Investigation of inhalational conscious sedation as a tool for reducing anxiety in adults undergoing exodontia

R. J. Hierons,¹ M. L. Dorman,² K. Wilson,³ P. Averley⁴ and N. Girdler⁵

VERIFIABLE CPD PAPER

IN BRIEF

- Illustrates the use of the modified dental anxiety scale (MDAS) in a primary care oral surgery service.
- Highlights the value of nitrous oxide inhalational sedation as a sedative tool in the treatment of adults undergoing routine and surgical exodontia.
- Demonstrates the effectiveness of a primary care adult oral surgery service in treating anxious patients.

Aim To determine whether adult patients' dental anxiety levels decrease following exodontia carried out under inhalational conscious sedation with nitrous oxide and oxygen (IHS) and local anaesthetic (LA). **Design** Retrospective analysis of pre- and post-operative modified dental anxiety score (MDAS) questionnaires completed by patients treated in a primary care oral surgery service between 21 July 2010 and 17 December 2010. **Methodology** 138 patients who had undergone exodontia were divided into three groups: moderate to severe anxiety (MDAS scores 11–25) treated under IHS and LA (n = 60), mild anxiety (MDAS scores 5–10) treated under IHS and LA (n = 43) and mixed anxiety (MDAS scores 5–15) treated under LA only (n = 35). The mean pre- and post-operative MDAS scores were analysed by means of one-tailed, paired t-tests. **Results** The moderate to severely anxious group treated under IHS and LA showed a statistically significant decrease of 3.68 between the mean pre- and post-operative MDAS scores (p = 0.000). The IHS mildly anxious group showed a decrease of 0.07 (p = 0.392) and the LA group showed a decrease of 0.23 (p = 0.227). Neither of these results were statistically significant. **Conclusion** These results support the use of IHS, to reduce anxiety of exodontia, in moderate to severely anxious adults undergoing minor oral surgery (MOS) procedures under LA in primary care oral surgery.

INTRODUCTION

One of the main indications for conscious sedation is 'to enable an unpleasant procedure to be carried out without distress to the patient'.¹ Oral surgery is often unpleasant meaning that adults who are able to tolerate routine dentistry with local anaesthetic (LA) alone may find a surgical procedure more tolerable with sedation. Standard sedation methods in adults include the use of intravenous midazolam² (IV) and, less frequently, inhalational sedation with nitrous oxide and oxygen¹ (IHS). IHS is widely used in paediatric dental practice

and is widely accepted as the safest form of dental sedation in this age group.^{3,4} There is less evidence in the literature investigating the use of IHS for adult dental procedures. One paper by Berge in 1999⁵ indicated a good acceptance by adults undergoing oral surgery with IHS, with very few complications. IHS is an ideal compromise between LA alone and IV sedation as it can often be used for anxious adult patients for whom treatment is unsuitable with IV sedation either on medical or social grounds. The analgesic properties of nitrous oxide make IHS a bonus along-side LA for use in minor oral surgery (MOS) procedures. In addition adults, if necessary, can attend for treatment unaccompanied.^{1,6,7}

Queensway Durham and Darlington Oral Surgery Service (QDDOSS) is a relatively new primary care oral surgery service, which accepts National Health Service (NHS) referrals from general dental practitioners (GDPs) in the region. Patients are assessed and treated by specialist oral surgeons. IHS is frequently used in QDDOSS for anxious adults undergoing MOS procedures. The commissioning Primary Care Trust (PCT) requires regular service

evaluation to ensure patients are receiving appropriate, cost effective, high quality and safe care. As part of this service evaluation, patients are asked to fill out a modified dental anxiety scale (MDAS)⁸ questionnaire pre- and post-operatively, regardless of the procedure and type of anxiety management they receive.

