ORIGINAL RESEARCH

Assessment of Effectiveness Acceptability Complications and Parental Satisfaction of Pediatric Dental Patients Treated under Nitrous Oxide-oxygen Inhalational Sedation Using Porter Silhouette Mask

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Abstract

Objectives: To estimate the concentration of nitrous oxide (N_2O) required for effective sedation to render dental treatment for an anxious child and to assess the child's behavior, patient acceptance, parental satisfaction, postoperative complications, and ease of manipulation of Porter Silhouette mask by the dentist during N_2O–O_2 sedation.

Study design: A total of 40 children, 6–10-year-old requiring dental treatment, were treated using N_2O sedation. The level of N_2O required for optimal sedation, patient behavior, level of acceptance of N_2O by the patient, clinical recovery score, and postoperative complications were observed throughout the study. At the end of the treatment, a questionnaire was given to the parents to evaluate parental satisfaction.

Results: The sedation was very effective, with 25–50% of N_2O concentration. About 92.5% of children were fully cooperative, the dentist was able to place the mask with comfort in 92.5% of children, significant improvement was seen in the patient's behavior with minimal complications, and 100% of the parents were satisfied with the treatment under sedation.

Conclusion: Inhalational sedation with N_2O using Porter Silhouette mask results in effective sedation, with increased patient comfort, and parental acceptance in providing dental treatment.

Keywords: Children, Nitrous oxide inhalational sedation, Porter Silhouette mask.

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Introduction

Fear, anxiety, and hypersensitivity to pain have been recognized as behavioral management problems in impeding or even recluding quality dental care to young, fearful children.[1,2] Dentists manage these children with various behavioral management techniques like tell-show-do, modeling, distraction, etc. However, some children, due to fear of pain and rejection, due to stress associated with therapeutic procedures, require alternative approaches, such as oral sedation, conscious sedation with N_2O–O_2, or general anesthesia.[3]

Conscious sedation is a drug-induced depression of consciousness during which the patient responds to verbal commands either alone or accompanied by light tactile stimulation.[4] Conscious sedation can be administered through various routes like intravenous, inhalational, and intranasal.

Nitrous oxide (N_2O) is colorless, odorless, and hardly visible gas with a sweet taste. N_2O gas possesses analgesic, anxiolytic, and psycho-sedative properties. Its blood–gas solubility coefficient is 0.47, minimum alveolar concentration is 104% (poorly soluble in the blood), with a rapid onset and recovery period.[5] The duration of the sedation can be controlled, and the dose is titratable throughout the sedation procedure.[6] N_2O is safe and effective in the reduction of anxiety and pain, and the majority of them with no recollection of the therapeutic procedures.[7]

The effectiveness and safety of sedation systems depend on the equipment designs and the operator's skills. Usage of nonscavenged mask designs resulted in the leakage of excess ambient nitrous gas into the surroundings. Occupational exposure to N_2O gas results in the incidence of liver disease, spontaneous abortions, renal lithiasis, and neurological disease. Rowland et al. confirmed reduced fertility

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with occupational exposure to nonscavenged delivery of N_2O gas for 5 or more hours a week.[8] In order to reduce these occupational hazards, the American Conference of Governmental Industrial Hygienists (1989) (N_2O threshold limit value of 50 ppm for an 8-hour exposure) and the National Institute for Occupational Safety and Health (1994) (stated that "occupational exposure to N_2O, when used as the sole anesthetic agent, shall be controlled so that no worker is exposed at time-weighted average concentrations >25 ppm during anesthetic administration) have established appropriate levels of occupational exposure to N_2O.[9] The vacuum flow rate for the scavenging mask should be 45 ppm when administering a mixture of N_2O and O_2 to the patient.[10]

The conventional scavenged masks were bigger in size, with improper fit leading to gas leakage, and also inaccessible in the upper anterior region. The scavenged mask designs reduce the ambient N_2O exposure, and the newly introduced silhouette nasal mask is claimed to eliminate all the drawbacks of conventional masks for sedation to be effective. Porter Silhouette nasal mask is a new low profile nasal mask with a breathing circuit designed with clear, thick, transparent, and lightweight tubing and a comfortable, conforming mask

The goal of the present study was to estimate the concentration of N_2O required for effective sedation to render dental treatment for an anxious child and to assess the child's behavior, patient acceptance, parental satisfaction, postoperative complications, and ease of manipulation of Porter Silhouette mask by the dentist during N_2O–O_2 sedation, and also see the correlation between the outcome and sedation related variables.

