Does relative analgesia with nitrous oxide reduce the number of general anaesthetic sessions and dental loss?

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Key points

- Suggests relative analgesia (RA) is an effective and reliable alternative to general anaesthesia (GA).
- Highlights that significant savings can be made by choosing RA.
- Discusses how, because RA carries a lower level of risk than GA, a more conservative treatment plan can be applied, thus saving more adult and deciduous teeth.
- Indicates that more than one appointment is often needed to finish the treatment using RA; so, an adjustment to the way that RA is being funded at present is required.

Background The use of general anaesthesia (GA) in dentistry is discouraged in all but essential cases. The use of sedation techniques, including relative analgesia (RA), is encouraged to reduce the demand for GA. **Aim** The research objective was to determine if RA reduces the number of GA administrations and teeth extracted. **Method** A service evaluation of the referrals for GA to the Community Dental Service South West of Cornwall over a period of two years and two months. **Results** The results showed that 88% of the referrals could be managed with RA rather than sedation. A total of 105 administrations of GA were avoided and 141 teeth restored which would have been extracted from the population of 118 patients. **Conclusions** The main conclusions drawn from this study are that RA is an effective alternative to GA and a number of teeth can be saved by opting, when appropriate, for this treatment option. It was also found that RA has a negligible morbidity rate.

Introduction

The ever-growing waiting lists for general anaesthesia (GA) exodontias compounded by a Conscious Sedation Service that is under-funded and overwhelmed prompted this service evaluation. The data collected will be used to support the expansion of the Relative Analgesia (RA) Service in Cornwall as well as providing valuable data for other potential service providers.

The aims of this study were to:

1. Establish the efficacy of the RA treatments provided over the course of two years and two months by one dentist with a part-time community role at West Country Dental Care (WCDC)
2. To determine if RA effectively reduces the need for expensive and higher risk GA sessions
3. To determine if RA also reduces the number of teeth extracted.

This study is important to provide evidence to the need for more appropriate and realistic funding of the Conscious Sedation Service.

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Literature review

Several authors have investigated the role of RA in the management of anxious children and compared it with GA in terms of effectiveness, morbidity, number of sessions needed and age of the patients.

Effectiveness/success rate

Blain & Hill,[1] Crawford,[2] Shaw *et al.*[3] and Shepherd & Hill[4] studied patients (mostly children) referred for extraction and found success rates for treatment under RA varying between 83.4 and 96.7%. The samples sizes used in these studies ranged from 53–265 patients. None of these trials were randomised controlled trials, and thus the evidence level is not as high as would be desired. The consistency in the success rates does, however, add weight to the evidence of efficacy.

Foley[5] studied the efficacy of inhalation sedation for other types of dental treatment in 312 children and a success rate of 93% was found for a range of dental treatments, including minor oral surgery procedures, endodontics, restorative dentistry and impression taking. This author also found that the operator experience is inversely proportional to the length of appointments but did not establish a link with success rate.

The studies cited above all used a titrated dose of nitrous oxide in oxygen as per current recommended practice.[6]

Some authors have investigated the use of a fixed dose of nitrous oxide. Cooper *et al.*[7] found a success rate of 92% on 22 patients aged between 16 and 57 when a fixed concentration of 25% nitrous oxide was used.

Lindsay & Roberts[8] published a single blind trial, aimed at 22 children aged 5–11, comparing nitrous oxide to control, where the patient and relatives were blinded as to the medical gas received. In this study, there appeared to be no significant difference between active treatment and control.

More recent studies by Foley[9] and Burnweit *et al.*[10] have suggested that RA is a good

Table 1 Reasons for patients being unable to cope with RA and their ages

	Age	Reasons for not accepting RA
Unsuccessful RAs	6	Did not like the sound and feel of both handpieces
	6	Does not like the feel of the bur
	7	Unable to cope with the nosepiece
	7	Unable to cope with the nosepiece
	7	Unable to cope with the nosepiece
	8	Unable to cope with the nosepiece
	9	OK with the RA but unable to cope with the treatment
	14	Unable to cope with the nosepiece

alternative to GA for a range of procedures both dental and non-dental on a sample of 150 to 166 patients aged 10 to 20.

