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Inhalation sedation with nitrous oxide as an alternative to dental general anaesthesia for children

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Summary

This review paper examines (using systematic methodology) the evidence for the use of inhalation sedation (IHS) instead of dental general anaesthesia (DGA) for dental treatment. It finds that this is an area of healthcare lacking high-quality clinical evidence (i.e. derived from randomized controlled trials). However, evidence from seven case series studies (level of evidence 3) of variable quality and design is examined. Those studies suggest that IHS is effective for a large proportion (83–97 per cent) of selected subgroups of children who would have otherwise required DGA. This may represent 45–64 per cent of all children who are referred for DGA. There is a remarkable degree of consistency between all studies in the reported treatment effectiveness of IHS, despite differences in design and populations treated. IHS is particularly suitable for orthodontic treatment, for older children, and for children requiring no more than four extractions. Morbidity associated with IHS is minor and infrequent, and user satisfaction is high, or higher compared with DGA. Comparing with DGA, IHS requires significantly longer time per episode and more treatment sessions per patient. In teaching dental hospitals, staffing costs for IHS are estimated to be cheaper by about a third compared with outpatient DGA. Indications for further areas of research are made.

Keywords: inhalation sedation, dental, anaesthesia, children

Introduction

General anaesthesia is still widely used in the United Kingdom for dental extractions particularly for children. Following many reports but most notably the Poswillo Report of 1990,[1] there were changes in the guidance from the General Dental Council (GDC) to dentists about the standard of care including equipment and personnel required for dental general anaesthesia (DGA). Initially this caused a decrease in the number of general anaesthetics being given for dental treatment. Centres were then set up in many Health Authority areas – some in dental practices and some in the Community Dental Service (CDS) – offering referral services for DGA. This increased general anaesthetic provision. In 1998–1999, there were about 65 000 episodes of dental general anaesthesia (DGA) performed by the CDS in England.[2] During the same year there were over 41 000 DGA episodes administered in the NHS in Scotland.[3] The majority of patients in both areas were children under 16 years of age.

However, in 1998, there were several highly publicized fatalities of patients receiving DGA in dental surgeries. One of these fatalities resulted in a criminal conviction. In November 1998, the GDC issued reviewed guidance to dentists[4] requiring that a general anaesthetic for dental treatment be given by a medically qualified anaesthetist on the specialist register of the General Medical Council or by a trainee or non-consultant NHS career grade under the supervision of a named consultant. After this, the Department of Health published a review of the use of sedation and general anaesthesia in Primary Dental Care *A conscious decision*'.[2] This recommended that from 2002, DGA should only be performed in 'hospital settings with critical care facilities'. This recommendation was adopted by the Chief Dental Officer and the Department of Health.[5] Consequently, there has been an increase in demand and waiting times for DGA in hospitals.

The *Conscious decision* document encourages 'the promotion of alternatives to general anaesthesia such as local anaesthesia and conscious sedation'.[2] Conscious sedation has been defined as:

'A technique in which the use of a drug or drugs produces a state of depression of the central nervous system enabling treatment to be carried out, but during which verbal contact with the patient is maintained throughout the period of sedation. The drugs and techniques used to provide conscious sedation for dental treatment should carry a margin of safety wide enough to render loss of consciousness unlikely.

The level of sedation must be such that the patient remains conscious, retains protective reflexes, and is able to understand and to respond to verbal commands. "Deep sedation" in which these criteria are not fulfilled must be regarded as general anaesthesia.'[6]

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The majority of general anaesthetics are administered to child patients often for extractions.[2,3] Dental general anaesthesia involves a short session of anaesthetization, usually using a combination of intravenous and inhaled anaesthetic agents. Treatment is then carried out on the unconscious patient. A period of monitored recovery is required.

The *Conscious decision* report[2] together with recommendations from other agencies[1,6,7] indicates the usefulness of inhalation sedation (IHS) with a combination of nitrous oxide and oxygen for child outpatient sedation.

For dental treatment, IHS is administered using dedicated equipment, which allows the titration of nitrous oxide to sedative levels (usually concentrations of $\leq$50 per cent N_2O). This is delivered to the patient via a nasal mask to which appropriate scavenging equipment is also attached. Following a brief induction period, treatment is carried out usually with the administration of local anaesthesia while verbal contact with the patient is maintained. The sedative effect of IHS is readily reversible.[8,9] This form of sedation has a high safety record.[10]

In this document the term 'IHS' will refer to IHS with nitrous oxide in oxygen followed by administration of local anaesthesia unless otherwise stated.

Despite its simplicity IHS is under-provided in relation to DGA,[3,11,12] including to children having dental extractions for orthodontic reasons.[13,14] This present situation requires a strategic rethink of services for children referred for DGA, including a review of the available treatment options. Against this background we aimed to carry out a systematic review of the literature on IHS as an alternative to DGA for children.

