A prospective study of the use of nitrous oxide inhalation sedation for dental treatment in anxious children

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ABSTRACT. Aim To determine baseline data in relation to procedures undertaken during nitrous oxide inhalation sedation sessions within the Hospital Dental Service. Study Design A prospective study. Methods Data was collected over a twelve-month period for patients attending the Department of Paediatric Dentistry, Dundee Dental Hospital, Dundee, Scotland, for dental treatment using nitrous oxide inhalation sedation. Overall behaviour and the outcome of treatment were assessed by the dentist providing sedation using the Frankl and Houpt Behaviour Rating Scales respectively. Results Data was available for 312 patients (F:169; M:143) with a median age of 11.0 (inter-quartile range 8.8, 12.7) years. Overall, 93% of patients successfully completed treatment using sedation. The majority of treatments comprised dental extractions; 19.8% and 41.3% were primary and permanent tooth extractions respectively. Regarding permanent teeth, nearly 50% were first permanent molar extractions compared with just over 30% for first premolars. Nearly three-quarter of cases were treated using a mixture of 30% nitrous oxide and 70% oxygen, with a median sedation time of 35.7 minutes. Only 7% of cases failed to commence or complete treatment and overall, there was a greater failure rate amongst visiting Community Dental Officers, compared with Hospital-based clinicians. Conclusion Extraction of first permanent molar teeth can be successfully achieved using inhalation sedation. There is both a need for further postgraduate training in sedation techniques as well as the necessity to train further Specialists in Paediatric Dentistry to undertake care within the Community Dental Service.

KEYWORDS: Inhalation sedation, Efficacy, Hospital Dental Service.

Introduction
Child anxiety about dental treatment is a well-recognised problem, with several studies demonstrating that fear of invasive procedures, such as injections and the ‘drill’, is the cause of dental anxiety amongst children [Cuthbert and Melamed, 1982; Bedi et al., 1992; Alvesalo et al., 1993]. The use of conscious sedation as a safe alternative to general anaesthesia for dental care in anxious patients has been encouraged by the Department of Health, the General Dental Council, the Royal College of Anaesthetists and the Society for Advancement of Anaesthesia in Dentistry [Department of Health, 2000; General Dental Council, 2000; Society for the Advancement of Anaesthesia in Dentistry, 2000; The Royal College of Anaesthetists, 1999]. Nitrous oxide inhalation sedation is the standard technique for managing paediatric patients with dental anxiety; the majority of studies which have been undertaken within the United Kingdom, however, have focused on mainly orthodontic extractions in the slightly older child patient [Shaw et al., 1996; Shepherd and Hill, 2000]. As such, this prospective study was designed to investigate the range of treatments and the efficacy of nitrous oxide sedation over a twelve-month period in the Hospital Dental Service.

Materials and methods
Study Design. The study was designed as a prospective, observational survey undertaken within the Department of Paediatric Dentistry, Dundee Dental Hospital, from April 2003-March 2004, inclusive (i.e. twelve months).

Clinical technique. An operator/sedationist (n = 10) accompanied by a second appropriately trained person (n = 8) administered nitrous oxide/oxygen sedation (RA) via a nasal mask using a Quantiflex® MDM relative analgesia machine. The nitrous oxide was
titrated in 5-10% increments to the maximum desired level for each individual patient (according to the operator/sedationists’ objective perception of the optimal level of sedation), whilst the clinician provided reassurance and positive reinforcement. Upon completion of dental treatment, the nitrous oxide flow was reduced in 10% increments and finally, 100% oxygen was administered for two minutes before the nasal mask was removed. Dental treatment was undertaken according to a predetermined treatment plan. All patients were assigned, in sequence, from the departmental sedation waiting list, with the exception of those patients who were treated by the Consultant. These patients were booked directly into a sedation session for more involved dental procedures, e.g. traumatic dental extractions and minor oral surgical procedures.

Questionnaire design. Following treatment, the dentist completed a questionnaire which sought the following details.

- **Patient details**
  - Sex of the patient.
  - Age of the patient.

- **Details of personnel**
  - The identity and the sedation experience of the operator/sedationist.
  - The identity of the second appropriately trained person, i.e. the dental nurse.