Lyratzopoulos & Blain[11] concluded, in a review, that the evidence supporting the practice of RA was of poor quality.

Cost

Data produced by the National Institute for Health and Care Excellence,[12] showed that the cost per child treated at a primary care-based sedation referral service was £273.01 (including the cost of the assessment appointment) compared with £719.90 which was the cost of a general anaesthetic in hospital. The difference in costing is due to the lower staffing levels involved in sedation. It can be argued that this data, albeit the most up-to-date available, is outdated by six years, but it is a reasonable belief that the cost differential between the two treatment options will still be maintained.

Patient age

Bryan[13] assessed the outcomes of treatment with RA in relation to the patient's age and found a high failure rate on patients aged seven or younger, possibly because they lack the communication skills and maturity to understand and respond to basic commands and suggestions by the dentist. This is also supported by other studies.[1,5]

Morbidity

The risks of a carefully titrated dose of N_2O are negligible due to the fact that the N_2O is eliminated via pulmonary ventilation, thus ensuring a quick recovery and reversal of any potential side-effects.[14]

However, diffusion hypoxia can occur if the N_2O is administered without appropriate recovery time with supplemental O_2. In this instance, the alveolar O_2 is diluted due to the rush of N_2O from the blood to the lungs. Nevertheless, as mentioned before, this condition can be easily avoided by administering supplemental O_2 post-treatment for 2 to 3 minutes.[15]

Several authors reported less morbidity associated with RA than with GA and stated that the morbidity level when using RA is 10% or lower.[3,4,10,11,16] In all these articles, headaches, nausea and vomiting were the most common side-effects.

Moreover, Bridgman *et al.*[17] and Rodd *et al.*[18] also stated that morbidity during induction and post-GA was common and found that symptoms such as nausea, vomiting, sickness and psychological trauma were the most frequent while Atan *et al.*[19] reported pain and drowsiness as the most frequent symptoms post-GA and stated that these depended on anaesthetic time.

Number of sessions and treatment times

Several authors[1,3–5,7,9] stated that they required one to three RA sessions to complete the treatments and that the average appointment times (including acclimatisation, treatment and recovery time) varied between 30–45 minutes per session. Only Veerkamp *et al.*[20] stated that three to nine sessions were needed. The significance of this is that the way that sedation is being funded does not reflect the increased number of visits that this treatment modality requires when compared to GA. This was also supported by Landes.[21]

Nevertheless, other authors[1,2,4] provided treatments under GA in one session and even though the operating times were considerably shorter (between 5–30 mins depending on the type of procedure), the pre-anaesthetic and recovery times were significantly longer.

Table 2 Number of appointments required for RA

Appointments	Totals	%
1	58	49%
2	26	22%
3	21	18%
4	11	9%
5	2	2%
Totals	**118**	**100%**

Fear at sequential visits

Studies by Veerkamp *et al.*[22] and Nathan *et al.*[23] concluded that RA allows learning to occur and, consequently, fear levels to decrease during sequential visits. Conversely, with GA the patient experiences the amnesic effect of the general anaesthetic, losing the ability to learn from this experience.

Nevertheless, there is no available research on the number of teeth that could be potentially saved if the patients had been treated with RA instead of GA. It is a well-known fact that treatment planning for GA is more radical, to prevent a repeat GA with its associated risks; consequently, this service evaluated the success rate of treatments under RA and established the number of teeth saved by choosing this as a treatment option for this cohort of patients.

Methodology

The data was collected by a part-time community dental officer with limited sedation experience over a period of two years and two months, and consisted of a convenience sample of 118 children and young adults who were referred to WCDC in the West of Cornwall.