MDAS is a simple validated scale used to measure dental anxiety, adapted from Corah's Dental Anxiety Scale (CDAS)⁹ by Humphris *et al.*⁸ (see Table 1). MDAS is simpler than CDAS with shorter more consistent answers. In addition MDAS has an essential fifth question regarding LA. When the MDAS score is totalled it gives a clear indication of the respondent's anxiety level. By reference to the CDAS/MDAS conversion tables¹⁰ a score of 5–10 indicates mild anxiety, a score of 11–18 indicates moderate to severe anxiety and a score of 19–25 indicates probable dental phobia. The cut off point of 19 was determined by Humphris *et al.*⁸ using a reliably defined group of dental phobics rather than clinical judgement without supporting data (as per Corah *et al.*¹¹). MDAS has been validated for use by adults in both

¹Specialist Oral Surgeon, Queensway Oral Surgery Services, 293 Yarm Road, Darlington, DL1 1BA;

²Specialist Oral Surgeon & Honorary Clinical Tutor, Queensway Oral Surgery Services, 170 Queensway, Billingham, Teesside, TS23 2NT; ³Associate Specialist & Honorary Clinical Lecturer, Sedation Department, School of Dental Sciences, Newcastle upon Tyne, NE2 4BW; ⁴Managing Partner, Queensway Dental Clinic, 170 Queensway, Billingham, Teesside, TS23 2NT; ⁵Professor of Sedation Dentistry, Sedation Department, School of Dental Sciences, Newcastle upon Tyne, NE2 4BW

*Correspondence to: Rebecca Hierons
Email: rebecca@queensway.co.uk

Online article number E9
Refereed Paper – accepted 12 June 2012
DOI: 10.1038/sj.bdj.2012.839
©British Dental Journal 2012; 213: E9

primary and secondary care and is quick to complete, easy to understand, consistent and valid. As well as giving a good indication of dental anxiety levels it is also able to identify specific problem areas for patients, such as the drill or injections.^{8,12–14}

The aim of this investigation was to determine whether patients' dental anxiety levels reduce after exodontia carried out under IHS with LA. If anxiety is reduced with the use of IHS to support exodontia it may have significant implications for the management of individuals undergoing oral surgery and could result in less anxiety before future dental procedures.

The objectives of this investigation were to compare the pre- and post-operative MDAS scores in mildly anxious adults with moderate to severely anxious adults undergoing routine, soft tissue and surgical exodontia under IHS with LA and LA alone. This analysis will determine whether the level of dental anxiety experienced by patients change and whether IHS may be responsible for reductions in anxiety levels. In addition, mean MDAS scores will be analysed to determine whether or not post-operative anxiety is increased for any patient group. This analysis is needed as it is important that patients receive appropriate anxiety management during their care.

MATERIALS AND METHODS

The investigation was designed as a retrospective analysis of pre- and post-operative completed MDAS questionnaires from patients treated in a primary care oral surgery service (QDDOSS) between 21 July 2010 and 17 December 2010.

The County Durham and Tees Valley Research Ethics Committee confirmed that ethical approval was not required under NHS research governance arrangements as this investigation was considered to be an appropriate service evaluation exercise.

The null hypothesis was as follows: 'There will be no difference between the mean pre- and post-operative MDAS scores in adults who have undergone routine, soft tissue or surgical exodontia with LA plus or minus IHS'.

A power calculation was carried out to determine the sample size required in each group to detect a mean difference of three points between pre- and post-operative MDAS scores. This was considered to be a clinically significant reduction in anxiety

