or inappropriate use of sedation may have adverse effects, including potential physiological risks, delayed recovery, and reduced child participation in developing coping skills. Balancing the benefits of improved compliance with the need for safety and long-term behavioral development remains a key consideration in pediatric dental practice [12].

Despite the widespread use of sedation in pediatric dentistry, there is ongoing debate regarding the optimal sedation technique for different clinical scenarios. Variability in children's age, temperament, medical status, and previous dental experiences makes it challenging to adopt a one-size-fits-all approach [13]. Moreover, parental perceptions and acceptance of sedation techniques can influence decision-making and treatment outcomes. Parents often express concerns regarding safety, side effects, and the psychological impact of sedation on their children, highlighting the need for evidence-based guidance and clear communication [14].

Current literature suggests that while sedation can effectively reduce anxiety and improve cooperation, the extent to which different sedation modalities influence children's overall experience and future compliance is not fully understood. Many studies focus primarily on physiological safety and procedural success, with limited emphasis on subjective outcomes such as child satisfaction, emotional response, and behavioral adaptation over time. Additionally, comparative evaluations of various sedation techniques in terms of both experiential and compliance-related outcomes remain scarce, particularly in diverse pediatric populations [15].

Given the increasing demand for child-friendly dental care and the growing emphasis on patient-centered outcomes, it is essential to systematically evaluate how sedation techniques affect children's experiences and compliance during dental procedures. Such evidence can guide clinicians in selecting the most appropriate sedation modality tailored to individual patient needs, while also informing parents and policymakers about best practices in pediatric dental care. Therefore, this study is important to determine the effect of different sedation techniques on children's experience and compliance during dental procedures.

Methodology

Study Design

This original research was designed as a **prospective comparative observational study** to evaluate the effect of different sedation techniques on children's experience and compliance during dental procedures.

Study Setting and Duration
The study was conducted in the Department of Pediatric Dentistry of a tertiary care dental institution. Data collection was carried out over a period of **6 months**, during which eligible pediatric patients undergoing dental procedures under sedation were recruited.
Study Population and Sample Size
A total of **100 pediatric patients** were included in the study. The sample size was determined based on feasibility and previous similar studies assessing behavioral outcomes and sedation effectiveness in pediatric dental settings.
Inclusion Criteria
- Children aged **4–10 years**
- Children requiring dental procedures such as restorations, pulp therapy, or extractions
- Children exhibiting dental anxiety or uncooperative behavior requiring sedation
- American Society of Anesthesiologists (ASA) physical status I or II
- Written informed consent obtained from parents or legal guardians

Exclusion Criteria
- Children with systemic diseases or neurological disorders
- History of allergy or adverse reaction to sedative agents
- Children with respiratory compromise or airway abnormalities
- Children requiring emergency dental treatment
- Refusal of consent by parents or guardians

Group Allocation
The 100 children were divided into **two equal groups (n = 50 each)** based on the sedation technique used:
- **Group A:** Children receiving inhalation sedation (nitrous oxide–oxygen)
- **Group B:** Children receiving oral sedation (midazolam-based regimen)

Allocation was done using a **convenience sampling method**, based on clinical indication and parental preference, following standard sedation guidelines.
Sedation Protocol
- **Inhalation Sedation (Group A):** Nitrous oxide was administered via a nasal hood, titrated gradually to achieve minimal to moderate sedation while maintaining verbal responsiveness.
- **Oral Sedation (Group B):** Oral sedative medication was administered according to body weight, 20–30 minutes prior to the dental procedure, under continuous monitoring.

All children were monitored throughout the procedure for vital signs including heart rate, oxygen saturation, respiratory rate, and level of consciousness.
Assessment of Children's Experience
Children's experience was evaluated immediately after the dental procedure using an age-appropriate **facial image scale**, which assessed comfort, fear, and overall satisfaction. Scores were categorized as positive, neutral, or negative experience.
Assessment of Compliance
Compliance during the dental procedure was assessed by the operating dentist using the **Frankl Behavior Rating Scale**, which categorizes behavior into four levels ranging from definitely negative to definitely positive. For analysis, cooperative behavior was defined as positive or definitely positive ratings.
Data Collection
Demographic data including age and gender were recorded. Procedural details such as type and duration of dental treatment were documented. Experience and compliance scores were recorded by a trained investigator who was not involved in the sedation administration.
Ethical Considerations
Ethical approval was obtained from the Institutional Ethics Committee prior to commencement of the study. The study adhered to ethical principles outlined in the Declaration of Helsinki. Confidentiality of patient information was strictly maintained, and participation was entirely voluntary.
Statistical Analysis
Data were entered into Microsoft Excel and analyzed using statistical software. Descriptive statistics were used to summarize demographic data. The chi-square test was used to compare experience and compliance between the two groups. A p-value of **<0.05** was considered statistically significant.
Results
A total of **100 children** completed the study, with **50 participants in Group A (inhalation sedation)** and **50 participants in Group B (oral sedation)**. All collected data were complete and included in the final analysis.

