ORIGINAL RESEARCH

Comparative Assessment of Anxiety during Inferior Alveolar Nerve Block under Nitrous Oxide + Oxygen and Oxygen Inhalation Sedation in Children Aged 3–12 Years: A Randomized Clinical Trial

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Abstract

Aim: A comparative evaluation of children's anxiety with the use of nitrous oxide–oxygen (N_2O–O_2) inhalation sedation during the administration of inferior alveolar nerve block (IANB).

Materials and methodology: A total of 60 children between 3 and 12 years of age, with Frankl's behavior rating of 2–3 requiring IANB for any dental procedure were enrolled in this randomized clinical study. Group I ($n = 30$) received N_2O and oxygen inhalation sedation at a concentration in the range of 25–50%, whereas group II ($n = 30$) received 100% O_2 as a placebo. The physiological parameters like pulse rate, respiration, blood pressure, and O_2 saturation were measured at the baseline, intraoperatively [during and after administration of local anesthesia (LA)] and postoperatively after the termination of the gases in both groups. The sedation level was measured intraoperatively (before administration of LA) using the Ramsay Sedation Score (RSS). The discomfort and anxiety were measured at the baseline, intraoperatively, and postoperatively using the Face, Legs, Activity, Cry, Consolability (FLACC) behavior scale. The data were evaluated using the statistical software International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS) statistics 20.0.

Results: There was a significant difference in the FLACC scores between the two groups, intraoperatively (*p*-value—0.002), and postoperatively (*p*-value—0.049). The mean of the RSS for group I was 2.80 + 1.03, and for group II was 1.80 + 0.81. All the physiological parameters recorded were within the normal range.

Conclusion: The use of N_2O–O_2 inhalation improved the anxiety levels in children while receiving the IANB and showed significant anxiolytic and sedative effects as compared to O_2 inhalation.

Clinical significance: Nitrous oxide–oxygen (N_2O–O_2) inhalation can be used as a nonpharmacological behavior management adjunct for invasive treatments for children with utmost comfort for the child.

Keywords: Anxious children, Inferior alveolar nerve block, Inhalation sedation, Nitrous oxide, Nitrous oxide–oxygen.

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Introduction

Today, dental treatment is easily accessible to most part of the population, yet the fear of pain and rejection in stressful situations makes it difficult to provide quality dental care.[1] Dental fear and dental anxiety are often considered two sides of the same coin. Dental anxiety has clearly been shown to be associated with avoidance of regular dental care.[2,3] Anxious children require approximately 20% more chair time than less anxious children,[4] leading to management difficulties affecting the efficiency of treatment by more frequent interruptions, which may cause the treatment time to prolong.[5] Children often show a negative response to the use of injection for LA. Inadequate LA has been reported in approximately 12% of all pediatric dental patients, increasing the need for supplemental analgesia and alteration of the anxiety response.[6]

To overcome the obstacles related to dental fear and anxiety, nonpharmacological behavior management techniques are frequently utilized and are sufficient to gain a child's confidence and permit the dentist to perform the procedures. However, it is difficult to attain the same in very fearful or anxious children, thus warranting the need for pharmacological behavior management techniques,

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such as conscious sedation, which has proved to be a valuable tool by practitioners.[7] Averley et al.,[8] stated that conscious sedation is a safer alternative to general anesthesia wherever possible. According to the Council of European Dentists,[9] "the standard sedative technique" in pediatric dentistry at present is N_2O–O_2 inhalation sedation. Unique advantages of nitrous oxide inhalation sedation (NOIS) include rapid onset of action, maintaining the effect of sedation as long as administered, producing analgesia with minimal impairment of any reflexes, and fast postoperative recovery within 5 minutes.[10] The administration of N_2O–O_2 prior to and during LA for dental treatment was a highly accepted and often practiced behavior modification technique for anxious pediatric patients.[11,12]

Owing to the benefits, NOIS was used in the present study with the purpose to focus on the effectiveness and success of N_2O–O_2 inhalation sedation alone on anxious children while using the IANB.