Table 1 The Modified Dental Anxiety Scale (MDAS)⁸

CAN YOU TELL US HOW ANXIOUS YOU GET, IF AT ALL WITH YOUR DENTAL VISIT?				
PLEASE INDICATE BY INSERTING 'X' IN THE APPROPRIATE BOX				
1. If you went to your Dentist for TREATMENT TOMORROW, how would you feel?				
Not Anxious ☐	Slightly Anxious ☐	Fairly Anxious ☐	Very Anxious ☐	Extremely Anxious ☐
2. If you were sitting in the WAITING ROOM (waiting for treatment), how would you feel?				
Not Anxious ☐	Slightly Anxious ☐	Fairly Anxious ☐	Very Anxious ☐	Extremely Anxious ☐
3. If you were about to have a TOOTH DRILLED, how would you feel?				
Not Anxious ☐	Slightly Anxious ☐	Fairly Anxious ☐	Very Anxious ☐	Extremely Anxious ☐
4. If you were about to have your TEETH SCALED AND POLISHED, how would you feel?				
Not Anxious ☐	Slightly Anxious ☐	Fairly Anxious ☐	Very Anxious ☐	Extremely Anxious ☐
5. If you were about to have a LOCAL ANAESTHETIC INJECTION in your gum, above an upper back tooth, how would you feel?				
Not Anxious ☐	Slightly Anxious ☐	Fairly Anxious ☐	Very Anxious ☐	Extremely Anxious ☐
Instructions for scoring (remove this section prior to patient use) Not anxious = 1 Slightly anxious = 2 Fairly anxious = 3 Very anxious = 4 Extremely anxious = 5 Total score is a sum of all five items, range 5 to 25: Cut off is 19 or above which indicates a highly dentally anxious patient, possibly dentally phobic				

levels by reference to Freeman *et al.*'s work.¹⁰ A standard deviation set at five points for the mean of the pre- and post-op scores (estimated on work by Humphris *et al.*)⁸ was considered appropriate. This power calculation produced a required sample size of 45 patients per group, with a 90% confidence of detecting a significant difference (p value (α) of 0.05).

Patient management

The records of all patients assessed and treated in Darlington under QDDOSS between 21 July 2010 and 17 December 2010 by a single surgeon (RJH) were reviewed. The surgeon had pre-operatively assessed all of these patients after they had filled in their medical history questionnaire and pre-operative MDAS form in reception. After full assessment and examination, and following radiographs where indicated, a treatment plan was formulated and written consent gained. A decision as to the type and nature of sedation required was made following discussion with the patient depending on appropriateness and need. An appointment date was then agreed and a printed appointment card

given to the patient along with verbal and written pre-operative information and a copy of the consent form.

The patient returned for their treatment visit and their medical history, written consent, and treatment plan were confirmed. Post-operative instructions were re-iterated. Patients treated under LA were discharged following completed treatment.

Those patients treated using IHS had a Porter/Brown nasal mask placed with a nitrous oxide/oxygen mixture being delivered from a Matrx MDM[®] machine calibrated to an accuracy of 0.5 l/min or 5% (the same machine was used throughout the investigation period). Active scavenging was used with a scavenging rate of ≥ 45 l/min. The nitrous oxide was titrated appropriately in 10% increments until the target conscious sedation level was achieved, with a maximum limit of 70% nitrous oxide. At the end of the surgical procedure, all patients received 100% oxygen for 3 minutes before being discharged into the recovery area.

The LA used for all patients were 2% lidocaine with 1:80,000 adrenaline (Xylocaine, Dentsply Pharmaceutical, York, PA 17404)

Table 2 Inclusion criteria

Adults >16 years
Spoken/written English
No regular medication (see text for exceptions)
No recreational drug use (see text for exceptions)
Dental extractions only
Treatment under LA with or without IHS (N ₂ O/O ₂)
Completed pre- and post-operative MDAS forms without help or prompting

for upper infiltrations and inferior dental blocks (using the Halstead approach) and 4% articaine with 1:200,000 adrenaline (Septanest, Deproco, Kent, UK) for lower infiltrations and long buccal blocks. Once adequate local anaesthesia was achieved, teeth were either luxated, elevated or extracted with forceps (or a combination of these techniques) following soft tissue release as necessary. If required, a muco-periosteal flap was raised, bone removed and teeth sectioned and elevated appropriately. The soft tissues were repaired with 3/0 Vicryl® sutures (Ethicon, Johnson & Johnson Medical Limited, Livingston, Scotland) as necessary. All patients were asked to bite on a gauze swab soaked in chlorhexidine mouthwash (Corsodyl®, GalaxoSmithKline Consumer Healthcare, Brentford, Middlesex) to aid haemostasis.

All patients were given verbal and written instructions before being discharged. Two additional forms were attached to the written post-operative instructions: the first was a satisfaction feedback questionnaire and the second a post-operative MDAS form. Patients were asked if they would fill in these forms in the waiting room and completed forms were then filed in the patient's card by the receptionist.