- **Details of sedation/treatment**
  - The duration of the appointment.
  - The maximum level of the nitrous oxide/oxygen mixture.
  - The dental treatment undertaken, i.e. restorative work or dental extractions.
  - Which and how many teeth were treated at each visit.

Retrospectively, the number of visits for each course of treatment for each of the operators was calculated. In addition, the Frankl Behaviour Rating Scale [Hosey and Blinkhorn, 1995] was used to grade the child’s behaviour during treatment (i.e. 1: refusal/distress; 2: uncooperative/reluctant; 3: co-operative/reserved; 4: interested/enjoyed).

The Houpt Behaviour Rating Scale [Hosey and Blinkhorn, 1995] was used to record the overall behaviour and outcome of treatment (i.e. aborted/no treatment rendered; 2: poor/treatment interrupted and partially completed; 3: fair/treatment interrupted but completed; 4: good/difficult but all treatment performed; 5: very good/limited crying or movement; 6: excellent/no crying or movement).

Data analysis. Patient ages and sedation times were rejected as being normally distributed (Kolmogorov-Smirnov Test) and hence, median patient ages and sedation times were calculated and compared with Mann-Whitney U tests. In relation to both behaviour and outcome of treatment, significant differences between male and female patients were defined by Chi square ($\chi^2$) analysis. Finally, patients for whom dental treatment was abandoned were analysed according to operator/sedationist status with statistically significant differences defined by Chi square ($\chi^2$) analysis. All data was analysed using MINITAB™ statistical software, Release 13.31.

Results

Data was collected for 312 patients (169 females and 143 males) with a median age of 11.0 (inter-quartile range 8.8, 12.7) years. The age breakdown and frequency of age distribution according to gender is given in Table 1 and Figure 1 respectively. In addition, the median age range of patients according to operator/sedationist status is given in Table 2. Both the Consultant and the Staff Grade dentists treated patients who were older than the SHO grade and this was statistically significant. Retrospective review revealed that 521 patient attendances were recorded.

<table>
<thead>
<tr>
<th>Patient gender</th>
<th>N° of patients</th>
<th>Median age (yrs)</th>
<th>Range (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (all)</td>
<td>143</td>
<td>10.9 (8.7, 12.9)</td>
<td>4.1-15.9</td>
</tr>
<tr>
<td>Female (all)</td>
<td>169</td>
<td>11.2 (9.1, 12.6)</td>
<td>3.8-16.0</td>
</tr>
<tr>
<td>Male (completed)</td>
<td>131</td>
<td>10.9 (8.7, 13.0)</td>
<td>4.1-15.8</td>
</tr>
<tr>
<td>Female (completed)</td>
<td>160</td>
<td>11.5 (9.1, 12.6)</td>
<td>3.8-16.0</td>
</tr>
<tr>
<td>Male (abandoned)</td>
<td>12</td>
<td>9.3 (7.7, 11.5)</td>
<td>5.9-13.5</td>
</tr>
<tr>
<td>Female (abandoned)</td>
<td>9</td>
<td>9.9 (5.8, 11.8)</td>
<td>4.5-15.4</td>
</tr>
</tbody>
</table>

| TABLE 1 - Study demographics according to patient gender and age: median values are given with 25% and 75% quartiles in parentheses. |
for inhalation sedation outpatient activity over the study period, i.e. data was available for 59.9% of sedation activity. Over the twelve-month period, 10 dentists acted as operator/sedationist including the following: one Consultant, two Staff Grade dentists, two Community Dental Officers (CDO) and five Senior House Officers/General Professional Trainers (SHO/GPT). Eight different dental nurses acted as the second appropriately trained person. In relation to sedation experience at the start of the study, this ranged from less than six months to 18 years for the sedationists and from two months to nine years for the dental nurses.

Overall, 291 patients (160 females and 131 males) with a median age of 11.1 (inter-quartile range 8.8, 12.7) years successfully completed treatment with sedation. Regarding the duration of sedation for the different operators, this ranged from a median of 30 minutes for the Consultant grade to 40 minutes for the SHO/GPT grade with the difference between grades being statistically significant (Table 2). Nearly three-quarters of cases were successfully treated using a mixture of 30% nitrous oxide and 70% oxygen. The median sedation time increased with increasing administration of nitrous oxide from 30 to 45 minutes for a mixture of 20% nitrous oxide and 80% oxygen and 40% nitrous oxide and 60% oxygen respectively (Table 3a). In relation to those cases which were aborted, again the majority of patients received sedation with 30% nitrous oxide and 70% oxygen. In contrast to the completed cases, however, the median sedation time decreased with an increasing administration of nitrous oxide from 38 to 28 minutes, although there were no statistically significant differences between the duration of sedation comparing the maximum levels of sedation (Mann-Whitney U, P < 0.05) (Table 3b).