Methodology

A randomized controlled, double-blinded study was conducted in the Department of Paedodontics and Preventive Dentistry in 60 3–12-year-old children visiting the department selected as per the selection criteria. The study had received Institutional Ethical Committee approval (SVIEC/ON/Dent/BNPG15/D15024). Informed and written consent was obtained from the participants and their parents participating in the study.

Inclusion Criteria

- Normal healthy subjects in accordance with the American Society of Anesthesiologists (ASA) physical status classification[13] category 1.
- Children falling under Frankl's behavior rating scale[14] 2–3.
- Those requiring IANB for dental procedures not exceeding 1 hour duration.
- First exposure to NOIS and LA.

Exclusion Criteria

- Parents who were unwilling to give written consent.
- Children with a history of chronic obstructive pulmonary diseases, upper respiratory tract infections, anatomic abnormalities in the airway, presence of tonsillar hypertrophy, or those at increased risk for airway obstruction.
- Any known allergy or hypersensitive reaction to the LA agent being used during the procedure.

Selected children were randomly divided into two groups of 30 each (by chit pick method). Group I (intervention group) received N_2O–O_2 and group II (control group) received 100% O_2.

Blinding was done as follows:

- The subject: The subject handed over the chit to the administrator prior to the procedure. The administrator kept a note of the same separately.
- The observer: The observer was seated in such a way that the digital screen of the flowmeter of the N_2O unit was not in the sight of evaluation.

Details of Examination

The parents of the selected subjects were given a detailed description about the study through the information sheet. Written and informed consent and assent were obtained from the parents and subjects. The parents were instructed to allow only light meals and clear liquids 2 hours prior to the scheduled procedure.

Baseline Recordings

On the day of the procedure, the subject was seated on the chair; the baseline values of the physiological parameters, namely pulse rate, blood pressure, O_2 saturation, and respiration rate, along with the demographic details, such as name, age, gender, and behavior rating were recorded by the observer.

The probe of the pulse oximeter was placed on the left index finger. The cuff to measure the blood pressure was secured on the right arm. The respiratory rate was measured by observation. A nasal hood of the appropriate size was selected by trial and error method. The nasal hood was secured in place and checked for its fit and any leakage. The procedure began with the administration of 100% O_2 for 5 minutes. O_2 was administered to about 5–6 L/minute in every subject to determine the minute, volume, and flow rate of gases. The reservoir bag was monitored carefully, so as to ensure uniform breathing.

Group I

Slow induction technique for the administration of N_2O–O_2 was preferred for the study. After determining the flow rate, the N_2O concentration was increased in increments of 5–10% every 3 minutes until the desired level of sedation was obtained. The participants were administered N_2O at a concentration between 25 and 50%. IANB was administered at this point by the operator using the standard protocol. After ensuring profound anesthesia, the N_2O flow was tapered by reducing 5–10% N_2O every 3 minutes, and 100% O_2 was given for 3–5 minutes to prevent diffusion hypoxia and to allow complete recovery from sedation. The physiological parameters of the subject were monitored at all times.

Group II

Nearly 100% O_2 was administered at an appropriate flow rate as per the subject's tidal volume. The IANB was administrated after 10 minutes of administration of O_2.

Assessment of the Subject

Every subject was monitored preoperatively, intraoperatively (during and after LA administration), and postoperatively for the vitals, behavioral scale, and level of sedation.

The observer scored the participant's response based on the FLACC pain scale at all times (preoperative, intraoperative, and postoperative). The response just before the administration of LA was scored based on RSS to assess the sedation level.

Discharge of the Subject

The subject was discharged after ensuring that all the physiological parameters were well within normal limits and that the subject did not experience any major side effects like nausea, vomiting, or headache.