Sample selection

The inclusion criteria for this investigation are summarised in Table 2. The service only treats adults over 16 years and patients had to be able to understand written English in order to fill in their MDAS questionnaires independently (patients who had not completed pre- and post-operative MDAS questionnaires in the practice or with the help of an interpreter were excluded). Patients included were all fit and well and taking no regular prescription medication. The exceptions were the oral contraceptive pill (OCP), the contraceptive implant or depo-provera injection, hormone replacement therapy

Table 3 Table of patient groups

Patient groups	Total number (n)	Males	Females
IHS MDAS 11–25 moderate–severe anxiety	60	25	35
IHS MDAS 5–10 mild anxiety	43	22	21
LA	35	23	12
Total	138	70	68

Fig. 1 Histogram of age distribution

(HRT) and antibiotics for dental problems. Patients on over-the-counter analgesics were included but not those on prescription-only analgesics. Individuals who used recreational drugs regularly, except tobacco or alcohol, were excluded. All patients who had undergone any procedure other than removal of teeth or roots were excluded as were individuals who had intravenous sedation. These inclusion criteria were used to try and limit confounding variables as much as possible when comparing MDAS scores between groups.

Suitable patients were identified from their clinical records. Pre- and post-operative MDAS forms were retrieved from their record cards. A data sheet was used to collect patients' demographics, medical history and pre- and post-operative MDAS scores along with the number of teeth removed and whether the procedure involved soft tissue release, bone removal and/or sectioning of teeth. Patients supported with IHS had the percentage of nitrous oxide used recorded. Data were entered onto an Excel spreadsheet (2007) and divided into three groups as to whether they were moderate to severely anxious (pre-operative MDAS score 11–25) and treated using IHS and LA,

mildly anxious (pre-operative MDAS score 5–10) and treated using IHS and LA or using LA alone.

The parametric data were analysed in Excel and Minitab 15. One-tailed, paired t-tests were computed for each group of patients to determine any statistical significance in the difference between the pre- and post-operative MDAS scores.

RESULTS

A total number of 451 patients were provided with specialist oral surgery services at QDDOSS between 21 July 2010 and 17 December 2010 (66 operating days) and 138 of these patients met the inclusion criteria (see Table 2).

The first group were moderate to severely anxious individuals with pre-operative MDAS scores of 11–25 treated under IHS and LA (n = 60). The second group were mildly anxious individuals with pre-operative MDAS scores of 5–10 treated under IHS and LA (n = 43). The third group were patients with variable pre-operative MDAS scores (range 5–15) who were treated under LA only (n = 35).

The gender distribution of the sample is shown in Table 3. There was a higher proportion of males in the LA group (66%)

and the highest proportion of females was in the moderate to severely anxious group (58%). The ratio of males to females in the mildly anxious group was almost equal.

The age ranges of the three patient groups are shown in Figure 1. All patients were ≥ 16 years old and the oldest patient was in the LA group at 71 years. The mean age in all groups was between 30 and 38 years old.

The maximum, minimum and mean percentages of nitrous oxide administered to the IHS groups are shown in Figure 2. One individual in the mildly anxious IHS group received the maximum dose of 70% nitrous oxide, whereas the majority of patients in both IHS groups received 30–60%. The mean percentages of nitrous oxide administered in both IHS groups were similar at 45–48%.

The percentages of routine, soft tissue and surgical teeth removed are shown in Figure 3. The majority of procedures in all groups involved either soft tissue release and/or hard tissue removal (68% in the moderate to severely anxious IHS group, 77% in the mildly anxious IHS group and 71% in the LA group). The mildly anxious IHS group had a greater percentage of surgical extractions at 25% – approximately double that of the other two groups. Routine exodontia ranged from 23–32%.