As regards dental treatment undertaken, a breakdown of treatment according to operator status is given in Figure 2. In all cases, with the exception of the CDO, the majority of treatment consisted of dental extractions; for the CDO operators the greatest volume of treatment comprised dental restorations. Overall, 67% of treatments were extraction cases with nearly one-third and two-thirds consisting of primary and permanent tooth extraction respectively and the remainder consisting of a combination of extraction of both tooth types (Fig. 3). Concerning extraction of primary teeth, the vast majority were molars, with 33.3% and 38.7% consisting of first and second primary molars respectively. In relation to permanent teeth extraction cases, 31.2% of these were first premolars and 46.2% were first molar teeth respectively (Fig. 4). In 59.4% and 33.3% of cases, one and two teeth were extracted per visit respectively, with only relatively small numbers of patients having more than two extractions at each visit (Fig. 5). Restorations were placed in just over 20% of cases and again, the breakdown in relation to primary and secondary.
TABLE 3 - Maximum sedation levels and the duration of treatment under sedation for (a) completed and (b) abandoned cases: median values with 25% and 75% quartiles in parentheses. Comparing median sedation times at the five levels of maximum sedation for completed and abandoned cases, those followed by the same letter are not significantly different from each other (Mann-Whitney U, P < 0.05). There were no statistically significant differences between median sedation times, comparing completed and abandoned cases at the same maximum level of sedation (Mann-Whitney U, P < 0.05).
permanent teeth was similar to that for the extraction cases (Fig. 3). In addition, in 23 cases, the patients were introduced to sedation and underwent no dental treatment, whilst in 5 cases, soft tissue excisional biopsies were performed. Concerning the number of visits for a course of treatment, this varied from one to four in all cases for all operators, with the exception of the CDO and SHO grades, where the number of visits ranged from one to three (Fig. 6).

In relation to patient behaviour during treatment, the behaviour scores for male and female patient were similar, with the majority of patients demonstrating good co-operation during their dental treatment (Table 4). Similarly, there appeared to be little difference in the outcome of treatment between male and female patients, with the majority of children demonstrating good/excellent behaviour during nitrous oxide sedation, allowing completion of dental treatment (Table 4).

Twenty-one cases (9 females and 12 males), median age 9.6 (inter-quartile range 7.0,11.6) years were abandoned. Comparing those patients who successfully completed treatment with those for whom treatment was abandoned, the latter group were younger and the difference was statistically significant (Mann-Whitney U, W = 4371.1, P = 0.021). Four
patients refused to attempt sedation whilst the remaining seventeen patients were aborted at various stages throughout the appointment. In eleven cases, local analgesia for treatment was given and thereafter, treatment subsequently abandoned. Overall, over half of the cases were abandoned by the SHO/GPT grade; in relation, however, to the number of cases seen by this grade, less than 10% of cases were abandoned. According to the number of patients seen, over 20% of those treated by the CDO were aborted and this was statistically more significant than for any of the other operator/sedationists (Table 5).

**Discussion**

Recent guidelines have stressed the use of competently provided conscious sedation as an alternative form of pain and anxiety control to general anaesthesia for patients requiring dental treatment [General Dental Council, 2000; Royal College of Anaesthetists, 1999; Society for the Advancement of Anaesthesia in Dentistry, 2000].

The present prospective study was designed, therefore, to determine the current activity and efficacy of an inhalation sedation outpatient service within the Hospital Dental Service of NHS Tayside, over a twelve-month period. Overall, data was collected for 312 patients, representing 60% of the actual outpatient attendance; whilst this was less than ideal, the data would appear to give a reasonable representation of activity within this particular unit. The reasons that data was not collected for nearly 40% of patients, however, are unclear, although, in part, this could be explained by staff-turnover, particular with the Senior House Officer/General Professional Trainee grades and the additional administrative burden of recording study data; other workers have highlighted that the greatest barrier to recording audit data as lack of time [Johnston et al., 2000].

