Acceptance and side effects of nitrous oxide oxygen sedation for oral surgical procedures

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Two-hundred-and-forty-one treatment sessions with nitrous oxide oxygen sedation were performed in 194 patients undergoing ambulatory oral surgery procedures. Removal of mesiodentes and tooth transplants were the most frequent procedures in age groups under 13 years, while removal of impacted teeth was predominant in older age groups. Local anesthesia was used in addition to inhalation sedation in 238 sessions. Median gas volume rate was 10 l/min, median concentration 50% and median duration of procedures 31 min. In 10 sessions (4.1%) sedation was not accepted, while in 25 (10.4%) sessions the procedure could be completed with some difficulty. No potentially dangerous complications were noted. Side effects occurred in 18 sessions in 16 patients. All side effects were minor and easily handled. Logistic regression analysis revealed that failure, defined as poor acceptance and/or presence of side effects, was associated with ASA class 2 and general apprehension, especially based on previous negative experience with medical or dental treatment. Nitrous oxide oxygen sedation is a reliable, efficient and safe adjunct to local anesthesia in both healthy children and adults undergoing ambulatory oral surgery procedures.
☐ *Conscious sedation; dentistry; inhalation administration; local anesthesia*

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Inhalation of nitrous oxide and oxygen is a well-known and documented procedure in providing sedation and analgesia in various fields of adult (1) and pediatric medicine (2, 3) as well as in dentistry (4). General treatment in children has been the most widely used indication for inhalation sedation in dentistry (5); however, increasing use in dental treatment of adults with odontophobia has been reported (6).

Data for acceptance and side effects of nitrous oxide oxygen sedation are derived mainly from sedation of apprehensive children undergoing general treatment and minor dentoalveolar surgery such as uncomplicated extractions. Acceptance rates of 89–93%, and mild side effects such as nausea and vomiting in 5–10% of cases, have been reported (7–9). Serious complications seem rare with nitrous oxide oxygen sedation. Jastak (7) reported 0.66% potentially serious complications.

Oral surgery procedures are believed to produce more pain than general dental treatment, with increased demands for sedation and anesthetic effects. While in general dentistry the analgesic effects of the nitrous oxide gas can be adequate for performing treatment, additional local anesthesia will be needed with oral surgery procedures (10).

Preoperative fear and anxiety are closely related to pain reports (11). Oral surgery patients may therefore experience increased anxiety levels which, along with increased use of local anesthesia and more painful procedures, may lead to poor acceptance and higher rates of complications and side effects of nitrous oxide oxygen sedation. Shaw (9) showed that nitrous oxide oxygen sedation was clinically successful and acceptable by parents and children as well as cost effective, but called for further research into the use of inhalation sedation for surgical problems.

A literature search has yielded few data on the acceptance and side effects of nitrous oxide oxygen sedation in conjunction with ambulatory oral surgery procedures other than simple extractions (7, 9). No data on associations between predictive variables and the acceptance and occurrence of side effects have been found.

The aims of this study were to evaluate the acceptance and side effects of nitrous oxide oxygen sedation in combination with local anesthesia for ambulatory oral surgery procedures, and to identify factors associated with non-acceptance and side effects.

Materials and methods

Patients

One-hundred-and-ninety-four patients between 3 and 46 years of age (mean age 14.5 years; median age 12 years) were selected to undergo oral surgery procedures under conscious sedation with nitrous oxide and oxygen, and local anesthesia. Sex and age distribution is given in Table 1 and Fig. 1.

Patients were allocated to treatment under conscious sedation on the basis of information contained in referral letters, past medical and dental history as well as from clinical evaluation by experienced clinicians. Indications for use of sedation were classified on the basis of information obtained from interviews of the patients or parents. Criteria for classification of indications were

Table 1. Age and sex of 194 patients given nitrous oxide oxygen sedation in conjunction with oral surgery procedures

Age group	*n*	Females	Males
<10 years	57	19	38
10–12 years	57	31	26
13–19 years	35	20	15
>19 years	45	30	15
Total		100	94