Statistical Analysis

Chi-square analysis was used to find the significance of study parameters on a categorical scale. Student *t*-tests (two-tailed, paired, and unpaired) were used to find the significance of study parameters on a continuous scale between two groups. Analysis of variance

Table 1: Pulse rates and O_2 saturation within normal physiological limits preoperatively, intraoperatively, and postoperatively

			Pulse rate			*O_2 saturation*		
	Group	*N*	*Mean*	*Standard deviation*	*p-value*	*Mean*	*Standard deviation*	*p-value*
Preoperative	Group I	30	93.43	15.395	0.840	96.557	3.9549	0.611
	Group II	30	94.17	12.418		96.033	3.9713	
During LA	Group I	30	92.27	16.295	0.855	95.083	4.1520	0.526
	Group II	30	91.60	11.312		95.740	3.8197	
After LA	Group I	30	85.23	21.703	0.117	96.233	4.5047	0.495
	Group II	30	92.27	10.716		96.937	3.3363	
Postoperative	Group I	30	89.60	13.713	0.142	97.660	2.4608	0.858
	Group II	30	94.43	11.307		97.553	2.1069	

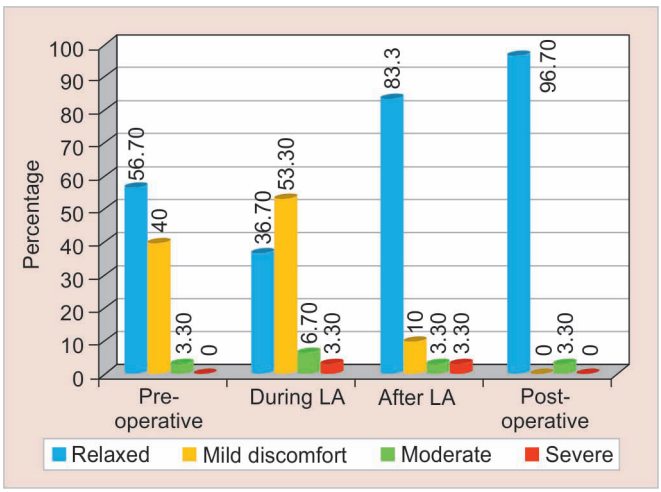

Fig. 1: Intragroup comparison of the FLACC scale score preoperatively, intraoperatively, and postoperatively using a Chi-squared test in group I

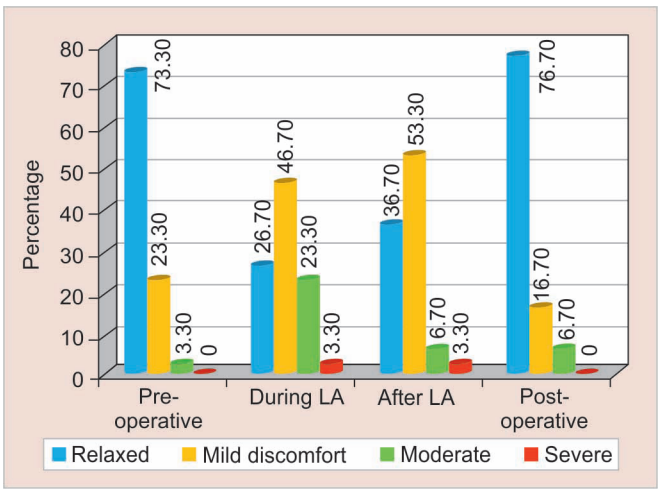

Fig. 2: Intragroup comparison of the FLACC scale score recorded preoperatively, intraoperatively, and postoperatively using a Chi-squared test in group II

(ANOVA) was used to find the significance of study parameters between the groups (intergroup analysis). Further *post hoc* analysis was carried out if the values of the ANOVA test were significant. The statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data, and Microsoft Word and Excel were used to generate graphs, tables, etc..

Results

Of the 60 participants, 34 (56.7%) were male and 26 (43.3%) were female, with a mean age of 8.57 and 7.50, respectively. A total of 31 subjects (51.7%) displayed Frankl Behavior rating of 2, while 29 (48.3%) displayed a rating of 3. Group I had 16 (53.3%) participants with a rating of 2 and 14 (46.7%) with a rating of 3. Group II had an equal number of participants with ratings 2 and 3.

All the participants in both groups displayed pulse rates within normal physiological limits preoperatively, intraoperatively, and postoperatively (Table 1). Group I showed reducing levels of pulse rate from baseline to intraoperatively to postoperatively but was not statistically significant; it had clinical significance as compared to group II. All the participants in both groups displayed O_2 saturation within normal physiological limits. About two of the 30 participants from group I showed O_2 saturation levels below 90% during the administration of LA; however, it regained the normal value soon after the procedure.