The median pre- and post-operative MDAS scores for each patient group are shown as boxplots in Figures 4–6. In these plots the upper and lower whiskers extend to the maximum and minimum data points from the top and bottom of the box respectively. The interquartile range box contains the middle 50% of the data. The top line of this box represents the third quartile (Q3) and 75% of the data are less than or equal to this value. The middle line represents the median point or second quartile (Q2). The bottom line of the data box represents the first quartile (Q1) and 25% of the data are less than or equal to this value. Note the absence of lower whiskers on the LA boxplot (Fig. 6) as the minimum possible MDAS score is 5 which is at the level of Q1 in this patient group. Note also the fall of six points between the pre- and post-op median MDAS scores in the moderate to severely anxious IHS group while there was no difference in the pre- and post-op median MDAS scores in the other two groups.

The difference in mean pre- and

Fig. 2 Histogram of nitrous oxide (%) given to the two IHS patient groups

Fig. 3 Histogram to show routine, soft tissue and surgical exodontia

Fig. 4 Boxplot of pre- and post-operative MDAS scores in the moderate to severely anxious IHS group

post-operative MDAS scores between males and females in each patient group is shown in Figure 7. The mean female

pre-operative MDAS scores were higher than that of the males in all three groups – the highest score being 17.19

Fig. 5 Boxplot of pre- and post-operative MDAS scores in the mildly anxious IHS group

Fig. 6 Boxplot of pre- and post-operative MDAS scores in the LA group

Fig. 7 Histogram of male and female pre- and post-op MDAS scores

between the mean female pre- and post-operative MDAS scores was greater than the fall between the mean male MDAS scores in the moderate to severely anxious IHS group (a score of 4.08 compared with 3.08). In contrast, the mean male MDAS scores in the mildly anxious IHS and LA groups showed only small post-operative decreases. However, the mean differences between pre- and post-operative female MDAS scores in these two groups were negligible to none.

The mean pre- and post-operative MDAS scores for each patient group with their standard deviations and p values are shown in Table 4. Notably the biggest difference was in the moderate to severely anxious IHS group, which demonstrated a statistically significant fall of 3.68 points between the mean pre- and post-operative MDAS scores ($p = 0.000$). The null hypothesis was therefore rejected for this group. The IHS mildly anxious group demonstrated a mean decrease between pre- and post-operative MDAS scores of 0.070 ($p = 0.392$). The LA group showed a mean decrease of MDAS scores of 0.229 ($p = 0.227$). Neither of these differences was statistically significant.

DISCUSSION

The cut-off (MDAS ≥ 11) score for the moderate to severely anxious patient group was obtained from Freeman, Clarke and Humphris' work on conversion tables from CDAS to MDAS, whereby a CDAS score of 8 (mild anxiety) is equivalent to an MDAS score of 10.¹⁰ This allowed the mildly anxious group to be evaluated separately as to include all the IHS patients in one group would have skewed the results. In the moderate-severely anxious group 50% of the patients had an MDAS score of ≥ 19 as shown in the boxplot for this group – the median pre-operative MDAS score was 19 (Fig. 4). Thus the scores in this group were reasonably distributed between 11 and 25, which minimised any skewing of the data.

The inclusion criteria were deliberately narrow to try and limit confounding variables as much as possible. Not including patients on any prescription medicines, for example, meant that the possible influence of any mood-altering medication was eliminated. Further aspects that helped to limit confounding factors were staff and premises continuity. Additionally, patients

in the moderate to severely anxious IHS group (compared with an MDAS score of 15.6 for their male counterparts). The other

two groups had similar pre-operative mean female MDAS scores, also higher than the equivalent male MDAS scores. The fall

Table 4 Pre- and post-operative MDAS scores with their standard deviations and p values

Patient groups	Mean pre-op MDAS	Standard deviation	Mean post-op MDAS	Standard deviation	Difference between pre- and post-op MDAS scores	p value
IHS MDAS 11–25 moderate-severe anxiety (n = 60)	16.48	4.03	12.80	4.38	3.68	0.000
IHS MDAS 5–10 mild anxiety (n = 43)	7.44	1.75	7.37	2.16	0.07	0.392
LA (n = 35)	7.20	2.83	6.97	2.55	0.23	0.227

were always asked to complete their pre-operative forms in the waiting room by the receptionist before their assessment and post-operative forms were also completed in the waiting room after treatment in a similar manner.

