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TECHNIQUES

Rationale and pre-requisites for use of nitrous oxide in pediatric dentistry

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Abstract

Dental fear and anxiety pose a major challenge in rendering dental treatment for children. It becomes difficult to communicate with an anxious or fearful child, which is essential to build trust and rapport with the dentist. Pain threshold is also lowered in a child who is fearful or anxious making it even more difficult for a dentist to deal with the child. Therefore, understanding fear/anxiety, their manifestations and management is the key step in creating an environment of harmony between the child and the dentist. Nitrous oxide, being anxiolytic, is used in dentistry for allaying fear and anxiety, thereby creating a positive feeling, which in turn helps in building a positive dental attitude. Therefore, nitrous oxide is also considered as a behavior guidance technique. Besides reducing fear and anxiety it also has other advantages. In addition, to practice this technique effectively and safely, it is imperative to understand the indications and contraindications of its use.

Keywords Nitrous oxide · Anxiolysis · Behavior guidance · Dental fear · Dental anxiety · Indications/contraindications of nitrous oxide · Advantages/disadvantages of nitrous oxide · Inhalation sedation

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Quick reference/description

Pediatric dentistry can be quite taxing for all the people involved, especially the child patients. Comprehension of the basics of fear and anxiety in children forms the basis of a clinician's ability to render the best possible care to children and establish a long-term, healthy association with them. Nitrous oxide sedation is a safe and reliable behavior management tool for anxious children that when used in conjunction with other behavior guidance techniques, can bring about desired behavior, facilitate positive dental experiences, and develop a positive dental attitude in children.

Indications

- In children who are apprehensive or nervous about the upcoming dental treatment
- Examination of a child with a prior negative dental experience
- Dental examination for preschoolers
- Examination in children with special health care needs like autism spectrum disorders, attention deficit hyperactivity disorder and cerebral palsy, in situations, where profound local anesthesia cannot be achieved
- In children of all ages if they can accept the nitrous oxide delivery hood
- Nitrous oxide sedation is best suited for children falling under ASA category I and II, and for children in ASA category III with medical consultation

Materials/instruments

- Nitrous oxide delivery system including flowmeter, reservoir bag and breathing circuit having a nasal delivery hood
- Nitrous oxide and oxygen cylinders mounted on a yoke or attached to a manifold
- Scavenging pump

Procedure

The rationale behind using nitrous oxide in children is to achieve anxiolysis by inhaling it through a nasal hood. A child should be willing to accept the use of nasal hood and allow its placement throughout the procedure. However, this may not be a simple and easy task for all children. Each child has a distinct personality which is known as temperament. Children are categorized into different clusters of temperament by Thomas and Chess (Table 1).

It has been suggested that the inhalational nitrous oxide–oxygen technique is more effective in children with "easy temperament". Children with difficult or slow to warm up temperament are also more likely to be fearful and anxious.

Table 1 Clusters of temperament by Thomas and Chess

Clusters of temperament	Description	Behavioral characteristics
Easy (about 40% of children)	Child is usually in positive mood and adapts easily to new experiences	The child is generally cheerful and expresses distress or frustration mildly
Difficult (about 10% of children)	Child reacts negatively, cries frequently, and does not accept new situations easily	The child fusses or cries loudly in new situations, may express unpleasant mood and throw temper tantrums
Slow to warm up (about 15% of children)	Child has low activity level and takes time to get adapted to new circumstances	The child is shy, clings quietly to his/her parents. The child takes time to get adapted to the new environment or situation

Such children will not accept nasal hood easily and therefore, the first step to the use of nitrous oxide- oxygen for anxiolysis is to understand the temperament of the child for an effective introduction of nasal hood. Certain behavioral traits (Table 1) and signs of fear or anxiety (Table 2) should help a dentist in categorizing a child into easy, difficult, or slow to warm up temperament.

Following this the dentist should make an effort in communicating with children having "difficult" and "slow to warm up" temperament.