Table 2. Indications for use of nitrous oxide oxygen sedation in 194 oral surgery patients

	n	%
Immaturity	85	43.8
General apprehension (anxiety, fear)	66	34.0
Apprehension based on previous negative experience of dental/medical treatment	27	13.9
Fear of needles	16	8.2

adopted from Hallonsten et al. (8) and are given in Table 2. Immaturity was assessed on the basis of chronological age related to the planned surgical procedure and a clinical evaluation of the behavior of the patient. Apprehension, both general and related to previous experience with medical or dental treatment, as well as fear of needles, was grouped according to information from patients on direct questions. Patients' previous experiences with general anesthesia, nitrous oxide oxygen sedation and premedication were recorded. Indications for premedication were based solely on previous positive individual experience with this combination. Preoperative evaluations as well as surgical (Table 3) and sedation procedures were performed by certified oral surgeons in a dental school oral surgery clinic.

Past medical history

Past medical history was unremarkable in 169 (87%) patients; 8 (4.1%) patients indicated present respiratory disease, and 8 patients indicated some form of allergy. Three patients had been treated for cleft lip and palate. Two patients had a cardiovascular condition. Depression,

Table 3. Oral surgical procedures performed on 194 patients under nitrous oxide oxygen sedation

Procedure	*n*	%
Removal of impacted permanent teeth	66	27.4
Removal of mesiodentes	40	16.6
Extraction of permanent teeth	39	16.2
Autotransplantation	38	15.8
Removal of temporary teeth and root fragments	21	8.7
Exposure of impacted crowns	19	7.9
Frenulectomies	7	2.9
Removal of cysts	4	1.7
Periapical surgery	2	0.8
Implant fixture insertion	2	0.8
Dressing change	2	0.8
Removal of tumor (odontom)	1	0.4
Total	241	100

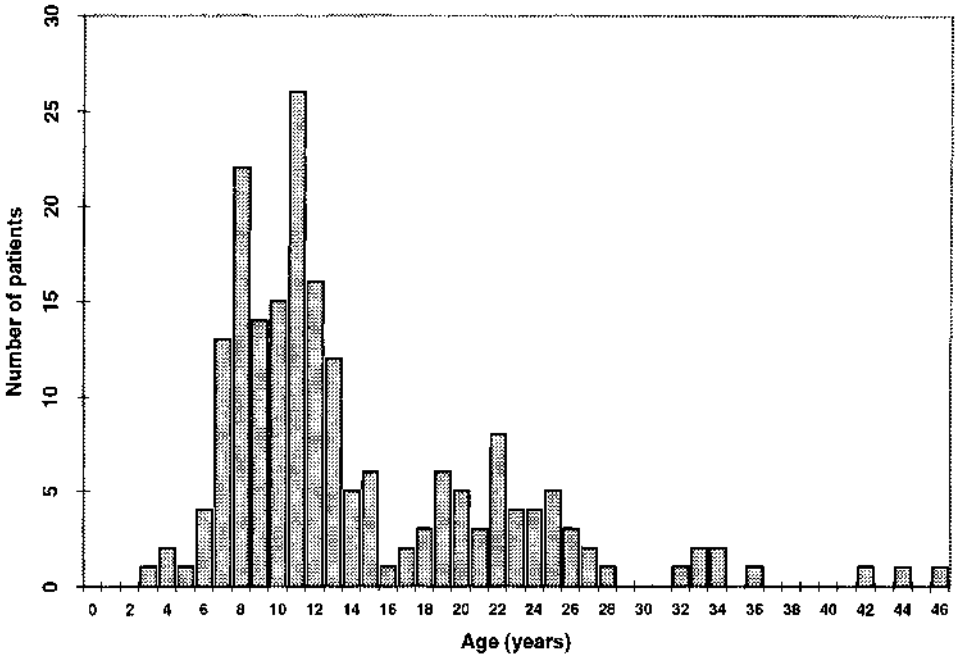

Fig. 1. Age distribution of 194 patients given nitrous oxide oxygen sedation in conjunction with oral surgery procedures.

diabetes, intestinal disease and nocturnal enuresis were indicated by one patient each. No patients with psychiatric disorders or mental retardation were included in the study. Eleven (5.6%) patients met the criteria of the American Society of Anesthesiologists for class 2, due to respiratory and cardiovascular disease and diabetes. The remaining patients were categorized as ASA class 1.