Humphris *et al.* has demonstrated that anxiety falls with increasing age with individuals over 60 years old being generally less anxious than their younger contemporaries.^{8,12} He has shown additionally that females are more anxious than males, regardless of age.^{8,12} This was also demonstrated in two of the three patient groups in this investigation: the moderate to severely anxious and LA groups had a greater proportion of females (Table 3). Numbers in the mildly anxious group were similar – perhaps a reflection of the sample size (although the LA group was smaller). Interestingly, while the mean female pre-operative MDAS score was higher than that of the males in the moderate to severely anxious group (17.19 compared to 15.6), the mean fall between female pre- and post-operative MDAS scores was greater than that of their male counterparts, 4.08 compared with 3.08 (Fig. 7).

The nitrous oxide dose was recorded for each patient as shown on the Matrix MDM® machine used (unchanged throughout). The machine had a 5% calibration error in favour of oxygen, so the recorded nitrous oxide levels were slightly higher than the actual doses delivered. The mean recorded levels for the IHS groups were 45–48% (Table 2). These levels were not dissimilar to other studies (Berge⁵ 46.9%, Zacny *et al.*¹⁵ 38.3–40.6%) and a number of authors have used 50% N₂O.^{16–18}

A greater number of surgical procedures were carried out in the mildly anxious IHS group – approximately double that of the other two groups (Fig. 3). This is not surprising as one of the main indications

for conscious sedation is ‘to enable an unpleasant procedure to be carried out without distress to the patient’.¹ The surgical removal of a tooth can be unpleasant even for mildly anxious individuals and therefore the administration of IHS is entirely justified.

Unfortunately it was impossible to match each patient group in terms of numbers. This was a drawback when attempting to compare t-test results between groups. Nonetheless, even if numbers had been the same, standard deviations would still have been variable between groups owing to the smaller range in MDAS scores of the mildly anxious and LA groups.

If the power test is rerun with a standard deviation of two points the sample size required is computed to be nine per group. Thus the mildly anxious IHS and LA groups both had sufficient numbers to run paired t-tests.

It is worth noting that treatment itself has been shown to decrease dental anxiety¹⁹ – however, the significant fall in anxiety levels in the moderate to severely anxious group cannot be explained by this alone as treatment was one of the common factors across the groups.

Collado *et al.*¹⁸ demonstrated an improvement in cooperation in a group of 164 patients who underwent dental treatment with a 50% N₂O/O₂ premix over the course of three or more sessions. Zacny *et al.*¹⁵ also documented a reduction in anxiety levels of a group of 46 patients receiving 38–40% N₂O. Possibly, the lack of amnesic effect of nitrous oxide helps patients to remember the sense of wellbeing it gives them which decreases anxiety and increases cooperation for future procedures.

Additionally, the fact that no groups’ mean anxiety levels increased after treatment not only supports the use of IHS for

selected patients undergoing oral surgery but also provides assurance that these patient groups achieved adequate levels of anxiety management with IHS.

While initially it seems that the alternative hypothesis holds true for the moderate-severely anxious IHS group, these results must be interpreted with caution. It is difficult to compare the three groups directly owing to the variables within them. Standardising the groups would not be possible without a randomised controlled trial but this is hardly ethical when treating moderate to severely anxious patients who require sedation, a sentiment echoed by Zacny *et al.*¹⁵ This was also well demonstrated in Venchard *et al.*'s work when they were unable to randomise surgical patients into an IHS group and had to abandon this part of their study because the patients had been unable to have their surgical treatment completed.²⁰ This evaluation effectively demonstrates that it is entirely possible to treat patients surgically with IHS alone, providing they are adequately assessed and selected pre-operatively.

CONCLUSION

The aims of this investigation were two-fold. The primary outcome was to determine whether IHS would decrease anxiety levels in moderate to severely anxious patients undergoing MOS procedures. The second outcome (the service evaluation aspect) was to ensure that anxiety scores were not increasing in any patient group and thus to establish that patients were receiving appropriate anxiety management.

