

Comparative Evaluation of Changes in Physiological and Psychomotor Effects in Pediatric Patients during Extraction under Different Concentrations of Nitrous Oxide–Oxygen Inhalation Sedation

Abstract

Introduction: Nonpharmacological behavioral management techniques are routinely used to create an environment that facilitates and builds a rapport between the child and the dentist to carry out procedures with minimal disruption. However, the discomfort associated with oral injections produces varying degrees of stress in all patients. Nitrous oxide (N₂O)–oxygen (O₂) inhalation sedation is one of the most widely used modalities for the management of fear and anxiety in children. **Objective:** The objective was to evaluate changes in physiological and psychomotor effects in pediatric patients during extraction under different concentrations of N₂O–O₂ inhalation sedation. **Materials and Methods:** A total of 300 healthy patients in the age range of 6–12 years (mean 8.9 years), who needed extraction of primary tooth, were included in the study. Pulse rate, SpO₂, blood pressure (BP), and temperature were recorded at baseline, 30% N₂O concentration, 50% N₂O concentration, and again postoperatively. In addition, anxiety levels and neuromuscular coordination were recorded at the respective intervals. **Results:** The results revealed a mean decrease in pulse rate and BP from baseline and an increase in temperature and O₂ saturation during the sedation procedure. The findings were statistically significant. Significant impairment of coordination and psychomotor ability was seen at each step. Anxiety had significantly reduced after the onset of sedation due to the anxiolytic effect of N₂O. **Conclusion:** N₂O–O₂ inhalation sedation under different concentrations reduces the anxiety of the patient and produces adequate sedation with vital signs within normal limits along with temporary impairment of psychomotor ability and coordination.

Keywords: FLACC scale, N₂O–O₂ inhalation sedation, Trieger test, Wong–Baker Faces rating scale

Introduction

Nitrous oxide–oxygen (N₂O–O₂) inhalation sedation has been recognized as a safe and effective technique to reduce anxiety, produce analgesia, and enhance effective communication between a patient and a health-care provider.^[1] It has gained reputation as the most popular mode of sedation over other modalities. N₂O is a nonirritating, colorless, inert gas with a faint sweet smell and odor. It is an effective analgesic/anxiolytic agent which causes central nervous system depression and euphoria with little effect on the respiratory system.^[1–3]

Analgesia produced by 20% N₂O is almost equivalent to 15 mg of morphine intravenously. Its unique properties such as rapid onset, faster recovery, minimal adverse effects, ease of administration, wide

margin of safety, analgesic and anxiolytic effects, and rapid reversibility make it an ideal drug for use in children.^[3]

The physical characteristics of N₂O regarding its uptake, distribution, and elimination from the body are well known. However, the interactions between these physical constants and the effects of N₂O–O₂ inhalation on psychomotor function of patients who are awake have been less researched.^[4]

Subjective evaluations of efficacy of N₂O in dentistry have been widely researched, but the objective evaluations of psychomotor effects have been less commonly reported. Few investigators have used clinically adaptable objective and quantitative measures of modalities pertinent to patient recovery from dental anesthesia. For this reason, psychomotor functions were chosen as the measure of N₂O-induced effects;

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visual motor coordination was the particular modality of interest.^[4]

Thus, the purpose of this study was to evaluate and compare the changes in physiological and psychomotor effects on pediatric patients during extraction under different concentrations of N₂O–O₂ inhalation sedation.

Materials and Methods

This study was carried out in the Department of Pediatric and Preventive Dentistry, ITS Dental College and Hospital, from March 2019 to September 2019. Ethical clearance was obtained from the Institutional Ethical Committee prior to the commencement of study.

A total of 300 children of both the sexes, between the ages of 6 and 12 years, with a treatment plan of extraction of primary teeth were selected for the study. Children categorized under American Society of Anesthesiologists physical Status I and II with binocular vision and Frankl behavior rating scale of 3 and 4 were included in the study. Those who presented with clinical conditions contraindicating the use of N₂O–O₂ or having known allergy to lignocaine were excluded from the study.

The parents/guardians of the children were given a complete verbal explanation about the procedure, advantages and need of use, safety, and possible side effects of N₂O–O₂ inhalation sedation. A written consent for inhalation sedation from the guardian and an assent from the participant of the study were obtained. American Academy of Pediatric Dentistry (AAPD) fasting guidelines were explained to the guardian and given in written format as well.