The majority of cases where treatment was completed were achieved with a mixture of 30% nitrous oxide and 70% oxygen with a median sedation time for all operators of 35.7 minutes. There were statistically significant differences in sedation times between the Consultant and the CDO and SHO/GPT grades; this could be explained by the greater proportion of restorative cases seen by the CDO operators and by the relative inexperience of the SHO/GPT dentists, all of whom were less than 2 years qualified and with, in all cases, less than 12 months experience of dental treatment using sedation. Published work, to date, of sedation in the clinical trial setting has demonstrated shorter sedation times compared with the current study. For example, one such study, a randomised, controlled, crossover trial comparing oral midazolam and nitrous oxide for paediatric dental sedation demonstrated a median sedation time for the nitrous oxide group of 10

<table>
<thead>
<tr>
<th>Operator/sedationist</th>
<th>Proportion of all cases seen per operator (%)</th>
<th>Proportion cases abandoned per operator (%)</th>
<th>Proportion cases abandoned per n° seen per operator (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultant</td>
<td>14.7</td>
<td>4.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Staff Grade</td>
<td>35.8</td>
<td>19.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.6&lt;sup&gt;a,b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Community Dental Officer</td>
<td>6.1</td>
<td>19.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.1&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>SHO/GPT</td>
<td>43.3</td>
<td>57.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.9&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Table 5 - Breakdown of abandoned cases according to the operator/sedationist status. Comparing abandoned cases between individual operator grades, those followed by the same letter are not significantly different from each other ($\chi^2$, $P < 0.05$).
minutes (range 5 to 25 minutes) [Wilson et al., 2002]. Presumably the greater age of the children (all were more than 10 years of age) and the fact that only orthodontic extractions were being undertaken accounted for the shorter sedation times. As mentioned previously, approximately one third of patients in this study were less than 10 years of age and also a range of dental treatments were being undertaken. The benefit, however, of ascertaining the duration of a range of dental treatments undertaken using sedation has assisted with the planning of service provision and as such, maximised the number of patients treated at each sedation session.

Overall, 93% of patients attending for dental treatment using inhalation sedation successfully completed treatment and this would appear to be in agreement with other workers, who retrospectively reviewed sedation activity over a three-month period in the Community Dental Service and who found a similar success rate [Bryan, 2002]. As regards dental treatment, 67% of cases involved dental extraction, and for primary teeth over 70% of these were molar teeth. In comparison, a relatively small number of primary teeth were either restored or received endodontic therapy in the present study, reflecting the late referral of patients to a specialist paediatric service by practitioners working within Primary Care.

Regarding permanent teeth, more first permanent molars were extracted than both first and second premolars combined; the majority of the latter being extracted for orthodontic reasons. Previous studies have also confirmed the efficacy of inhalation sedation for orthodontic extractions [Blain and Hill, 1998; Lyratzopoulos and Blain, 2003; Shepherd and Hill, 2000]. The finding that nearly 50% of extraction cases were carious or hypoplastic first permanent molars was surprising, although encouraging. The author’s personal experience of other units would confirm that other workers routinely plan treatment of patients for first permanent molar teeth accounting for nearly 50% of extraction cases.

In only 7% of cases did patients fail to commence or complete treatment, a similar finding to a previous retrospective review of sedation treatment in the Community Dental Service (CDS) [Bryan, 2002]. In the present study, over 20% of cases seen by the visiting Community Dental Officers were aborted. This could be accounted for by the different case mix seen by this grade or due to less experience of sedation personnel. Preliminary data accounting for the shorter sedation times. As mentioned previously, approximately one third of patients in this study were less than 10 years of age and also a range of dental treatments were being undertaken. The benefit, however, of ascertaining the duration of a range of dental treatments undertaken using sedation has assisted with the planning of service provision and as such, maximised the number of patients treated at each sedation session.

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Conclusion
Inhalation sedation for dental treatment in children resulted in successful completion of treatment in 93% of cases. The treatment most frequently undertaken was dental extraction, with the removal of first permanent molar teeth accounting for nearly 50% of extraction cases.

Regarding sedation personnel, preliminary data would appear to confirm the need to train further Specialists in Paediatric Dentistry in the use of inhalation sedation to undertake care within the Community Dental Service.

References