Clinical procedure

A Porter Instruments Company (Hatfield, PA) MXR machine was used to administer the N_2O–O_2 gas mixture. Maximum concentration of nitrous oxide was set at 65%. Patients were given 100% oxygen for 5 min or until a reading of $\geq$99% oxygen saturation was obtained from the Biox 3740 Pulse Oxymeter (Ohmeda, Louisville, CO). Percentage nitrous oxide was increased gradually, starting at 10% according to Hallonsten (8). The maximum percentage nitrous oxide needed was clinically assessed by monitoring the response of patients to verbal command, needle prick of oral mucosa, and report of paresthesia. Gas flow rate was manually adjusted to match the patient's tidal volume.

Once sedated, local anesthesia was administered according to the planned procedure. On completion of the procedure, the patients were given 100% oxygen for 5 min. The patients were observed in the clinic for 30 min after termination of gas administration. Duration of sedation was recorded as time from start to finish of gas administration, including pre- and post-oxygenation.

Assessments

Acceptance was assessed clinically. It was judged successful 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 non-acceptance. For recording of intra- and postoperative side effects, patients were specifically encouraged to report any unpleasant events. Questions on intra- and postoperative problems were asked before discharge. Questions on postoperative problems were repeated at the first follow-up visit after 1 week.

Statistics

The SPSS for Windows (version 7.5.1) statistical software package was used for data management in order to obtain frequencies, cross tabulations and logistic regression analyses. Chi square analysis was used to assess comparison between proportions. In patients who were subjected to more than 1 session, analyses of predictor variables were made from the first session only, to avoid bias from non-independent predictors. Logistic regression analyses were used to assess association between predictor variables and the dependent variable. Grouping of continuous variables was made according to corresponding percentiles. Variables were included in the multiple regression model when showing univariate P values less than 0.2 and if they were strongly suspected a priori of being confounders.

Results

The analyses comprised 241 consecutive treatment sessions in 194 patients. One treatment session was received by 161 (82.6%) patients, 23 (11.8%) patients had 2 sessions, 7 (3.6%) patients 3 sessions, 2 patients 4 sessions, and one patient 5 sessions. Ten (4.1%) treatment sessions were given on an emergency basis, and in 7 (3.6%) sessions, patients had not complied with preoperative diet restrictions.

In 2 follow-up visits for changing wound dressings no local anesthetics or premedication were given. A separate third session in another patient ended up with no local anesthetic administered. This 14-year-old female patient did not experience any sedative effects and refused injection. She was later referred for treatment under general anesthesia.

In 2 treatment sessions, local anesthesia using mepivacaine 30 mg/ml (Carbocain Dental,® "Astra") was used. Another 5 patients were given premedication with oral diazepam 5–10 mg, combined with local anesthesia with lidocaine, while in the remaining 231 sessions only lidocaine 20 mg/ml with 12.5 µg/ml adrenaline (Xylocain-Adrenaline®, "Astra") was used. Judging by uni- and multivariate analyses, neither premedication nor different types of local anesthesia had any effects on the outcome variables.

Mean gas volume rate was 9.5 l/min, median volume rate 10 l/min, range 5–15 l/min. Mean gas concentration was 46.9%, median 50%, range 25–65%. Mean duration of sedation procedures was 33.6 min, median 31 min, range 9–90 min. The short sedation procedures were used with changes of wound dressings.

Distribution of procedures is listed in Table 3. In the age group under 10 years, removal of mesiodentes (28/64) was the most frequent procedure. In the age group 10–12 years autotransplants (27/72) were predominant, while removal of impacted teeth was predominant in the 2 older age groups (14/47 and 44/59).

Overall acceptance

In 10 (4.1%) treatment sessions, 6 females and 4 males (age range 8–24 years) were unable to accept treatment under nitrous oxide oxygen sedation. Three patients were treated under nitrous oxide oxygen sedation and local anesthetics in later sessions. One patient was later treated under local anesthesia only, while 4 were referred for treatment under general anesthesia. The remaining 2 patients failed to attend scheduled follow-up visits. In 25 (10.4%) sessions, treatment could be completed with some

Table 4. Level of acceptance of nitrous oxide oxygen sedation according to ASA* classification in 194 patients undergoing oral surgery procedures

			ASA* 1		ASA* 2	
	n	%	*n*	%	*n*	%
Accept without problems	166	85.6	161	88	5	45
Accept with some difficulty	22	11.3	17	9	5	45
Does not accept treatment	6	3.1	5	3	1	10
Total	194	100	184	100	11	100

* American Society of Anaesthesiologists.

difficulty related to insufficient clinical sedative effect. The remaining 206 (85.5%) treatment sessions were all completed without difficulty.