No fillings were offered under GA other than in exceptional circumstances (that is, patients with severe learning disabilities or children under 18 who could not tolerate treatment under RA). Intra-venous sedation or oral sedation were not provided for patients aged 18 or under within this service.

The inclusion criteria consisted of patients without a learning disability, aged between four and 18 with a mild to moderate anxiety towards dental treatment and who were willing to try RA.

Exclusion criteria covered patients under four or over 18 years old, those who had a learning disability or lacked the maturity and communication skills to be treated under RA or had ASA (American Society of Anaesthesiologists) status of three or more.

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Fifteen patients were excluded from this study because they were over 18 years old.

In addition to the routine clinical notes, further data were recorded on Microsoft EXCEL and several parameters were logged including: type of treatment provided, which teeth were treated, maximum amount of N_2O and litres per minute flow (LPM flow), number of visits required, the number of teeth saved (if any) by avoiding a GA, and the number of Special GAs or GAs saved (if any). A special GA is a GA where adults and children with special needs, who are unable to cope with dental treatment by any other means, receive dental treatment (fillings, extractions or root canal treatment as appropriate).

When the patients were able to cope with RA but only for part of their dental treatment (fillings, for example) and required a GA for the extractions, a YES* note was made on EXCEL on the column labelled as 'Success' and both columns labelled 'Saved XGA' and 'Saved Special GA' were left blank.

However, for the patients who were uncooperative for treatment under RA, an entry on EXCEL was then made as NO on the 'Success' column and a reason for this was added. Consequently, the columns labelled 'Saved Special GA' and 'Saved XGA' were left blank. Conversely, for those patients who had all the required treatment under RA, YES was written on the 'Success' column.

The calculation of the number of deciduous teeth saved by avoiding a GA was noted on EXCEL, by recording the teeth that were restorable but would have been extracted had the patient/parent chosen to proceed with the treatment under GA instead.

Similarly, the number of saved permanent teeth was also calculated, following The Royal College of Surgeons Faculty of Dental Surgery guidelines,[24] based on the premise that if the patient had opted for the GA and:

1. The tooth was restorable, the patient would have lost this tooth because, as stated before, no fillings are provided under GA. An entry such as 'X permanent teeth saved' was then inserted on EXCEL, in which 'X' was replaced by the number of teeth saved
2. The tooth was not restorable an '–' entry was inserted on EXCEL, meaning that no adult teeth were saved.

After collecting all the data and grouping it into the relevant categories, the data in each category was analysed to answer the strategic research objective set out at the beginning of this service evaluation.

Results & discussion

Success/effectiveness rate

A success rate of 88% was found. This is consistent with the results found by other authors[2,3,5,7] while Blain & Hill[1] established a slightly lower rate of success at 83.4% and Shepherd & Hill[4] a much higher rate of 96.7%.

In this service evaluation the main reasons for the referrals were pain, sepsis or both, and only 3% of this sample were referred for orthodontic extractions. This contrasts with studies by other authors whose patients were either referred solely for orthodontic reasons[3,4] or this was the referral reason for 50% of their data.[5] In fact, pain and sepsis were exclusion factors for the majority of the cases cited in the literature review.

The only authors who included emergency dental extractions for pain relief were Cooper *et al.*[7] and they recorded a success rate of 92%. Nevertheless, the patients in their sample were aged between 16 and 57 years old and as shown on the literature review, age can affect the success rate. It could be argued that pain and sepsis could reduce the success rate of RA, as patients presenting with symptoms are likely to be more challenging to treat; thus, a reduced success rate was to be expected for the service evaluation described in this article, but was not observed.

Indeed, RA was only unsuccessful in 7% of the cases and partially successful in 5% of the patients seen, meaning that the latter were able to tolerate fillings under RA but required a GA for the extractions.

RA non-compliance was mostly due to a sense of claustrophobia caused by the nosepiece. Only two patients could not accept the treatment because they did not like the feel of the fast/slow handpiece.