Materials and Methods

An observational investigation was performed by the Department of Pedodontics and Preventive Dentistry, Ragas Dental College and Hospital, Chennai, Tamil Nadu, India. The study design was approved by the Institutional Review Board of Ragas Dental College and Hospital, Chennai, Tamil Nadu, India.

A sample of 40 potentially cooperative 6–10 years age-group children indicated to be treated under sedation requiring scaling, extraction, restoration, pulp therapy, crowns, and other minor surgical procedures were included in the study (Fig. 1). Subjects were allocated to treatment under conscious sedation on the basis of information contained in referral letters, past medical history, and dental history, as well as from the clinical evaluation by an experienced clinician. The decision to treat children under sedation was based on the recommended indications from Hallonsten et al.[11] Children with obstructed nasal airways, systemic illness, medically compromised, and below 5 years with minimal communication skills were excluded from the study. Parents/guardians of the subjects were explained about the procedure, need, safety, and side effects of N_2O–O_2 inhalation sedation, including other options prior to the procedure and written consent was obtained. Treatment procedures were carried out under sedation following the sedation guidelines.



Fig. 1: Patient under sedation

Preoperative instructions were given to the patients and parents of selected patients. Patients were asked not to eat for at least 2 hours before the treatment procedure was done under conscious sedation. Before the start of the procedure, patients were enquired about the follow-up of food restriction instructions.

The N_2O–O_2 sedation machines (Quantiflex MDM ANALOGUE relative analgesia machine, Matrix Medical Inc. Orchard Park, New York, USA) and Porter Silhouette nasal mask was used to deliver N_2O. Patients were made to sit in the dental chair. The appropriate size mask was selected from the available sizes and adapted at close proximity to the nose by the operator. Patients were instructed to breathe only through the nose throughout the procedure. A pulse oximeter was placed in the patient's right index finger to monitor the pulse rate and O_2 saturation level throughout the procedure.

Induction Procedure

At the start, 100% O_2 was delivered *via* the silhouette mask for 2–5 minutes, and then N_2O–O_2 concentration was slowly increased up to the maximum desired level of each patient was achieved (patient should be quiet and nearly motionless but able to understand and respond to verbal commands). This was then followed by the dental procedure with or without local anesthesia (LA). During the procedure, the patients were reminded to breathe through the nose in order for the gas to work effectively. At the end of the treatment 100% O_2 was administered for about 3–5 minutes. Gas flow rate was manually adjusted to match the patient's tidal volume. The entire treatment procedure was done under the guidance of a certified anesthetist, and O_2 saturation was monitored with the pulse oximeter.

Parameters evaluated

The amount of N_2O–O_2 gas administered throughout the length of the treatment procedure, recovery time, and the treatment done were noted.

The behavior of the patient during the treatment session was recorded using a French modified Venham Scale at five different periods during the session.[12]

- Ti: First contact with the dentist, whether in the waiting room or in the surgery.
- T0: On placement of the mask over the nose.
- T1: At least 3 minutes after the start of the sedation but before starting any treatment.
- T2: During the administration of LA.
- T3: During dental treatment.

Acceptance was assessed clinically using the level of acceptance to the American Society of Anesthesiologists classification by the operative dentist.[13] It was judged successfully by the clinician if the planned procedure could be completed without any reported or observed problems. Patients who refused to commence the surgical part of the treatment after induction of sedation were classified as nonacceptance.

Dentist comfort while placing the mask during the treatment procedure was recorded as, (1) easy to place, (2) placed with certain difficulty, and (3) unable to place.