During communication, the dentist should also make a sincere effort in understanding the basis of fear. This can be done by initiating a conversation with the child in an empathetic manner, like "You look scared of something" or "what are you scared of?" Or "why are you looking unhappy?" Answer to these questions would help the dentist understand the type of fear which a child might be having.

Fear can be innate or acquired (Fig. 1).

Innate fear develops irrespective of past experience. Children with innate fear will generally be crying without reason saying,"I want to go home" or child may say "I am just scared, and I don't know why I am scared?".

Acquired fear can be conditioned, objective, or subjective. Conditioned fear has major implications in dentistry like becoming anxious following application of topical anesthesia in anticipation of injectable anesthesia in the second visit due to a prior experience of a painful anesthetic injection after topical application.

Unbearable pain during the first dental visit can develop into an objective fear and is a strong predictor for long-term dental anxiety. Conditioned fear and objective fear are usually evident when the child has a previous dental history.

Subjective fear can develop in a child by hearing negative dental experiences from the family and is a strong determinant of dental fear in young children.

Furthermore, child may be having specific dental fear which he/she may express vividly. Examples of these and their mitigation strategies are highlighted in Table 3.

Strategies to manage such fearful children will be based on a combination of a meaningful communication with lot of patience, basic behavior management strategies (such as tell show do, distraction, positive reinforcement etc.) and relaxation therapy.

Some important clinically relevant concepts while communicating with these children are:

Table 2 Recognizing signs of fear

Responses to fear	Signs of fear
Inner feeling/Cognitive response	Use of negative statements or statements regarding possible danger from fearful situation. Eg: I am scared, I do not like this place, I don't want to get my teeth checked
Outer behavioral response	Avoidance or escape from the fearful situation, crying, clinging to parents, physical combativeness
Physiological response	Increased heart rate and respiratory rate, sweating, mouth dryness, trembling, shaking, respiratory changes