Healthy patients (ASA class 1) showed better acceptance than ASA class 2 patients ($P < 0.0001$) (Table 4). No associations were found between acceptance levels and patient age, sex, type of procedure or previous experience with general anesthesia or sedation.

Side effects

Side effects occurred in 16 (8.2%) patients. The total number of side effects occurring during the sedation procedures was 12 (5.0%), and after completion of the procedures 6 (2.5%). Distribution of side effects is given in Table 5. Recorded side effects were all minor and easily managed. No potential serious complications nor any case of oversedation was noted.

Increased occurrence of side effects was found with use of less than 10 l/min gas flow ($P = 0.020$) and less than 50% concentration of nitrous oxide ($P = 0.042$). In the latter group of 10 patients, young (9 years or less), immature, ASA 1 patients were slightly overrepresented. A tendency for intraoperative nausea was noted in patients with general apprehension, otherwise no associations between possible explanatory variables (age, sex, ASA classification, previous experience with general anesthesia or sedation, type of procedure, duration of procedure and preoperative food restrictions).

Multivariate analysis

Treatments accepted without difficulties and without side effects were classified as successful, all others as not successful. Logistic regression analysis is presented in Table 6. Patients classified as ASA class 2, and patients with general apprehension and fear based on previous negative experience with medical or dental treatment, showed a significantly increased odds ratio for non-success. A non-significant reduction in odds ratio for patients older than 9 years as well as for patients with previous experience with general anesthesia and nitrous oxide oxygen sedation was also noted.

Discussion

Selection of the present patient group was based primarily on evaluations made by referring general practitioners. Knowledge of availability of this type of treatment among practitioners might have influenced this selection. Some patients who could have been treated with nitrous oxide oxygen sedation may have been referred for treatment in general anesthesia directly. If an increased number of such patients had been included in this study, this might have led to decreased success rates.

Age composition of the present group of patients, including a significant number of adolescents and adults, differs from that in several previous studies (7, 12, 13). The type of procedures reported also differs from earlier studies in some respects. Shaw (9) reported primarily simple

Table 5. Side effects related to nitrous oxide oxygen sedation used during 241 oral surgery procedures in 194 patients

	Side effects			
	Intraoperative		Postoperative	
	n	(%)	*n*	(%)
Nausea	7	(2.9)	3	(1.2)
Restlessness	4	(1.7)	–	
Vomiting	1*	(0.4)	2	(0.8)
Headache	–		1*	(0.4)
Total	12	(5.0)	6	(2.4)

* Same patient.

Table 6. Odds ratio (OR) and 95% confidence interval (95% CI) for predictors of non-successful outcome of nitrous oxide oxygen sedation in conjunction with oral surgery procedures in 194 patients. Success defined as absence of side effects and acceptance without difficulty

	n				
	Total	Success	Non-success	OR	95% CI
ASA class 1	183	155	28	1.00*	
ASA class 2	11	5	6	7.70	1.83–32.42
				$P = 0.0054$	
Indication for sedation					
Immaturity	85	75	10	1.00*	
General apprehension	66	49	17	3.20	1.13–9.03
Based on experience†	27	21	6	4.67	1.21–18.03
Fear of needles	16	15	1	0.45	0.04–4.75
				$P = 0.041$	
Age					
9 years or less	57	48	9	1.00*	
10–12 years	57	47	10	0.75	0.25–2.23
13–19 years	35	29	6	0.49	0.13–1.89
20 years and older	45	36	9	0.46	0.12–1.73
Sex					
Females	100	81	19	1.00*	
Males	94	79	15	0.74	0.33–1.68
Experience					
Nitrous oxide sedation	10	9	1	1.00*	
None	166	136	30	3.12	0.32–30.21
General anesthesia	13	12	1	0.68	0.03–15.76
Premedication	5	3	2	4.10	0.20–83.60

* Reference category.
† Apprehension based on previous negative experience with dental or medical treatment.

extractions of 331 teeth, thereof 130 temporary teeth and 174 premolars. Only 5 out of 337 procedures were classified as ordinary oral surgery procedures. Jastaks (7) reported 1,060 procedures with nitrous oxide oxygen sedation, including 311 classified as "surgery". Cooper (14) and Crawford (13) reported simple extractions in 24 and 53 patients, respectively. The present study comprises a significant number of removals of impacted permanent teeth, mesiodentes and autotransplants (Table 3); procedures assumed to represent increased physical and emotional strain to patients.