The armamentarium comprised of a continuous flow type of inhalation sedation unit Matrix Quantiflex MDM (Matrix Medical Inc. Parker Hannifin corporation, 245 Township Line Road, Hatfield, USA); an automated cardiac monitor to continuously assess the pulse rate, O₂ saturation, and blood pressure (BP); a thermometer to record the temperature; Wong–Baker Faces Pain Rating Scale; FLACC scale for the assessment of anxiety; Trieger's drawing test for the assessment of neuromuscular coordination; and appropriate armamentarium for extraction.

The patients were made to lie on the dental chair in a comfortable semi-recline position. The baseline physiological signs such as pulse rate, O₂ saturation, BP, respiratory rate, oral temperature, and anxiety were recorded. Trieger's drawing test was performed to determine baseline psychomotor ability and neuromuscular coordination.

Patients were preoxygenated with 100% O₂ for 2–3 min, and the flow rate was determined. N₂O was then administered in increments of 10%, and signs of sedation level were monitored. Not more than 50% N₂O was administered to any patient.

The physiological vital signs and anxiety were again assessed at 30% N₂O and 50% N₂O levels. In addition, Trieger's drawing test was performed at these two concentrations of N₂O.

Once the child achieved appropriate anxiolysis, local anesthesia was administered and extraction was carried out with minimal pain perception. 100% O₂ was administered for 5 min before discharging the patient. Postoperative vital signs and anxiety were assessed with similar measures, and a postoperative drawing was taken.

Test scoring criteria

The Trieger modification of the Bender Motor Gestalt test (BGT) was used to evaluate the perceptual motor ability.

The Trieger modification of the BGT is scored by counting the dots missed by the pencil line and deviations of the pencil line from a straight smooth line. Score 1 is given for each missed dot. Score 2 is given for deviation of lines from straight.^[4,5]

Statistical analysis

The data obtained were compiled systematically and analyzed using Statistical Package for Social Sciences for Windows (SPSS Inc., Chicago, IL, USA, 2011).

Freidman's test was used to compare the mean between baseline, 30% N₂O concentration, 50% N₂O concentration, and postoperatively. Wilcoxon signed-rank test was used for inter-interval comparison, and the results were tabulated. The level of statistical significance was set at $P \leq 0.05$.

Results

Data were collected from 300 patients with a median age range of 8.9 years. The baseline demographics and clinical characteristics are shown in Table 1. The mean values of vital signs (pulse rate, BP, O₂ saturation, and temperature), at baseline and at different N₂O–O₂ concentrations, are depicted in Graph 1.

Table 2 depicts the inter-interval comparison of vital signs, anxiety scores, and drawing tests. The values of all the physiologic parameters (pulse rate, BP, O₂ saturation, and temperature) were within the normal clinical range throughout the sedation period. There was a statistically significant difference from baseline to 30% N₂O–O₂, baseline to 50% N₂O sedation, and

Table 1: Demographics and clinical characteristics

	Total	Male	Female
Total number of children	300	162	138
Mean age (years)	8.9	9.3	8.5
Teeth involved			
Maxillary teeth	127	79	54
Mandibular teeth	173	83	84

Table 2: Inter-interval comparison of vital signs, anxiety scores, and drawing test scores

Parameters	Mean difference					
	Baseline–30% N ₂ O	Baseline–50% N ₂ O	Baseline–postoperatively	30% N ₂ O–50% N ₂ O	30% N ₂ O–postoperatively	50% N ₂ O–postoperatively
Pulse rate						
Mean difference	4.58	10.18	7.22	5.60	2.64	–2.96
P	<0.001*	<0.001*	<0.001*	<0.001*	0.308	0.046*
Systolic BP						
Mean difference	6.52	8.42	4.58	1.90	–1.94	–3.84
P	<0.001*	<0.001*	0.006*	0.042*	0.217	<0.001*
Diastolic BP						
Mean difference	2.54	2.20	2.08	–0.34	–0.46	–0.12
P	0.016*	0.009*	0.069	0.244	0.911	0.778
Oxygen saturation						
Mean difference	–1.34	–1.54	–1.26	–0.20	0.08	0.28
P	<0.001*	<0.001*	<0.001*	0.293	1.000	0.029*
Temperature						
Mean difference	–0.04	–0.11	–0.17	–0.07	–0.13	–0.06
P	0.785	<0.001*	0.008*	0.014*	0.030*	0.640
Wong baker						
Mean difference	1	1.4	0.8	0.4	–0.1	–0.3
P	<0.001*	<0.001*	<0.483	<0.465	<0.41	<0.425
FLACC						
Mean difference	1.6	3.3	2.69	1.04	–1.07	–0.05
P	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.171
Trieger drawing test score						
Mean difference	–6.2	–8.2	0.6	–2.0	5.6	7.6
P	<0.001*	<0.001*	<0.296	<0.001*	<0.001*	<0.001*

*P value significant. BP: Blood pressure, FLACC: Face, Legs, Activity, Cry, and Consolability

post-operatively ($P \leq 0.05$). The level of discomfort or pain and anxiety was assessed using the FLACC scale and Wong–Baker's scale [Graph 2]. A significant decrease in the levels of anxiety and discomfort was experienced by the children throughout the procedure [Table 2].