It appears that the null hypothesis is not supported for moderate to severely anxious adults treated under IHS and that their anxiety levels do fall post-operatively. This result needs to be interpreted with some

caution, however, as there are several confounding factors unaccounted for.

Nonetheless, these results are extremely encouraging. They fully support the use of nitrous oxide in mild, moderate and severely anxious adult patients in oral surgery but careful patient selection is vital.

The results also indicate that this cohort of patients treated in this primary care specialist oral surgery service have received adequate anxiety management which has not increased their dental anxiety for future dental procedures.

1. Standing Dental Advisory Committee, Department of Health. *Conscious sedation in the provision of dental care: report of an expert group on sedation for dentistry*. London: Department of Health; 2003.
2. Faculty of Dental Surgery Royal College of Surgeons of England. *Standards for conscious sedation in dentistry: alternative techniques*. London: FDS RCS (Eng); 2007.
3. The National Clinical Guideline Centre. *Sedation in children and young people*. London: NICE, 2010.
4. Needleman H L. Conscious sedation for paediatric outpatient dental procedures. *Int Anesthesiol Clin* 1989; **27**: 102–108.
5. Berge T I. Acceptance and side effects of nitrous oxide oxygen sedation for oral surgical procedures. *Acta Odontol Scand* 1999; **57**: 201–206.
6. Department of Health. *A conscious decision. A review of the use of general anaesthesia for dentistry*. London: Department of Health; 2000.
7. Kaufman E, Chastain D C, Gaughan A M, Gracely R H. Staircase assessment of the magnitude and time-course of 50% nitrous-oxide analgesia. *J Dent Res* 1992; **71**: 1598–1603.
8. Humphris G M, Morrison T, Lindsay S J. The Modified Dental Anxiety Scale: validation and United Kingdom norms. *Community Dent Health* 1995; **12**: 143–150.
9. Corah N L. Development of a dental anxiety scale. *J Dent Res* 1969; **48**: 596.
10. Freeman R, Clarke H M, Humphris G M. Conversion tables for the Corah and Modified Dental Anxiety Scales. *Community Dent Health* 2007; **24**: 49–54.
11. Corah N L, Gale E N, Illig S J. Assessment of a dental anxiety scale. *J Am Dent Assoc* 1978; **97**: 816–819.
12. Humphris G M, Dyer T A, Robinson P G. The modified dental anxiety scale: UK general public population norms in 2008 with further psychometrics and effects of age. *BMC Oral Health* 2009; **9**: 20.
13. Humphris G M, Freeman R, Campbell J, Tuutti H, D'Souza V. Further evidence for the reliability and validity of the Modified Dental Anxiety Scale. *Int Dent J* 2000; **50**: 367–370.
14. Newton J T, Edwards J C. Psychometric properties of the modified dental anxiety scale: an independent replication. *Community Dent Health* 2005; **22**: 40–42.
15. Zacny J P, Hurst R J, Graham L, Janiszewski D J. Preoperative dental anxiety and mood changes during nitrous oxide inhalation. *J Am Dent Assoc* 2002; **133**: 82–88.
16. Onody P, Gil P, Hennequin M. Safety of inhalation of a 50% nitrous oxide/oxygen premix: a prospective survey of 35,828 administrations. *Drug Saf* 2006; **29**: 633–640.
17. Ong K S, Seymour R A, Tan J M. A prospective randomized crossover study of the preemptive analgesic effect of nitrous oxide in oral surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; **98**: 637–642.
18. Collado V, Hennequin M, Faulks D *et al*. Modification of behaviour with 50% nitrous oxide/oxygen conscious sedation over repeated visits for dental treatment a 3-year prospective study. *J Clin Psychopharmacol* 2006; **26**: 474–481.
19. Jöhren P, Jackowski J, Gängler P, Sartory G, Thom A. Fear reduction in patients with dental treatment phobia. *Br J Oral Maxillofac Surg* 2000; **38**: 612–616.
20. Venchard G R, Thomson P J, Boys R. Improved sedation for oral surgery by combining nitrous oxide and intravenous midazolam: a randomized, controlled trial. *Int J Oral Maxillofac Surg* 2006; **35**: 522–527.