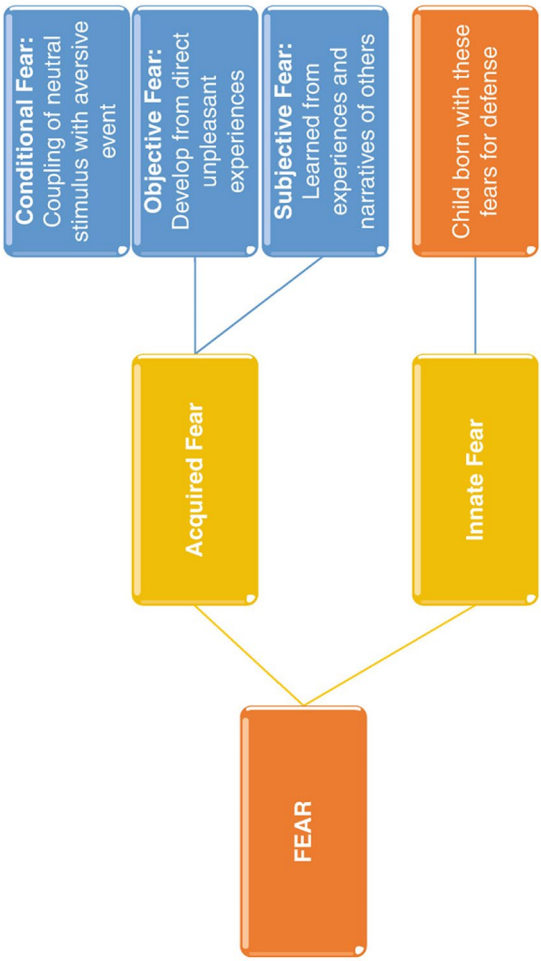

Fig. 1 Types of fear and their acquisition in children

Table 3 Etiology of fearful behavior and mitigation strategies

Etiology of dental fear in children	Examples	Mitigation strategies
Fear of pain or anticipation of pain	Needles, injections, dental handpieces	– Explaining the difference between pain and touch or pressure to help the child to dissociate pain from fear
Lack of trust or fear of betrayal	Lying, not preparing child for the procedure	– Building trust between the child and the dentist via honest and proper communication – 'Tender love care' (TLC) is an empathetic non-judgmental communication with the child to acknowledge the child's feelings. The child should be asked about their feelings with open-ended questions using words without negative connotations – The dentist should address the source of the child's fear and mitigate or eliminate the stimuli to gain the child's trust
Fear of loss of control during the appointment	Anticipation of inability to breathe or talk	– Use of behavior guidance or management techniques depending on the child's cognitive ability – Tell-show-do technique – Offering decisional control to the child by allowing him/her to decide the first tooth to be treated or working on a tooth till the count of 5/10 – Offering control over noxious stimuli by allowing the child to raise a hand in case of pain or perceived threat
Fear of unknown	Not informing the child about the steps of the procedure	– Tell-show-do technique – Explaining the child about the treatment procedure – Modeling on parents, siblings or other children
Fear of intrusion (Most difficult to manage)	Fear of restraints, disclosure of oral hygiene	– Non-judgmental communication between the dentist and the child about the child's dental status

- Do not pressurize or appease children with "difficult" temperament as this reinforces this temperament. Understanding and patience is required for children with difficult temperament.
- Do not push a child with "slow to warm up" temperament to accept the nasal hood as the child's shyness may worsen. They should be allowed to get accustomed to the environment of the clinic at their own pace. Let the child see the nasal hood, and observe their parent using it.
- Never make fun of a child's fear.
- Try to be empathetic and supportive while talking to a fearful child, like "I understand that you are not comfortable, but I would like to be your friend and help you".
- Positive reinforcement for good behavior such as willingness to accept nasal hood.
- Help a child explore ways to overcome fear through visual imagery, music, art therapy, breathing exercises and suggestive hypnosis.

The goal of these techniques would be to develop rapport with the child and introduce the nitrous oxide nasal hood in an effective manner. Following this, nitrous oxide may be used for anxiolysis which would help further in alleviating fear and anxiety.

The pathway for introducing nitrous oxide to children based on assessment of child's temperament is shown in Fig. 2.

In case of non-acceptance of basic behavior management techniques or nasal hood used for inhaling nitrous oxide, the pediatric dentist should move to advanced behavior guidance techniques such as sedation or general anesthesia.

Purpose of nitrous oxide in children

Inhalational nitrous oxide is an invaluable tool for behavior guidance in children and has purposes like (Fig. 3):

- Reduce fear and anxiety due to its anxiolytic and euphoric properties. In children with prior negative dental experiences, performing a proper examination is possible if the dentist can identify the cause of fear and introduce nitrous oxide before attempting an examination. Introduction of nitrous oxide before examination in children with special health care needs reduces their anxiety and helps in developing trust and confidence in the dentist.
- Facilitate communication between the child and the dentist by relaxing the child and allowing the dentist to determine and manage the child's fear.
- Inculcate a positive attitude in children towards the clinician and dental treatment. The analgesic, anxiolytic and euphoric properties of nitrous oxide allow the child to shed all inhibitions and comfortably enjoy the dental treatment. It builds the child's and parents' trust and confidence in the dentist.