Method

A systematic search of the literature was performed by the first author (G.L.). To ensure the search was systematic, a specific search question was constructed: 'What proportion of children judged untreatable without resort to DGA could complete or accept the planned dental treatment using inhalation sedation with Nitrous Oxide and local anaesthesia?'

An initial search was conducted with the text terms <*Dental* AND *Inhalation sedation*>, supplemented by additional searches using the terms < *Dental* AND *Conscious sedation* > and <*Dental* AND *Relative analgesia*>.

Following advice from the Senior Information Officer of the British Dental Association, an additional combined search using the subject headings <*Anesthesia, Dental* AND *Anesthesia, Inhalation* AND *Nitrous Oxide*> was also conducted. Electronic databases used were *Medline*, *EMBASE*, *CINAHL* and the Cochrane Library. The search was limited to English language, human subjects and publications post-1975 and was last performed in August 2002. Electronic searches were supplemented by citation tracking. The contents of the journals *International Journal of Paediatric Dentistry* (1991–2000) and *Dental Community Health* (1991–2000), and reference lists from three recent relevant key publications[2,6,7] were checked manually – with no added yield. Key authors who publish in this area were identified and their names used as search terms – no identified paper fulfilled the inclusion criteria. Four authors of UK-based studies were contacted and asked to supply details of any relevant unpublished work or published papers not identified by the primary search – this yielded two higher post-graduate degree theses relating to already identified published studies[15,16] and one audit survey in Scotland.[3] Four authors were contacted for supplementary information in relation to methodological details that were unclear and three responses were received.

Studies were included if they:

- reported on dental treatment using IHS with nitrous oxide (supplemented by local anaesthesia);
- reported on treatment of children;
- contained evidence of level 3 or higher, according to the Scottish Intercollegiate Guidelines Network;[17]
- included patients referred for DGA by a dental practitioner or fulfilling explicit criteria suggesting that conventional dental treatment (i.e. with local anaesthesia alone) was impossible;
- reported the rates of completion or acceptance of planned treatment among patients offered IHS.

Studies were excluded if they

- had no clear inclusion criteria for participating patients;
- reported only effects of IHS on physiological parameters (such as heart rate and oxygen saturation) or only examined pharmacological safety;
- included mainly other interventions, behavioural or medical, with or without IHS (e.g. hypnosis, behavioural management, administration of other oral, intravenous or inhaled agents);
- reported on fewer than 20 cases;
- included mainly adult patients or did not report results for children in subgroups;
- were non-systematic reviews or letters;
- were duplicate publications (wholly, or in part) of studies already included in the review.

Titles and abstracts of papers retrieved by the search were assessed against these criteria. If no abstract was available or no judgement could be safely made based on the abstract, the entire publication was reviewed. The second author (K.B.) independently reviewed the yield of the literature search previously performed and examined internal consistency of methodology against the pre-stated inclusion and exclusion criteria.

Results

Thirty-one papers were judged likely to fulfil the inclusion criteria and were accessed. Of those, 24 were excluded against the exclusion criteria (Table 1).[9,10,18–39] No randomized control trials (RCTs) examining the relative effectiveness of IHS compared with DGA in child patients were found. Seven non-analytical studies (case series), providing 'level 3' evidence,[17] met the search criteria and are reviewed below.

Table 1 Papers excluded from review, by applicable exclusion criteria*

Applicable exclusion criterion	Excluded studies (first author, reference)
No clear inclusion criteria	Rodrigo[18] Weinstein[19]
No reporting of treatment effectiveness (physiological or safety outcomes only)	Brook[20] Lindsay[21] Dunn-Russell[22] Primosch[23] Roberts[10] Cooper[24] Nathan[25] Trieger[26] Weinstein[19] Sher[27]
Mainly interventions additional to IHS with nitrous oxide used	O'Mullane[28] Shaw[29] Crawford[30] Warren[31] Parbrook[32] Major[33] Manford[34]
Study population <20	Blain[35]
Mainly adult patients or no separate reporting of results in children subgroups	Cooper[24] Rodrigo[18] Edmunds[36] Jastak[37]
Review papers or letters	Holroyd[9] Gillman[38]
Part-duplicate publication (with Shaw)[42]	Meechan[39]

*Some studies fulfil more than one exclusion criterion.

Study design of included studies (Tables 2 and 3)

The reviewed case series studies recruited selected patients who were offered treatment with IHS. Five studies were UK-based and two from Scandinavian countries. Two of the UK case series studies used comparative groups (patients offered treatment with DGA). No study was population-based. In total, 300 patients were treated with DGA and 1595 patients with IHS in the reviewed studies.