The mean values of Trieger drawing test are depicted in Graph 3. The results showed a significant impairment of coordination and psychomotor ability at each step, suggestive of an objective evidence of drug effect after the onset of N₂O sedation. There was an insignificant difference between baseline drawing score and 5 min after 100% O₂ inhalation, i.e. post-operative recovery.

Discussion

N₂O–O₂ inhalation sedation is one of the most common pharmacological means of behavioral modification advocated in children and anxious adults owing to its unique properties such as high efficiency, potency, fast onset, rapid recovery, and least adverse effects.^[6]

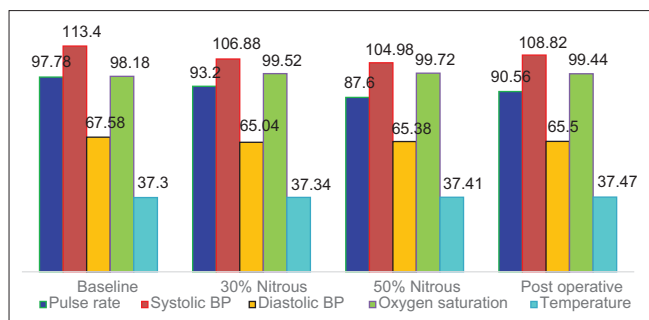
The present study examined the effect of different concentrations of N₂O–O₂ inhalation sedation on the physiological signs, psychological behavioral pattern, and visual motor coordination change experienced by children during extraction of teeth. A total of 300 children above

6 years of age were chosen so that the verbal explanations, instructions, and commands regarding the procedure could be understood by them. For enrollment of the patients, Frankl Behavioral Rating was used for the assessment of child's behavior, which is an efficient scale for relating the predicted behavior of a child with actual behavior during dental procedures.^[7–9]

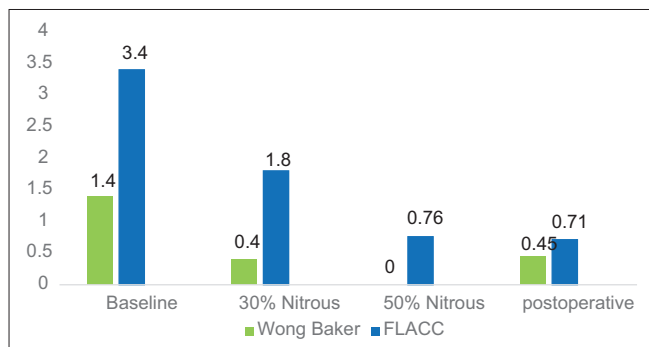
Monitoring of physiological parameters is necessary during sedation procedure. The parameters monitored in this study were pulse rate, O₂ saturation, BP (systolic and diastolic), and temperature.

All these parameters can be easily monitored clinically without any advanced equipment, but the use of an automated cardiac monitor in this study resulted in an additional benefit of quick, prompt, and immediate identification of any changes below normal or eminent hypoxia.^[3,10]

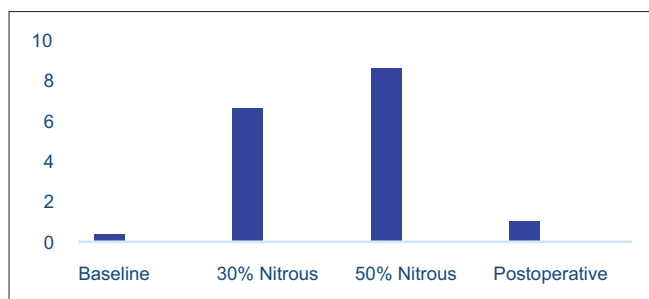
According to the present study, a significant decrease in the pulse rate was observed from baseline to 30% N₂O, baseline to 50% N₂O, postoperatively, and 30% to 50% N₂O concentrations, thus suggesting a decrease in anxiety level and resulting in calm and relaxed state of the child. The decrease in heart rate remained within acceptable limits throughout the procedure. Primosch *et al.* found a significant reduction