All the participants in both groups displayed systolic and diastolic blood pressure readings and respiratory rates within normal physiological limits at all times. A significant difference in group I at different time intervals in the FLACC scale score was observed, as shown in Figure 1. A significant difference can be observed in group II at different time intervals (Fig. 2).

The intergroup comparison of the preoperative FLACC scores of both groups showed no significant difference statistically. The initial discomfort experienced by the participants could be due to the placement of the nasal hood (Fig. 3).

The intergroup comparison of the intraoperative—during LA administration, FLACC scores of both groups showed no significant difference statistically (Fig. 4). The intergroup comparison of the intraoperative—after LA FLACC scores, which displayed a statistically significant difference (p-value 0.002). Around 25 out of 30 (83.3%) participants from group I felt relaxed after LA, as compared to 11 out of 30 (36.7%) participants in group II. The intergroup comparison of the postoperative FLACC scores displayed a statistically significant difference ($p = 0.0049$). A total of 29 out of 30 (96.70%) participants from group I felt relaxed after LA as compared to 23 out of 30 (76.70%) participants in group II (Figs 5 and 6).

Ramsay Sedation Score (RSS) was 2.80 for group I and 1.80 for group II. This difference was statistically highly significant ($p < 0.001$). The mean of RSS scores in group I and group II did not show

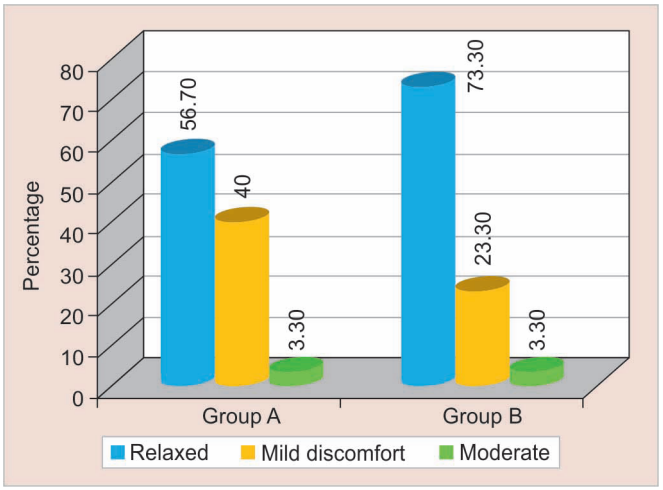

Fig. 3: Intergroup comparison of the FLACC scale score recorded preoperatively using a Chi-squared test

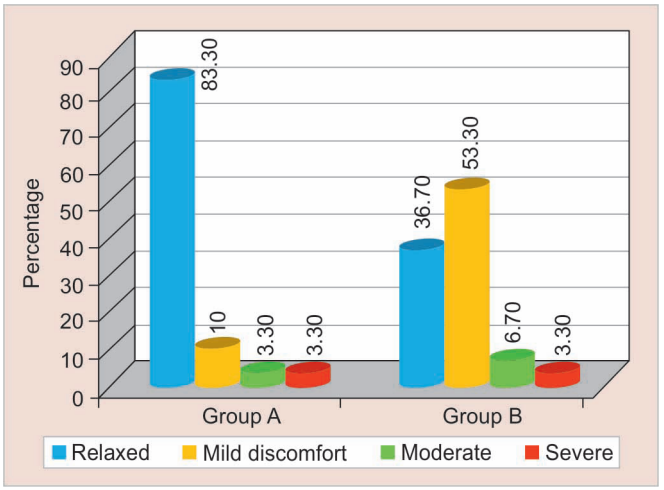

Fig. 5: Intergroup comparison of the FLACC scale score recorded preoperatively after LA administration using a Chi-squared test