The overall acceptance rate (Table 5) in this study shows that nitrous oxide oxygen sedation is an effective aid in the oral surgical care of patients who for various reasons have problems tolerating surgical procedures without general anesthesia. Acceptance rates compare well with previous reports on different patient groups, procedures, and N_2O concentrations (7–9, 14). Minor deviations in acceptance rates may be attributed to use of different verbal rating scales, and lack of strict criteria for evaluation of acceptance.

Problems with loss of patient cooperation during surgical procedures, as suggested by Shaw (9), were not encountered in this study. Better acceptance was found in the ASA class 1 group of patients (Table 5), which is in accordance with Jastak (7). Hallonsten reported impaired acceptance in young children, in accordance with a tendency reflected in the present study (Table 6). A tendency for better acceptance by patients previously treated under general anesthesia was noted (Table 6). Hallonsten (8), however, found no deviation from general level of acceptance for this group. Evaluation of pattern of acceptance rather than level of acceptance, as suggested by Hallonsten (8), was not possible in this study, as more than 82% of the patients were subjected to only one treatment session. Side effects were experienced by 8.2% of the patients. Nausea was the most frequent side effect both during and after the procedure (Table 4).

Jastak (7) reported side effects, predominantly nausea and emesis, in 7.45% of his patients. He found the same level of side effects regardless of patient ASA class. Hallonsten (8) reported a rate of side effects of 8.3%. She found more side effects with short sessions and low N_2O concentrations. Earlier studies suggest an increased rate of side effects with high N_2O concentrations, with procedures of long duration (15), and in young patients (16). No associations between side effects, duration of sessions or age were found in the present study. Likewise, ASA class and preoperative fear or apprehension did not affect the occurrence of side effects. Nitrous oxide concentrations below 50% in young immature patients were associated with more side effects. Normally, increased doses lead to more side effects. The present side effects may have been precipitated by anxiety during surgery as a result of inadequate effect of sedation.

In spite of differences in age composition of patient groups and type of treatment procedures, the reported level of side effects is remarkably consistent between these

studies. The present study does not indicate an increased level of side effects from nitrous oxide oxygen sedation in oral surgery patients.

Successful sedation has been defined to meet the needs of clinicians, and enables the identification of patients in whom nitrous oxide oxygen sedation may not be uneventful, and is of help in individual preoperative evaluations. Measures to prevent problems may therefore be taken, e.g. tranquillizers or antiemetics can be administered to prevent the most frequent problems, or direct referral for treatment under general anesthesia. The present study indicates that patients with general apprehension, especially when based on previous negative experience with medical and dental treatment, have an increased odds ratio for non-successful sedation. Expectations of painful oral surgery procedures may act to increase apprehension and fear. Sedation procedures normally sufficient in general dentistry may thus be inadequate for oral surgical procedures. Some of these patients, accepting general dental work under nitrous oxide oxygen sedation, may need general anesthesia when undergoing oral surgery procedures. As seen in Table 6, however, the majority of patients with apprehension, both general and based on previous negative experience of medical or dental treatment and fear of needles, will benefit from sedation with nitrous oxide and oxygen.

The total acceptance rate indicates the same overall acceptance of nitrous oxide oxygen sedation in association with oral surgery as for general dentistry. Only four patients in this study needed referral for treatment under general anesthesia. This low rate of referrals indicates that economic savings from use of nitrous oxide oxygen sedation with oral surgery can be significant, as reported for minor oral surgery in children (9).

In conclusion, nitrous oxide oxygen sedation with local anesthesia for oral surgery procedures is accepted at the same high level as when used for general dental work in children and adults. Side effects occur at the same level as with general dental work. ASA class 2 patients and patients with general apprehension, especially based on previous negative experience with medical and dental treatment, have an increased odds ratio for poor acceptance and/or side effects.

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