Graph 1: Mean value of different parameters at different N₂O concentration



Graph 2: Mean anxiety scores of Wong–Baker and FLACC



Graph 3: Mean Trieger test score

in pulse rate after inhalation of 40% N₂O.^[11] Wilson *et al.* also reported that the pulse rate remained within acceptable limits during extraction with 30% N₂O inhalation sedation.^[12] Trieger *et al.* also showed that with all concentrations of N₂O, there was a decrease in pulse rate, which was dose and time related and persisted well into the recovery period.^[4] However, Niwa *et al.* found that N₂O sedation had no influence on the cardiovascular system.^[13]

BP change during the procedure was quite stable. Both systolic and diastolic BP decreased from baseline to 30% and 50% N₂O levels and it was found to be statistically significant. The findings were in accordance with the study done by Wilson *et al.* who concluded that the mean arterial BP decreased significantly but remained within acceptable clinical limits during extraction.^[12] Trieger *et al.* observed a small increase of 4–5 mmHg in systolic BP following the administration of 50% and 70% N₂O

mixtures for 2 min. The highest (9 mmHg) increment was seen when 25% N₂O mixtures were inhaled.^[4] Saunders *et al.* found 7% of the patients treated with 50% N₂O having hypotension.^[2,14]

SpO₂ was monitored throughout the procedure and postoperatively to detect any signs of early hypoxia, which has been reported as one of the adverse effects of N₂O–O₂ inhalation sedation at high concentrations and rapid increase in increments of N₂O. Automatic pulse oximeter is comparatively more sensitive and more accurate for detecting signs of early hypoxia, so monitoring of all the parameters was done with an automatic monitor to rule out any bias which could have aroused with clinical examination. In the present study, the O₂ saturation was significantly higher at 30% and 50% N₂O levels. These findings were consistent with the results of Kaviani and Birang, who concluded that the mean SpO₂ increased during periodontal surgery under N₂O sedation.^[10] Quarnstrom *et al.* and Jeske *et al.* performed cases under N₂O sedation without giving postoperative O₂ and no hypoxic incidents were reported.^[15,16] Saunders *et al.* and Notini-Gudmarsson *et al.* treated patients with 50% N₂O, and none reported any case of hypoxia or headache.^[14,17] Brodsky *et al.* and Frumin and Edelist found that hypoxia is very rare in healthy patients and not clinically significant if normal ventilation is maintained even with very high levels of N₂O.^[18,19] The results of Khinda *et al.* suggest that diffusion hypoxia does not occur irrespective of the postsedation 100% O₂.^[6]

There was a significant increase in temperature as the level of sedation increased, which decreased postoperatively. This trend in temperature rise can be explained by the fact that N₂O induces thermoregulatory threshold for cutaneous vasoconstriction in humans.^[5]

The Trieger Dot Test is a modified version of Design 4 of the Bender–Gestalt Test designed to measure perceptual motor ability. The original Bender Motor Gestalt test, devised by Lauretta Bender (1938), consists of nine cards, each displaying a geometric figure. The cards are presented individually and the children are asked to copy the design before showing the next card. The scores are based on accuracy and organization of the figures.

In Trieger dot test, instead of requesting the child to reproduce the figure, dots placed at 12–13 mm interval are to be joined.

It is a reliable test which is used for the objective measurement of alteration and impairment in coordination and psychomotor ability after the induction and onset of N₂O sedation. The coordination ability at each stage can be assessed with Trieger drawing test.^[4,20-22]

In the present study, design 3 of Bender–Gestalt Test has been used keeping in mind the age group of the children. Significant impairment of coordination and psychomotor

ability was seen at each step suggestive of an objective evidence of drug effect after the onset of N₂O sedation. There was an insignificant difference between baseline drawing score and 5 min after 100% O₂ inhalation, that is, postoperative recovery.

The subjective and objective measurements of anxiety level were assessed with Wong–Baker’s scale and FLACC scale, respectively. These anxiety scales were observed by an independent observer. The FLACC scale has excellent reliability and validity in assessing pain in children. It comprises of five criteria, each assigned a score of 0, 1, or 2. Each of the five categories (F) face; (L) legs; (A) activity; (C) cry; and (C) consolability is scored from 0 to 2.^[23] With both the criteria, anxiety was significantly reduced after the onset of sedation due to the anxiolytic effect of N₂O, similar to that reported by Takkar *et al.*^[7]

Conclusion

N₂O–O₂ inhalation sedation under different concentrations reduces the anxiety of the patient and produces adequate sedation with vital signs within normal limits along with temporary impairment of psychomotor ability and coordination.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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