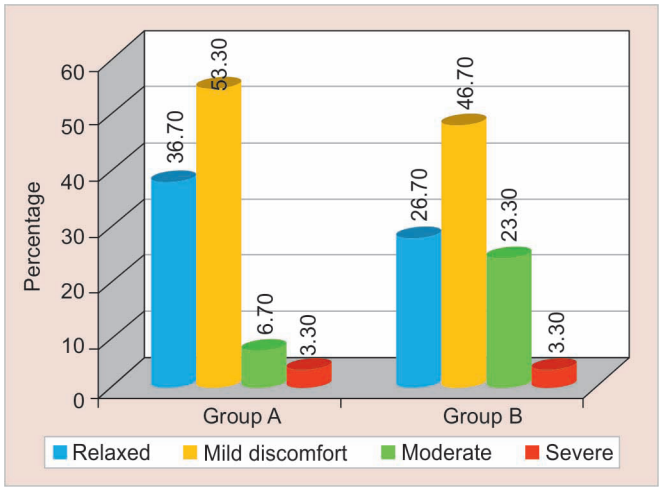

Fig. 4: Intergroup comparison of the FLACC scale score recorded preoperatively during LA administration using a Chi-squared test

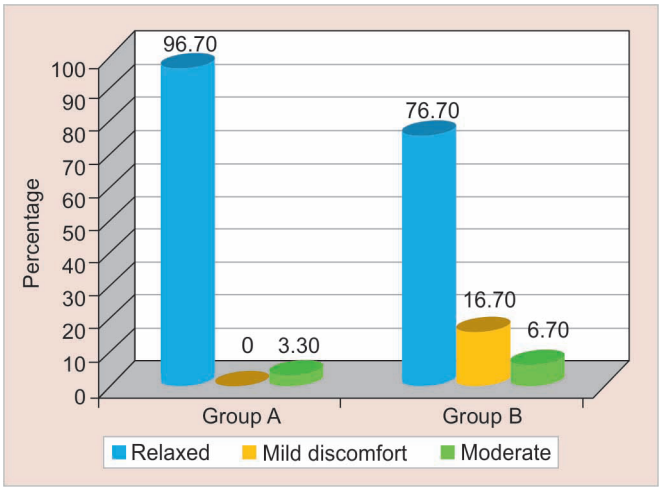

Fig. 6: Intergroup comparison of the FLACC scale score recorded preoperatively and postoperatively using a Chi-squared test

any significant gender predilection. RSS scores between both groups showed highly significant differences among the gender ($p < 0.001$). The gender-wise comparison between each group was calculated by Tukey's *post hoc* analysis.

Discussion

Pharmacological techniques of behavior management can be of great value to pediatric dental practitioners.[15] The goal of sedation is to alleviate fear and anxiety in order to facilitate treatment, and it serves only as an adjunct to behavioral shaping techniques and not a replacement.[16]

The present study included children between 3 and 12 years of age. Literature reviews have advocated the use of NOIS in children who are younger than 4 years can be performed safely but with caution.[17] Luhmann et al.,[18] reported the use of continuous flow N_2O (50%) in 2–6-year-olds for laceration repair, concluding it to be an effective procedural analgesic and sedative. The mean age of the participants in the present study was 8.57 + 3.059 years and 7.50 + 2.921 years in groups I and II, respectively. In relation to the mean age, there was no statistically significant difference between the success and failure of the administration of IANB, which were in contrast with Foley.[19] The results from this data can be interpreted in an encouraging way as the procedure was successfully performed, even in precooperative patients.

Klingberg et al.,[20] stated that dental anxiety is more prevalent in females. However, Zacny and Jun[21] reported that there was no difference in the subjective effects of NOIS at low concentrations among the gender of the participants. In the present study, a gender-wise comparison of the level of sedation was analyzed within both the groups respectively and between the groups. The groups, respectively, displayed no difference in the level of sedation among the gender of the participants, which was similar to the results found in other studies. There was a statistically highly significant difference between the genders of the participants among the two groups, suggesting the effectiveness of the sedative effect of N_2O inhalation ($p < 0.001$).

The American Academy of Pediatric Dentistry (AAPD) guideline[22] recommends only light meal or clear liquids 2 hours prior to the appointment.[23,24] The same was observed in the present study.

Al-Namankany et al.,[4] stated that the difficulty encountered with the use of nasal masks among children, though not reported in literature yet, is indeed observed in routine practice. Hence

with this notion in mind, children with positive and potentially positive behavior were included in the study. Moreover, as per the AAPD guidelines (2013),[20] NOIS is indicated in fearful, anxious, and cooperative children.