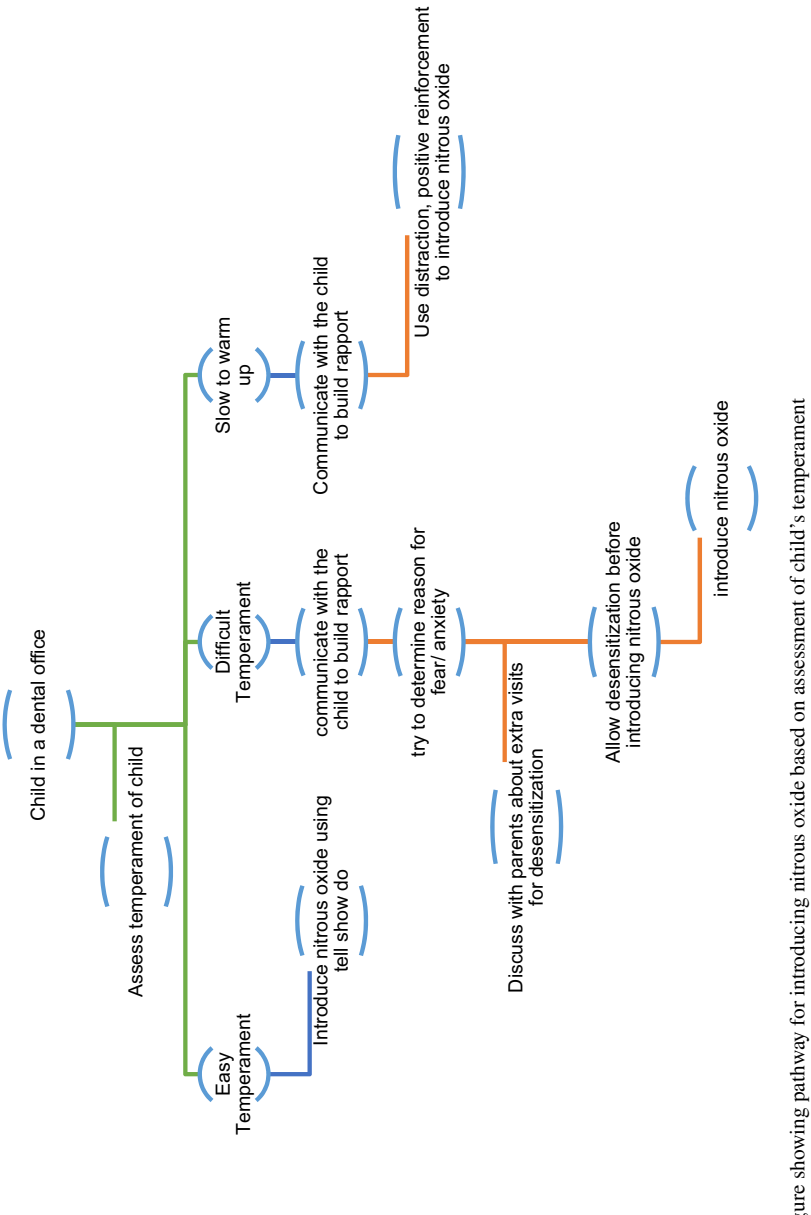

Fig. 2 Figure showing pathway for introducing nitrous oxide based on assessment of child's temperament

Fig. 3 Nitrous oxide sedation in a fearful child. **a, b** A fearful child trying to run out of the clinic and crying. **c** Introduction of nitrous oxide delivery hood. **d** Relaxed and happy child at the end of treatment

- Enhance the quality of treatment provided to the children by bringing about cooperative behavior and reducing unwarranted lip and tongue movements in children.
- Improve operator efficiency because of cooperative patient behavior that allows more work to be done in a single visit. It allows the clinician to practice quadrant dentistry by altering the sense of time and decreasing operator's fatigue.
- It has analgesic properties and hence, can also be used effectively as an adjunct to local anesthesia for pulp therapy of a tooth with acutely inflamed pulp or extraction of a tooth with an abscess, where local infiltration anesthesia remains inadequate.
- To control gagging during impression making, taking radiographs and restorative treatment. This is related to the anxiolytic property which helps in depressing the reflex.
- Reduce stressful environment and create a peaceful, stress-free atmosphere by decreasing occupational stress on the dental staff.
- Enhance the role of basic behavior guidance technique.
- To reduce number of anxious children needing dental treatment being treated under general anesthesia.

Nitrous oxide can be used in fearful as well as cooperative children for dental treatment. Based on the Frankl's behavior rating scale, using nitrous oxide for each category has a different purpose (Table 4).

Contraindications of nitrous oxide–oxygen inhalation

Systemic or behavioral contraindications

- Chronic obstructive pulmonary disease (COPD): Poor exchange of gases in COPD can compromise the safety factor of nitrous oxide sedation.