Nevertheless, one patient could cope with the RA itself but was still unable to accept any dental treatment. This was probably the result of underestimating the level of phobia of this patient, which in this case, was high.

Age

The age range in this service evaluation lies between 4 and 18, the mean being 7.8 and the mode 7. These findings are consistent with the samples of the majority of the studies discussed in the literature review[1,3,5,25] while other authors opted to reduce the age range.[8,9,20]

In this service evaluation a choice was made to include patients aged 7 or under, even though this could compromise the RA's success rate.[1,13,25] Table 1 describes the reasons why the patients in this service evaluation were unable to cope with treatment under RA and includes their relative ages. As can be seen in Table 1, 62.5% of these patients were aged 7 or under.

Morbidity

There was no morbidity reported by any of the patients in this study in this study as none of the patients reported feeling sick, having headaches or any of the most frequent symptoms associated with over-sedation with RA. This is significantly lower than the results found by other authors.[3,4,10,16]

Table 3 Types of dental treatment under RA

Types of dental treatment	Totals	%
Extractions only	38	32%
Extractions and fillings	9	8%
Fillings only	56	47%
Fillings and sealants	5	4%
Sealants only	2	1%
RA trial	3	3%
No treatment	4	4%
Stone and Smooth one deciduous tooth	1	1%
Totals	**118**	**100%**

Table 4 Number of teeth saved

Saved:	Totals
Deciduous teeth	34
Permanent teeth	107
Totals	**141**

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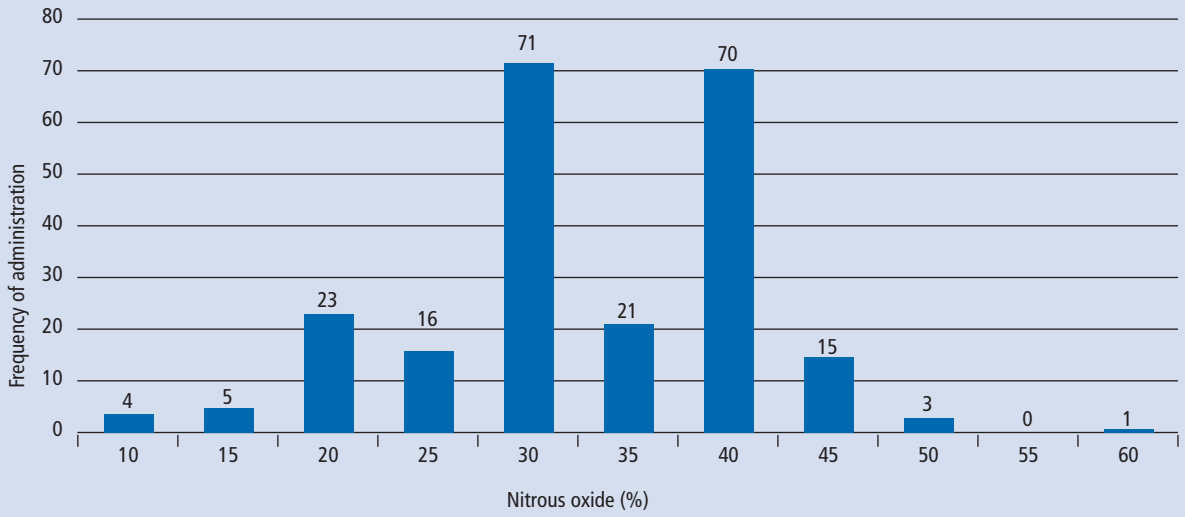
Fig. 1 Frequency of admistration of amount of nitrous oxide (%)



Number of sessions and types of dental treatment

Table 2 shows the number of appointments required to complete the treatments provided under RA; on just under half of the cases, the treatments were completed in a single visit. In 89% of the cases, treatment was completed in three appointments, at most.

The above findings are consistent with the results found by Shaw *et al.*[3] even though that study was based on patients requiring orthodontic extractions only, whereas in the current service evaluation described here, 97% of the patients seen were referred for other reasons (uncooperativeness, pain/sepsis).