The administration of LA by injections is an important consideration for pain control in a pediatric patient. IANB is the most common and painful technique for providing LA of the mandibular posterior teeth. Also, according to the AAPD guideline,[22] one of the disadvantages of NOIS is the interference of the nasal hood with the injection to the anterior maxillary region. Owing to the above mentioned factors, the administration of IANB was preferred over the other methods, such as to standardize the study protocol. The participants who had no previous history or exposure to IANB and NOIS were included in the present study to avoid bias.

Nitrous oxide–oxygen (N_2O–O_2) inhalation sedation can be induced by two different techniques,[10] namely, slow induction or titration and rapid induction. Slow induction or titration is a method of administering a drug in incremental amounts until a desired end point is reached, and this method was used to deliver N_2O to the participants in this study. Samir et al.[23] reported that rapid induction of a preadjusted mix of 30% N_2O and 70% O_2 has the same efficacy as slow induction in achieving optimal sedation in lesser time. However, the titration technique is regarded as the current standard of care when administering N_2O–O_2 for sedation.[10] This technique is considered the safest method with less adverse reactions as the level of sedation of the patient can be monitored at every increment.[19] The slow induction method was used for the present study.

American Society of Anesthesiologist's (ASA)[24] and American Academy of Pediatrics (AAP)[22] stated that a concentration of N_2O below 50% may be accepted as a dose for minimal sedation. According to AAP, there is risk of increased chance of moderate or deep sedation by N_2O concentration >50%.[15,22] Chapman et al.[25] stated that the analgesic effect of 30% N_2O is as effective as 10–15 mg of morphine. Therefore, a concentration of 25–50% of N_2O was maintained for the present study. The mean value of peak % N_2O delivered in this study was 33.50 ± 6.71%.

Matsumura et al.[26] stated that dental treatments are accompanied by patients' hemodynamic changes (for instance, an increase in blood pressure and pulse rate). Samir and Fere[15] stated that during NOIS, consciousness, respiration, and saturation are the three most crucial physiological factors that require regular monitoring. Takkar et al.[7] reported a reduction in the pulse rate from baseline during the administration of NOIS, which, however, was well within the normal physiological range. Young et al.[27] reported pulse oximeter response times of 17–150 seconds in detecting a sudden 10% decrease in O_2 saturation. In the present study, group I showed slight reduction in the pulse rate and blood pressure values, the effects of which were evident clinically, suggesting the anxiolytic effect of NOIS. In group I, the mean value of pulse rate decreased clinically from baseline (mean 93.43), intraoperatively (mean 92.27), and postoperatively (mean 89.60). In group B, the findings remained more or less constant at baseline (mean 94.17), intraoperatively (mean 91.60), and postoperatively (94.43). The observations in group I were clinically significant but not statistically ($p = 0.256$, $p > 0.05$). In this study, the O_2 saturation levels remained well within the normal limits throughout the procedure, that is, at baseline, intraoperatively, and postoperatively. Similar incidences were reported by Samir and Fere[15] and Kaviani and Birang,[28] where the O_2 saturation returned back to normal levels immediately without any intervention determining it as an error in pulse oximeter reading.

The most commonly observed effects of NOIS are fixed or bright eyes, reduced blinking, happy and smiling face, trans-like expression, relaxed hands and legs, aware of surroundings, response to verbal command, tingling, and heaviness in extremities as observed by Bonafé-Monzó et al.[1] and Samir and Fere[15] In the present study, the following effects were reported in participants from group I. However, the participants in group II were only calm and relaxed owing to the placebo effect of the gas.

Perkovic et al.[29] stated the level of dental anxiety is associated with increased intensity of expected pain. The pain perception of children can be a measure of their anxiety. Gronbaek et al.[30] used the visual analog scale score to assess the subject's overall discomfort experienced from the pain tests in their placebo-controlled, double-blinded, crossover trial using N_2O–O_2 as the sedative agent. Subramaniam et al.[31] used the Houpt's behavior rating scale to assess the behavior (sleep, body movement, and crying) of the child during a dental procedure when treated under 40% N_2O, 60% O_2, and triclofos sodium (70 mg/kg body weight). The FLACC pain/behavioral scale was used in this study as it is an effective tool to assess the anxiolytic effect of the gases in both groups. The FLACC scores showed that though children in group I had mild discomfort (53%) during LA administration, it was reduced significantly after LA administration (10%), and postoperatively (0%) ($p < 0.001$). Whereas in group B, the number of children who experienced mild discomfort (46.7%) during LA administration increased after LA administration (53.3%) and postoperatively (16.7%), which was statistically significant ($p < 0.001$). Intergroup comparisons showed statistically significant results after LA administration (p-value 0.002) and postoperatively (p-value 0.049). Similar findings were reported by Takkar et al.[7]