Table 4 Application of nitrous oxide in children according to Frankl's behavior rating scale

Category	Application of nitrous oxide
Definitely positive	– Improves operator efficiency and reduces the time required to complete dental procedures – Plays a major role in practicing quadrant dentistry in children – Improves the quality of dental treatment rendered to the child
Positive	– Instills a positive dental attitude in children and parents, and helps in creating a 'happy child'
Negative	– Removes fear and anxiety of dentist/dental treatment – Ensures that an otherwise unpleasant procedure be performed with ease
Definitely negative	– Reduces the number of cases being treated under general anesthesia – Allows emergency treatment in anxious and phobic children, who usually avoid dental treatment

- Bowel obstruction or abdominal pain: Nitrous oxide administration in bowel obstruction or constipation can cause abdominal pain. In bowel obstruction, nitrous oxide can cause abdominal distension leading to pain.
- Middle ear surgery/infections/otitis media: Use of nitrous oxide in children can cause earache after the procedure, particularly in cases of prior or recent middle ear surgery, infections or otitis media. In children with Crouzon syndrome, it can increase the risk of hearing loss.
- Severe emotional disturbances, psychiatric disorders or drug-related dependencies: Psychiatric patients can be on psychotropic drugs or medications that cause sedation. Therefore, administration of nitrous oxide sedation can cause additive effect and should be carefully done with adequate monitoring.
- Treatment with bleomycin sulfate: Interstitial pneumonitis is common with bleomycin therapy being used for certain tumors like Hodgkin's and non-Hodgkin's lymphoma. Nitrous oxide being administered along with 30–100% oxygen, can cause pulmonary toxicity on exposure to oxygen at these concentrations.
- Autoimmune disorders or children on immunosuppressive therapy: Nitrous oxide can depress bone marrow activity, which in turn decreases the production of leukocytes and erythrocytes. Hence, repeated exposure to nitrous oxide at small intervals in children on immunosuppressive therapy or with autoimmune disorders can further decrease the immune response of the body.
- Cobalamin deficiency: Nitrous oxide is contraindicated in vitamin B_{12} deficiency, methyltetrafolate reductase deficiency or methionine synthase deficiency as it further reduces the methionine levels needed for methylation reactions and protein synthesis.
- Children who are in pre-cooperative stage: A child less than 30 months of age usually does not comprehend the placement of the nitrous oxide delivery mask over the nose due to inadequate cognitive ability. Even if the child permits mask placement; it may only be for a few minutes. Forceful mask placement can increase anxiety.
- Extremely anxious and fearful children who are crying uncontrollably: If a child is unwilling to enter the dental clinic, he/she may not be a good candidate for nitrous oxide. Explaining the procedure of nitrous oxide sedation is usually unsuccessful in children, who do not even respond to audiovisual distraction.
- Children who are unable to communicate: Children with certain systemic disorders or mental delays may be unable to communicate and respond well to verbal commands during sedation making it difficult to determine the level of sedation. Children, who don't understand or speak the language used by the dentist, can face issues with comprehension.
- Child wants to get treatment done using nitrous oxide: Children can demand the use of nitrous oxide for each appointment once they are exposed to it in the first appointment due to its euphoric property.
- Children with behavioral issues: The introduction of the nitrous oxide delivery hood is difficult in defiant, stubborn or hysterical children.
- Child suffering from multiple sclerosis: Nitrous oxide administration can cause neuropathies or worsen the existing symptoms in children with multiple sclerosis.

- Recent eye surgery
- Latex allergy

Local contraindications

- Surgery involving the anterior surface of maxilla: The nasal mask in nitrous oxide sedation rests on the upper lip throughout the procedure, making upper lip retraction difficult for access during surgical procedures in the anterior maxilla, like extraction of an impacted tooth or removal of cysts and odontomes.
- Mouth breather: A child can be a mouth breather due to obstructions like deviated nasal septum, nasal polyps or enlarged adenoids. The obstructions can hamper nasal breathing making the use of nitrous oxide ineffective.
- Difficulty in breathing through nose or upper airway infection: Upper airway infections or nasal congestion can temporarily make nasal breathing difficult leading to ineffectiveness of inhalational nitrous oxide.