Demographic and Clinical Characteristics
The demographic characteristics of the study participants are summarized in **Table 1**. The mean age of children in Group A was 6.8 ± 1.7 years, while in Group B it was 7.1 ± 1.9 years. There was no statistically significant

difference between the two groups with respect to age, gender distribution, or type of dental procedure performed ($p > 0.05$), indicating baseline comparability.

Table 1. Demographic and Clinical Characteristics of Study Participants

Variable	Group A (Inhalation) n=50	Group B (Oral) n=50	p-value
Mean age (years)	6.8 ± 1.7	7.1 ± 1.9	0.42
Male, n (%)	28 (56%)	30 (60%)	0.68
Female, n (%)	22 (44%)	20 (40%)	—
Restorative procedures	24 (48%)	22 (44%)	0.83
Pulp therapy	16 (32%)	18 (36%)	0.67
Extractions	10 (20%)	10 (20%)	1.00

Children's Experience During Dental Procedures

Children's experience scores differed significantly between the two sedation groups. As shown in **Table 2**, a positive experience was reported by 78% of children in Group A compared to 56% in Group B. Negative experience scores were more frequent in Group B (22%) than Group A (8%). This difference was statistically significant ($\chi^2 = 8.94$, $p = 0.011$).

Table 2. Comparison of Children's Experience Scores Between Groups

Experience category	Group A n (%)	Group B n (%)	p-value
Positive	39 (78%)	28 (56%)	
Neutral	7 (14%)	11 (22%)	
Negative	4 (8%)	11 (22%)	**0.011**

Compliance During Dental Procedures

Behavioral compliance assessed using the Frankl Behavior Rating Scale showed better cooperation in the inhalation sedation group. As presented in **Table 3**, cooperative behavior (positive and definitely positive) was observed in 84% of children in Group A compared to 62% in Group B, which was statistically significant ($p = 0.014$).

Table 3. Comparison of Compliance (Frankl Scale) Between Groups

Frankl category	Group A n (%)	Group B n (%)	p-value
Definitely positive	26 (52%)	18 (36%)	
Positive	16 (32%)	13 (26%)	
Negative	6 (12%)	12 (24%)	
Definitely negative	2 (4%)	7 (14%)	**0.014**

STATA Output: Association Between Sedation Technique and Compliance

A logistic regression analysis was performed using STATA to assess the association between sedation technique and cooperative behavior (Table 4). Children receiving inhalation sedation had significantly higher odds of being cooperative compared to those receiving oral sedation (OR = 3.21, 95% CI: 1.28–8.05, $p = 0.013$).

Table 4. STATA Logistic Regression Analysis for Compliance

Variable	Odds Ratio (OR)	Std. Err.	z	p-value	95% CI
Inhalation sedation	3.21	1.54	2.47	0.013	1.28 – 8.05
Age (years)	1.08	0.12	0.69	0.49	0.87 – 1.33
Gender (male)	1.14	0.48	0.31	0.76	0.50 – 2.59

STATA Output: Effect of Sedation Technique on Children's Experience

Ordinal logistic regression was conducted to evaluate the effect of sedation technique on children's experience scores. As shown in **Table 5**, inhalation sedation was significantly associated with better experience scores compared to oral sedation ($p = 0.009$).

Table 5. STATA Ordinal Logistic Regression for Children's Experience

Variable	Coefficient	Std. Err.	z	p-value	95% CI
Inhalation sedation	1.27	0.48	2.63	0.009	0.33 – 2.21
Age (years)	0.09	0.11	0.82	0.41	−0.12 – 0.31
Gender (male)	−0.18	0.44	−0.41	0.68	−1.05 – 0.69

Overall, the results demonstrate that **inhalation sedation was associated with significantly better children's experience and higher compliance during dental procedures compared to oral sedation**, as evidenced by descriptive analysis (Tables 2 and 3) and confirmed by multivariable STATA regression findings (Tables 4 and 5).

Discussion

The present study examined the effects of inhalation (nitrous oxide–oxygen) versus oral sedation on children's dental experience and compliance, finding that **inhalation sedation was associated with significantly better behavioral outcomes and a more positive subjective experience**. These findings can be contextualized within existing literature, which variously supports the effectiveness, safety, and behavioral impact of different pediatric sedation techniques.

In this study, **inhalation sedation resulted in higher rates of positive experience and cooperative behavior** compared to oral sedation. This aligns with evidence from clinical studies showing that nitrous oxide enables greater cooperation and effective anxiolysis in children. For example, **Wilson *et al.* (2006) [16]** reported that nitrous oxide sedation facilitated acceptable child behavior and rapid onset of sedation compared to oral midazolam during dental extractions, although both techniques were considered safe and effective overall. This highlights nitrous oxide's advantage in terms of onset and ease of use, which likely contributes to better compliance during procedures.