Ramsay Sedation Score (RSS)[32] was used in this study. The mean RSS in group I was 2.80 and that of group II was 1.80. This indicated clinically and statistically significant ($p < 0.001$) level of sedation was achieved in group I, that is, with NOIS. In group I, five out of 30 children displayed RSS below 2, whereas in group II, 13 of 30 children had RSS below 2, which indicated that 43.3% participants remained "anxious and agitated" during the procedure. According to Ramsay et al.,[32] a score below 2 indicated unsatisfactory sedation. None of the participants from either group showed a score of five or more, indicating no incidence of oversedation in any of the participants. The mean RSS in both groups did not show any significant difference in terms of gender-wise comparison. Whereas, the intergroup gender-wise comparison of the mean RSS did reveal significant results ($p < 0.001$). The results confirmed the sedative effect of NOIS to be effective than O_2 inhalation, irrespective of gender.

Samir and Fere[15] used the Richmond Agitation-Sedation Scale to assess the sedation levels in their study. Takkar et al.[7] used the Observer's Assessment of Alertness/Sedation Scale for the same purpose and obtained reliable results.

The main complications related to pediatric conscious sedation are hypoxia, nausea, vomiting, and inadvertent general anesthesia (oversedation). According to Langa,[33] the most undesirable side effect of N_2O–O_2 administration was nausea and vomiting, but the incidence of these conditions was <1%. Sams et al.[34] in a retrospective review of case notes, reported that 48% of children had O_2 desaturation while sedated for dental treatment. Castera et al.[35] demonstrated a higher incidence of headache in patients treated with 50% N_2O. Notini-Gudmarsson et al.[36] gave no reports of headache in 38 patients treated with 50% N_2O. In the present study, one subject from group I reported of headache. No other adverse effects were reported in this study. Diffusion hypoxia theoretically

occurs on termination of N_20 administration. In the present study, no reported incidences of diffusion hypoxia were observed as all participants were administered 100% O_2 for 3–5 minutes to prevent the same and to allow complete recovery from sedation.

Conclusion

The anxious or fearful child can be positively modified with the help of NOIS as it has an anxiolytic and sedative effect on children, even at low concentrations. The overall results of the study displayed improved behavior and decreased anxiety among the children, though mild discomfort was experienced during the administration of IANB but it soon improved after the procedure. This is an important finding and evidence supporting the use of NOIS for children requiring LA.

Limitations and Recommendations

- The study was performed on a smaller sample, the age group wise comparison for the effect of NOIS could not be performed due to the smaller sample size, the standardization of the concentration of N_2O–O_2 was not done, keeping in mind the biologic variabilty of each participant, the NOIS was administered only for the administration of LA and not the entire procedure.[37]
- NOIS was used alone in the present study. The effect of combination techniques using NOIS with other oral sedative agents may be evaluated.
- Owing to the safety and efficacy of NOIS, the use of NOIS in pediatric dental practice should be encouraged on a regular basis.

Based on the design and observations of this study, the following can be postulated:

- Nitrous oxide–oxygen (N_2O–O_2) inhalation does significantly modify the behavior of anxious children as compared to O_2 inhalation alone, thus producing safe and effective minimal sedation in children.
- Physiologic parameters are not significantly influenced by N_2O–O_2 inhalation.
- No adverse reactions were reported with the use of N_2O–O_2 inhalation at a concentration of 25–50%.
- There was no difference in the effect of NOIS among the gender.

Within the limitations of the study, it can be concluded that NOIS proved to be a safe and effective sedative agent when compared to O_2 alone in decreasing anxiety among children during the administration of LA.

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