However, Shepherd & Hill[4] and Blain & Hill[1] did not need more than one appointment to treat their patients. The former, only did extractions under RA and the latter did not perform extractions at all. This suggests that the type of treatments provided can dictate the number of appointments required. For this reason, a more appropriate and realistic funding of treatment under RA, reflecting that more than one RA sessions may be needed to finish a course of treatment, is needed.

Table 3 shows the diversity of treatments provided during RA in this service evaluation. The majority of treatments consisted of extractions or fillings (roughly 80%) and, at 8%, a combination of fillings and extractions on the same appointment.

Amount of N_2O and flow

The mode for the flow rate was 6 litres per minute (LPM). The most frequent doses of N_2O administered in the RA sessions audited were 30% and 40%, administrated to 71 and 70 patients, respectively. Figure 1 shows how often the amounts of N_2O were administered in this service evaluation.

None of the N_2O amounts shared the same number of administrations (there was no mode). The range was 71 as the number of administrations varied from 0 to 71.

Only 18 patients (16%) required doses of nitrous oxide in excess of 40% and a concentration of 60% was used for one single patient.

The mean was 32.86% which signifies that of a total of 229 N_2O administrations, 110 were above the mean and 119 were below. The variance was 36.12 and this is an indicator of how far the N_2O administrations spread out from the mean. In this case, it is safe to say that the majority of administrations fell near the mean. This is further supported by the standard deviation from the mean which was 6, suggesting that the results of the sample were close to the mean.

It is not unusual to use up to 40% of N_2O for dental procedures.[1,4,5] A maximum of 50% was used by Burnweit *et al.*[10] while Cooper *et al.*[7] decided to use a fixed amount of 25%.

Number of teeth saved

The number of teeth saved is shown in Table 4. A total of 141 teeth were saved by opting for RA which is not surprising because, as stated before, this treatment option allows for a more conservative approach to treatment planning that the risk of a repeat GA makes impossible. Crawford[2] also supports this explanation. Of the saved teeth, 107 were permanent teeth.

Number of GA sessions (special GAs and exodontias GAs) saved and costs

A total of 85 exodontia GAs and 20 special GAs were also saved by attempting treatment under RA. A description of these results can be found in Figure 2.

There are previous no studies looking at this aspect of RA use and so a comparison to previous studies is impossible.

Nevertheless, when considering that, according to NICE,[12] and as mentioned previously in this article, a GA session in hospital costs approximately £719.90, saving 85 GA sessions saved £61,191.50 and avoiding 20 special GAs saved £14,398; again, these resources could fund 277 RA sessions at £273.01 each, including the cost of the assessment appointment.

It can be argued that, and as discussed previously, this data, albeit the most up-to-date available, is outdated by six years, but it is reasonable to think that the cost difference between the two treatment options will still be maintained.

The patients in this study were referred by the GDPs for treatment under GA. Given the success rate of 88%, it would be more appropriate for these patients to be referred for treatment under RA, or RA or GA as clinically indicated. This would mean that patients and parents would not arrive at the assessment appointment expecting treatment under GA.

Conclusions

The quality of the previous studies available is poor and more good quality studies looking at this topic are needed. There are

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no randomised control trials or high quality double blind papers and none of the available studies considered the number of GAs saved by treating with RA or the number of teeth saved that would otherwise be extracted if the patients were to be treated under GA.

In terms of effectiveness, the results of this service evaluation showed that RA has an 88% effectiveness/success rate and shows 0% morbidity, meaning that RA is a reliable, less risky and an effective way of treating children who would otherwise require a GA for treatment; treatment which, would mostly consist of extractions.