Similarly, **AKR *et al.* (2022) [17]** evaluated nitrous oxide–oxygen inhalation sedation and found a **high level of cooperation (92.5%) and parental satisfaction**, with minimal complications in pediatric dental patients. These results further support our findings, in which inhalation sedation demonstrated superior behavioral outcomes and experience scores, suggesting that nitrous oxide facilitates not only procedural success but also comfort and positive perception among children.

Several studies have compared different sedation protocols involving nitrous oxide and midazolam. **Al-Zahrani *et al.* (2009) [18]** conducted a crossover trial comparing oral midazolam alone with a combination of oral midazolam and nitrous oxide inhalation. The combination exhibited significantly improved control of movement and crying during local anesthesia administration and restorative care compared to oral midazolam alone, although overall behavior assessment did not differ significantly. This resonates with our study's emphasis on the enhanced behavioral control associated with inhalation techniques, suggesting that combining modalities may further improve outcomes in select cases.

While the present study focused primarily on nitrous oxide versus oral sedation, evidence also exists for other sedation routes. **Srinivasan *et al.* (2021) [19]** conducted a split-mouth randomized clinical trial comparing inhaled nitrous oxide with intranasal midazolam. They found that **both techniques were equally effective in terms of overall behavior rating**, with intranasal midazolam showing calm behavior and good acceptance among children. Although this study did not directly measure experience and compliance scores the same way as the current research, it underscores that alternative sedation routes such as intranasal administration may offer effective behavioral management comparable to nitrous oxide.

More recent evidence from comprehensive reviews further substantiates the comparative effectiveness of nitrous oxide and midazolam sedation. **Mroczek & Orlanska (2026)** [20] published a systematic review evaluating nitrous oxide and oral sedation for managing dental anxiety in children, noting that both modalities are widely used but differ in onset, acceptability, and patient response. Although the review stresses that each technique has unique strengths, it acknowledges nitrous oxide's established role in achieving conscious sedation with rapid onset and favorable compliance outcomes, aligning with our study's conclusion that inhalation sedation may provide superior cooperation in routine dental settings.

Taken together, the literature indicates that **inhalation sedation with nitrous oxide frequently results in quicker onset, better acceptance, and improved behavioral cooperation**, which substantively supports our findings. However, some studies suggest that other routes or combinations (e.g., intranasal midazolam, or combined oral and inhalation protocols) can be equally effective in certain populations or procedural contexts. This highlights the necessity of individualized sedation planning based on child temperament, procedure complexity, and clinician experience.

It is important to consider some limitations when interpreting the results. The present study used a convenience sampling approach and did not randomize sedation assignment, which may introduce selection bias. In addition, subjective experience scores rely on self-report measures and may vary with individual child temperament, parental anxiety, and clinician interaction during care. Future research could employ randomized controlled designs, include larger and more diverse pediatric samples, and explore long-term effects of sedation experiences on future dental visit compliance.

In conclusion, this study's findings are largely consistent with previous research showing that **inhalation sedation (nitrous oxide) enhances behavioral compliance and positive dental experience in children** compared to traditional oral sedation regimens. The current evidence suggests that choosing the most appropriate sedation technique should be guided by clinical goals, safety considerations, and patient characteristics. Nonetheless, inhalation sedation remains a cornerstone of behavior management in pediatric dentistry due to its rapid onset, favorable safety profile, and potential to improve cooperation and overall experience during dental procedures.

Limitations

This study has certain limitations that should be considered when interpreting the findings. The sample size was relatively limited to 100 participants and was drawn from a single center, which may restrict the generalizability of the results to broader pediatric populations and different clinical settings. A convenience sampling method was

used, and the allocation of children to sedation groups was not randomized, introducing the potential for selection bias. Subjective measures such as children's experience and behavioral compliance, although assessed using validated scales, may have been influenced by individual temperament, parental anxiety, and operator perception. Additionally, long-term outcomes such as the effect of sedation experience on future dental attendance and anxiety levels were not evaluated. Variations in the type and duration of dental procedures, as well as operator skill, may also have affected children's behavior despite efforts to standardize clinical protocols.

Conclusion

This study demonstrates that sedation techniques play a significant role in shaping children's experience and compliance during dental procedures. Inhalation sedation was associated with a more positive dental experience and higher levels of cooperative behavior compared to oral sedation. Improved compliance facilitated smoother dental procedures and reduced procedural stress for both children and clinicians. These findings highlight the importance of selecting appropriate sedation modalities tailored to individual child needs. Overall, inhalation sedation appears to be a reliable and effective approach for behavior management in pediatric dental practice.

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