The clinical recovery of the patient, that is, the patient's physical status and alertness were assessed before the discharge using the Modified Aldrete score.[14]

Recording of Intra and Postoperative Complications

Patients were specifically encouraged to report any unpleasant events like nausea, vomiting, headache, restlessness, oversedation, and hyperventilation (excluding initial hyperventilation) before the discharge and through a follow-up call the next day.

A simple written questionnaire (Fig. 2) was given to the parents following the dental treatment.

The descriptive and inferential statistical data were analyzed using IBM Corporation Statistical Package for the Social Sciences statistics for Windows, version 20.0 (Armonk, New York). Friedman test was used for between group comparisons and Chi-squared test was done to analyze the association. Significance was set at $p \leq 0.05$.

Results

Level of Cooperation with the Mask

A total of 23 (92%) boys and 14 (93.3%) girls showed complete cooperation to wear the mask during the treatment. About two (8%) boys and one (6.7%) girl required minimal intervention and adjustment of the mask during the treatment. There was no significant difference in the level of cooperation between boys and girls during the treatment with the mask in place ($p = 0.610$).

Behavior of the Patient (Table 1)

The behavior of the patient was evaluated from the initial visit till the end of the treatment. The degree of patient cooperation improved from the initial visit (Ti), during the application of the mask (T0), and during each perioperative step (T1, T2, and T3) ($p = 0.000$). The result showed slight bodily movement while administering LA in 13 children, who became calm during the rest of the treatment. All children showed improvement in their behavior and reduction in their anxiety from the initial visit (Ti) to the completion of the treatment (T0) ($p = 0.000$***).

1. Were you adequately informed about the use of sedation techniques in aiding in the treatment of your child

   Yes ☐ No ☐

2. What does your child recall regarding the experience?

   No recall ☐ Vague memory ☐

   Detailed memory ☐

3. Do you think that the technique of sedation was effective in allowing your child to receive the needed dental care with minimal psychological trauma?

   Yes ☐ No ☐

4. Would you permit your child to be treated again with this method?

   Yes ☐ No ☐

Fig. 2: Questionnaire

Ease of Placement of the Mask

A total of 37 (92.5%) dentists were able to place the mask easily on 37 children, while three (7.5%) required intervention during the treatment session. There was no significant difference in the ease of placement of masks between boys and girls ($p = 0.610$).

N_2O Concentration vs Recovery Time (Table 2)

The N_2O concentration required during the treatment ranged from 25 to 70%, and recovery time varied from immediate to 5 minutes. There was a significant increase in recovery time with the increase in N_2O concentration ($p = 0.001$).

N_2O Concentration vs Complication (Table 3)

Nitrous oxide (N_2O) concentration ranged from 25 to 70% with a minimal rate of complication like nausea, vomiting, headache, and mild ambulatory difficulties. There was no significant correlation between the concentration of N_2O and the occurrence of complications ($p = 0.397$).

Exposure Time vs Complication (Table 4)

Exposure time ranged from 10 to 45 minutes with minimal complications. There was no significant correlation between the N_2O exposure time and the occurrence of complications ($p = 0.966$).

Exposure Time vs Recovery Time (Table 5)

Exposure time ranged from 10 to 45 minutes, with recovery time varying from immediate to 5 minutes. There was a significant increase in recovery time with the increase in time of exposure of N_2O and O_2 ($p = 0.044$*).

Questionnaire Evaluation

All parents were given complete information regarding treating their child under N_2O sedation. Out of 40 children, two (5%) children had detailed memory of the treatment procedure done, 13 (32.5%) had a vague memory of the treatment procedure done, and 25 (62.5%) had no recollection regarding the treatment procedure done. All parents were satisfied with the treatment and felt the sedation technique was useful and effective in rendering treatment for their child with minimal psychological trauma. During the next visit, parents were ready to recommend their child and their peer groups to get treated under N_2O sedation.

Discussion

The 6–10-year-old children were included in the study as there will be an improvement in cognitive development as the age advances. Weinstein et al., in their study, noted that children under 6 years of age did not respond to inhalational sedation.[15]

The mask was comfortable and 92.5% of the children were fully cooperative to wear the mask during the entire treatment session; 7.5% of children required minimal intervention and adjustment during the procedure. Apprehensive children and those who required procedural adjustment with the gas concentration required intervention and adjustment during the treatment. No significant difference was seen between boys' and girls' responses.