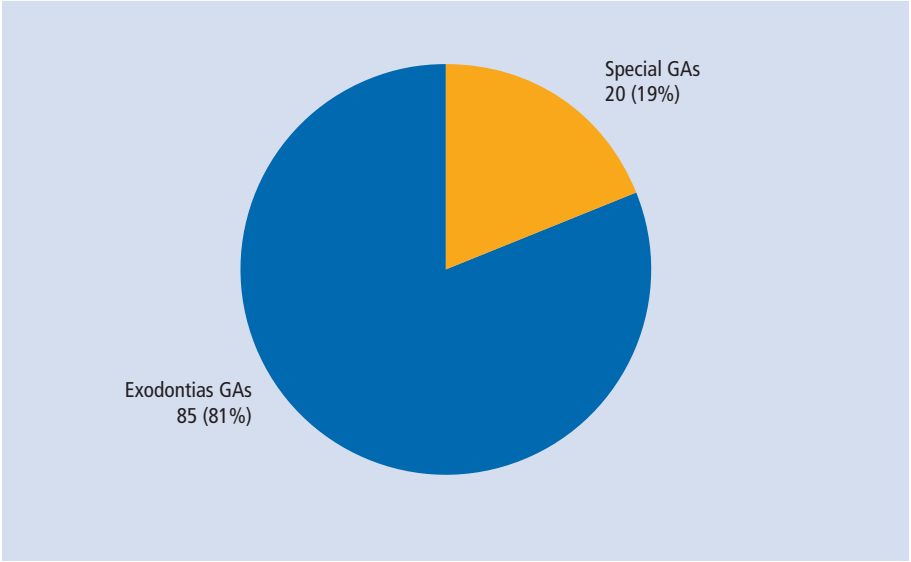
The success rate demonstrated by this study shows that these patients could be referred for sedation rather than GA, which suggests the need to better train referrers to make more appropriate referrals.

Moreover, in approximately 50% of the cases, RA did not seem to require more than one appointment for the conclusion of the treatment, even though the treatments provided were varied in nature and not limited to extractions only. However, an adjustment to the way that RA is being funded at present is needed, reflecting that on the other 50% of cases, more than one appointment was required to finish a course of treatment.

Furthermore, 105 GAs (exodontia GAs and special GAs) were avoided by successfully treating patients with RA, not only saving 141 teeth but also producing cost savings of £75,589.50.

The results of this service evaluation should be communicated to the GDPs within the area covered by WCDC, so that those who refer are aware of the efficacy of the service offered.