Advantages of nitrous oxide sedation

- Fast onset and recovery make nitrous oxide effective and safe in children.
- Ease of administration: Nitrous oxide is easy to administer if a child easily accepts the nasal delivery hood. A child can accept the nasal mask with ease if he/she uses a nebulization mask comfortably at home.
- Adjustment of depth of sedation based on clinical response: This property is very beneficial for maintenance of sedation in children in a non-hospital setting as the drug concentration can be titrated easily as per patient response.
- Ability to communicate during procedures: The child can communicate with the dentist and the parents during use of nitrous oxide, due to mild-moderate level of sedation, which has a positive impact on the parents and children.
- Nitrous oxide has a high safety index as compared to other agents.
- No impact on daily duties: The children and their parents can resume their daily activities soon after the procedure.

Pitfalls and complications

- Poor acceptance of the nasal mask in highly anxious children or in children of pre-cooperative age.
- Relative weak potency of nitrous oxide/oxygen due to its associated bio-variability.
- Associated with nausea or vomiting, especially in children with motion sickness or those, who consume fatty food before the appointment.
- Nitrous oxide has no role in post-treatment pain. Also, it is not an alternative to local anesthesia.
- Dependence on psychological assurance.

- Children with behavioral problems may become uncomfortable, because they are unable to comprehend the subjective symptoms like light-headedness or tingling sensation.
- Occupational hazard for the dental personnel: Chronic exposure of nitrous oxide can pose some health risk for the dentist and allied staff.
- Cost of equipment: Nitrous oxide sedation requires specialized equipment like flowmeters. Recurring need of nitrous oxide and oxygen cylinders, their obtainment and transportation from medical gas suppliers may be difficult.

Further reading

1. Gupta K, Emmanouil D, Sethi A (eds) (2020) Nitrous oxide in pediatric dentistry: a clinical handbook. Rationale for using nitrous oxide in pediatric dentistry. https://doi.org/10.1007/978-3-030-29618-6_1
2. Maren S, Holmes A (2016) Stress and fear extinction. Neuropsychopharmacology 41(1):58–79
3. Shim YS, Kim AH, Jeon EY, An SY (2015) Dental fear & anxiety and dental pain in children and adolescents; a systemic review. J Dent Anesth Pain Med 15(2):53–61
4. Cianetti S, Lombardo G, Lupatelli E, Pagano S, Abraha I, Montedori A et al (2017) Dental fear/anxiety among children and adolescents. A systematic review. Eur J Paediatr Dent 18(2):121–130
5. Behavior guidance for the pediatric dental patient. Reference Manual V 40: 6 2018–19 American Academy of Pediatric Dentistry. http://www.aapd.org/media/Policies_Guidelines/BP_BehavGuide.pdf. Accessed 8 Feb 2019
6. Emmanouil D, Kupietzky A (2014) Nitrous oxide/oxygen inhalation sedation in children. Behavior management in dentistry for children. 2nd ed. Philadelphia: W.B. Saunders Co. p. 145–58
7. Ulrich K (2015) N2O/O2 sedation in pediatric dentistry. Pocket Dent 426
8. Armfield JM, Heaton LJ (2013) Management of fear and anxiety in the dental clinic: a review. Aust Dent J 58(4):407 (**quiz 531**)
9. Tsao JC, Lu Q, Kim SC, Zeltzer LK (2006) Relationships among anxious symptomatology, anxiety sensitivity and laboratory pain responsivity in children. Cogn Behav Ther 35(4):207–215
10. Loeppky WP, Milnes AR (2007) When is it appropriate to use nitrous oxide and oxygen inhalation for children? J Can Dent Assoc 73(6):495–495a
11. Hosey MT (2002) Managing anxious children: the use of conscious sedation in paediatric dentistry. Int J Paediatr Dent 12(5):359–372
12. Wald C (1983) Nitrous oxide—are there any real contraindications? Quintessence Int Dent Dig 14(2):213–218