The dentist was able to place the mask with more comfort in the majority of the children. In three children who were very apprehensive required extra counseling and explanation before the placement of the mask. No significant difference was seen between boys and girls.

Table 1: Behavior of the patient using Modified Venham Scale

Behavior rating	*Score 0*	*Score 1*	*Score 2*	*Score 3*	*Score 4*	*Score 5*	
Ti	13 (32.5%)	21 (52.5%)	6 (15%)				Ti vs T0 = 0.000***
T0	37 (92.5%)		3 (7.5%)				Ti vs T1 = 0.083 (NS)
T1	39 (97.5%)	1 (2.5%)					T1 vs T2 = 0.000***
T2	27 (67.5%)	13 (32.5%)					T2 vs T3 = 0.000***
T3	40 (100%)						Wilcoxon signed-rank test

NS, not significant; *** $p < 0.001$

Table 2: Comparison between N_2O concentration and recovery time

		Recovery time			
Concentration	*Total*	*Immediate*	*1 minute*	*2 minutes*	*5 minutes*
25%	1	1 (100%)			
30%	13	11 (84.7%)	2 (15.3%)		
40%	19	5 (26.3%)	12 (57.9%)	2 (15.8%)	
50%	5		3 (60%)	2 (40%)	
60%	1			1 (100%)	
70%	1				1 (100%)

Table 3: Comparison between N_2O concentration and complication

Concentration	*Total*	*No complication*	*Ambulatory difficulties*	*Nausea and vomiting*	*Headache*
25%	1		1 (100%)		
30%	13	13 (100%)			
40%	19	16 (84.2%)	2 (10.6%)		1 (5.2%)
50%	5	2 (40%)	2 (40%)	1 (20%)	
60%	1	1 (100%)	0		
70%	1	1 (100%)			

Table 4: Comparison between exposure time and complication

Exposure time	*Total*	*No complication*	*Ambulatory difficulties*	*Nausea and vomiting*	*Headache*
10 minutes	7	6 (85.7%)	1 (14.3%)		
15 minutes	9	6 (66.7%)	2 (22.2%)		1 (11.1%)
20 minutes	10	8 (80%)	1 (10%)	1 (10%)	
30 minutes	8	7 (87.5%)	1 (12.5%)		
40 minutes	2	2 (100%)			
45 minutes	4	3 (75%)	1 (25%)		

Table 5: Comparison between exposure time and recovery time

		Recovery time			
Exposure time	*Total*	*Immediate*	*1 minute*	*2 minutes*	*5 minutes*
10 minutes	7	4 (57.3%)	2 (28.5%)	1 (14.2%)	
15 minutes	9	6 (66.7%)	3 (33.3%)		
20 minutes	10	2 (20%)	6 (60%)	2 (20%)	
30 minutes	8	3 (37.5)%	5 (50%)	1 (12.5%)	
40 minutes	2		1 (50%)	1 (50%)	
45 minutes	4	1 (25%)	1 (25%)	1 (25%)	1 (25%)

In this present study, the behavior was validated using the Modified Venham Scale rather than the child's anxiety, as the child will be in a semiconscious state during the treatment procedures to record the appropriate response for reliable anxiety levels using the anxiety scale.

The behavior of the child was assessed using the Modified Venham Scale, the degree of patient cooperation improved from the initial visit, during the application of the mask (T0), and each perioperative step (T1, T2, and T3). The mean Venham scores improved between the time patients came for the treatment (Ti) and the time the mask was placed (T0). Slight alterations were seen in the child's behavior like mild bodily movement while administering LA in 13 children, who became calm during the rest of the treatment showing the effective action of the mixture gas to reduce the anxiety of the patient. On evaluating the overall outcome, all children showed improvement in their behavior and reduction in their anxiety from the initial visit to the completion of the treatment. Similar results were observed in a study done by Galeotti et al., who showed improved behavior at the end of induction, and it slightly decreased during the administration of LA and during dental treatment, and by Collado et al. showed a degree of cooperation improved between initial induction and each perioperative procedures.[13,16]