Fig. 2 Saved special GAs/XGAs



1. Blain K, Hill F. The use of inhalation sedation and local anaesthesia as an alternative to general anaesthesia for dental extractions in children. *Br Dent J* 1998; **184:** 608–611.
2. Crawford A. The Use of nitrous oxide-oxygen inhalation sedation with local anaesthesia as an alternative to general anaesthesia for dental extractions in children. *Br Dent J* 1990; **168:** 395–398.
3. Shaw A, Meechan J, Kilpatrick N, Welbury R. The Use of Inhalation Sedation and Local Anaesthesia Instead of General Anaesthesia for Extractions and Minor Oral Surgery in Children: a Prospective Study. *Int J Paediatr Dent* 1996; **6:** 7–11.
4. Shepherd A, Hill F. Inhalation Sedation Compared with General Anaesthesia for Orthodontic Extractions. *Br Dent J* 2000; **188:** 329–331.
5. Foley J. A Prospective Study of the Use of Nitrous Oxide Inhalation Sedation for Dental Treatment in Anxious Children. *Eur J Paediatr Dent* 2005; **6:** 121–128.
6. The Royal College of Surgeons of England. Standards for Conscious Sedation in the Provision of Dental Care. 2015. Available at https://www.saad.org.uk/images/Linked-IACSD-2015.pdf (accessed April 2017).
7. Cooper J, Jobling D, Edmund D. Sedation for Minor Oral Surgery: Inhalation sedation with 25% Nitrous Oxide. *J Dent* 1978; **6:** 265–267.
8. Lindsay S, Roberts G. Methods for Behaviour Research on Dentally Anxious Children. The Example of Relative Analgesia. *Br Dent J* 1980; **149:** 175–179.
9. Foley J. Paediatric Minor Oral Surgical Procedures Under Inhalation Sedation and General Anaesthetic: a Comparison of Variety and Duration of Treatment. *Eur Arch Paediatr Dent* 2008; **9:** 46–50.
10. Burnweit C, Diana-Zerpa J, Nahmad M *et al.* Nitrous Oxide Analgesia for Minor Paediatric Surgical Procedures: An Effective Alternative to Conscious Sedation?. *J Paediatr Surg* 2004; **39:** 495–499.
11. Lyratzopoulos G, Blain K. Inhalation Sedation with Nitrous Oxide as an Alternative to Dental General Anaesthesia for Children. *J Pub Health Med* 2003; **25:** 303–312.
12. National Institute for Health and Care Excellence. Sedation in under 19s: using sedation for diagnostic and therapeutic procedures. Available at: http://www.nice.org.uk/guidance/cg112/resources (accessed February 2016).
13. Bryan R. The Success of Inhalation Sedation for Comprehensive Dental Care Within the Community Dental Service. *Int J Paediatr Dent* 2002; **12:** 410–414.
14. The Intercollegiate Advisory Committee for Sedation in Dentistry (IACSD). 2015. Available at https://www.rcoa.ac.uk/system/files/PUB-STDS-CONSC-SEDN-DNTL-2015.pdf (accessed October 2017).
15. Luhmann, J, Kennedy R. Nitrous Oxide in the Paediatric Emergency Department. *Clin Paediatr Emerg Dent* 2000; **1:** 285–289.
16. Hallonsten A, Koch G, Schroder U. Nitrous Oxide-Oxygen Sedation in Dental Care. *Community Dent Oral Epidemiol* 1983; **11:** 347–355.
17. Bridgman C, Ashby D, Holloway P. An Investigation of the Effects on Children of Tooth Extraction Under General Anaesthesia in General Dental Practice. *Br Dent J* 1999; **186:** 245–247.
18. Rodd H, Hall M, Deery C, Gilchrist F, Gibson B, Marshman Z. 'I Felt Weird and Wobbly'. Child-Reported Impacts Associated with a Dental General Anaesthetic. *Br Dent J* 2014; **216:** 1–5.
19. Atan S, Ashley P, Gilthorpe M, Scheer B, Mason C, Roberts G. Morbidity Following Dental Treatment of Children Under Intubation General Anaesthesia in a Day-Stay Unit. *Int J Paediatr Dent* 2004; **14:** 9–16.
20. Veerkamp J, van Amerongen W, Hoogstrate J, Groen H. Dental Treatment of Fearful Children, Using Nitrous Oxide. Part I: Treatment Times. *J Dent Child* 1991; **58:** 453–457.
21. Landes D. The Provision of General Anaesthesia in Dental Practice, an End Which Had to Come? *Br Dent J* 2002; **192:** 129–131.
22. Veerkamp J, Gruythuysen R, van Ameronge W, Hoogstraten J. Dental treatment of fearful children using nitrous oxide. Part 3: Anxiety during sequential visits. *J Dent Child* **1993:** 60**:** 175–182.
23. Nathan J, Venham L, West M, Werboff J. The Effects of Nitrous Oxide on Anxious Young Paediatric Patients Across Sequential Visits: a Double-Blind Study. *J Dent Child* 1988; **55:** 220–230.
24. Cobourne, M, Williams, A, Harrison M. A Guideline for the Extraction of First Permanent Molars in Children. 2014. Available at https://www.rcseng.ac.uk/-/media/files/rcs/fds/publications/a-guideline-for-the-extraction-of-first-permanent-molars-in-children-rev-sept-2014.pdf?la=en (accessed April 2016).
25. Tyrer G. Referrals for Dental General Anaesthetics – How Many Really Need GA? *Br Dent J* 1999; **187:** 440–443.