The N_2O concentration required during the treatment ranged from 25 to 70%, and recovery time ranged from immediate to 5 minutes based on the treatment procedures. It was observed that when the concentration of N_2O increased, the recovery time also increased. The majority of the studies also show recovery time within 3–5 minutes.[17,18] Trieger et al. concluded that psychomotor recovery occurs within 3–5 minutes after cessation of N_2O administered at various concentrations.[19] Contradicting our study, Korttila et al. state that the total recovery after inhalation is not instantaneous, and our patients need supervision for nearly 20–30 minutes after cessation of the gas.[17]

The N_2O exposure time ranged between 10 and 45 minutes, with recovery time ranging between immediate and 5 minutes. It was observed that when the time of exposure to N_2O gas was increased, the recovery time increased simultaneously but not more than 5 minutes. Ayer et al. reported immediate posttreatment recovery with 25 minutes of exposure to the sedation gas. A majority (82.5%) of cases in our present study showed recovery within 1 minute; this might be due to reduced leakage and effective gas delivery through the nasal mask.[20]

There was no correlation observed either with the N_2O concentration or with the time of exposure to the occurrence of complications. A study done by Conry et al. observed that N_2O sedation is free from major postrecovery side effects, even after extended exposure.[21] In the present study, nausea and vomiting (2.5%) were seen in one patient with 50% concentration and 20 minutes exposure, four patients (10%) had mild ambulatory difficulties with 40 and 50% N_2O concentration with an exposure time ranging from 10 to 45 minutes, and one patient had a headache with 40% concentration with 15 minutes of N_2O exposure. The side effect (vomiting) may be due to improper dietary instruction follow-up. Babl et al. observed 71% of patients undergoing treatment in the emergency department did not meet fasting guidelines and had no episodes of emesis, hence suggesting no association between fasting and emesis.[22] This present study also reports no association between episodes of emesis and fasting except for one child. Jastak et al. in 1975 reported side effects, predominantly like nausea and vomiting in 7.45% of their patients.[23] Mild ambulatory changes may be due to the residual influence of N_2O sedation, and mild headache might be due to the anxiety level of the patient. Complications which have occurred were easily manageable.

One of the favorable characteristics of N_2O sedation is its amnesic effect, which helps in reducing the awareness about the treatment procedure being carried out, and hence renders the dental procedure with minimal distress. The present study shows 62.5% of children with no recollection of memories and 32.5% with a vague recollection of memory, and also, from the patient's point of view, most of the children had no negative recollection regarding the dental experience. The present study results were similar to the study done by Kanagasundaram et al. and elBadrawy et al.[7,24]

Adequate prior information regarding the treatment under sedation was given to parents, and majority were satisfied with effectiveness of sedation with minimal psychological trauma. Parents were also ready to recommend sedation in the future for their children and refer other children to get treated under N_2O sedation. Similar results were shown by Arcari and Ferro in their questionnaire survey.[25]

In this present study, there were a few limitations. Samples were exposed to only one design of the mask. To confirm the study outcomes, larger samples are required with design variations and involving other confounding factors like monitoring scavenging efficiency using a spectrophotometer, carbon dioxide monitoring, checking vital signs, etc.

The study concludes the effectiveness of the N_2O treatment procedure using a silhouette mask in relieving the child's anxiety, improving their behavior with minimal discomfort and side effects to complete the dental treatment procedures successfully, and at the same time, instilling a positive attitude about dental events in the child.

Disclosure

This article is a part of the author's (Dr Santhosh Priya AKR) dissertation titled "Assessment of effectiveness, acceptability, complications, and parental satisfaction of pediatric dental patients treated under N_2O–O_2 inhalational sedation using Porter Silhouette mask" archived in the "The Tamilnadu Dr. M.G.R. Medical University" repository (http://repository-tnmgrmu.ac.in/id/eprint/14503).

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