Comparative group selection (studies with a comparative group only)

In both studies[40,41] patients treated with IHS and DGA were derived from an identical 'pool' of patients, namely patients initially referred for DGA to a dental teaching hospital. In both studies, patients treated with IHS and DGA were of similar mean age. However, one study had an unbalanced sex distribution between the two groups,[40] and in the other study there was an imbalance in the mean number of teeth requiring extraction per patient favouring the IHS group.[41] There was no between-group contamination in either study.

Study samples and exclusion criteria

One of the two comparative studies used exclusion criteria, applied to both groups.[41] A high proportion of children (42 per cent) who could have in principle benefited from IHS were excluded against these criteria, and for an additional 4 per cent parental consent was refused – in total it was possible to offer IHS to 54 per cent of all patients.[41]

In one non-comparative study,[43] IHS was offered to 73 per cent of all children who could have in principle benefited from it, as 27 per cent were excluded because it was *a priori* judged that they could only be treated under DGA or because of parental request for DGA. The other studies either do not provide the number of excluded cases[42] or do not report exclusion criteria.[40,44–46]

Patient inclusion criteria

Four studies, including both comparative ones, recruited patients initially referred for DGA.[40–43] In the other studies, patients were included if judged to be anxious and/or uncooperative to levels that would have precluded dental treatment under local anaesthesia.[44–46]

Age and sex of patients

All but one study[41] recruited slightly more girls than boys. Four studies offered IHS only to children.[40–43] One study also included adults but reports results for children patients sepa-

Table 2 Case series studies with a comparative group

Reference, year, country	Inclusion criteria	Exclusion criteria/ % excluded	Setting, *n*, study period	Comparator group	Mean age, % male, mean no. of extracted teeth (IHS/DGA)	Outcomes
Shepherd[40], 2000, UK	GDP referral for DGA	None stated	• UDH, Manchester • 60 (IHS)/35 (DGA) • 1994–1996	Patients referred for DGA to the same setting	• 11.9/12.3 years • 45/34% male • 3.2/3.6 teeth	Effectiveness Morbidity Time/session Visits/patient User satisfaction
Blain[41], 1998, UK	GDP referral for DGA	• Age <3 years • Non-English speakers • Intellectual impairment • Uncooperative to examination • Obstructed nasal airways (CI) • Oro-facial swelling (CI) 46% (42% against exclusion criteria, 4% because of lack of consent)	• UDH, Manchester • 265 (IHS)/265 (DGA) • 1992–1994	Patients referred for DGA to the same setting, age- and sex-matched	• 7.63/7.54 years • 54/54% male • 2.51/3.94 teeth	Effectiveness Time/session Visits/patient User satisfaction Cost IHS/GA Factors associated with treatment failure

CI, contraindication; GDP, general dental practitioner; UDH, university dental hospital; I, intervention group; C, control group.

rately.[44] In two studies over three-quarters of cases were children, but no separate reporting was provided.[45,46]

Type of treatment required

In four studies[40–43] all patients were judged by the referring practitioner to require dental extractions – and in two studies dental extractions were required either solely[40] or mainly[42] for orthodontic treatment. In the other three studies, the great majority of patients required dental extractions, some requiring other procedures.[44–46]

In the study by Blain[15], 215 of 265 (81.1 per cent) of patients who had extractions attempted with sedation required extractions because of dental caries and 51.9 per cent of these patients had also had symptoms from their teeth. The two studies including children treated for orthodontic reasons[40,42] by definition included elective cases only and one of these studies also states that children presenting in pain were excluded.[42] Published material relating to all other studies[43–46] does not allow us to draw conclusions about the symptom status (e.g. pain at presentation) of participants. It is also unclear for these studies whether treatment was elective or urgent, and whether extractions were due to dental caries.[43–46]

Type of treatment provided

In all studies, IHS with nitrous oxide was used, supplemented with local anaesthesia. Nitrous oxide was used in maximum concentrations of 65 per cent[46], 60 per cent[45] and 40 per cent,[40,41] with one study using a fixed concentration of 25 per cent.[44] No information was provided in two other studies.[42,43] In two studies, a small proportion of patients (2 per cent and 5.6 per cent) also received benzodiazepine pre-medication as an adjunct to IHS.[45,46]

Setting

Four studies were conducted in teaching dental hospitals,[40–42,45,] one in a community clinic,[43] one had a mixed community and tertiary setting,[44] and the setting of one study is unclear.[46]

Outcomes reported

Effectiveness

All studies examined aspects of treatment effectiveness. The definition of effectiveness differs between studies. UK studies define effectiveness as the completion of the planned treatment.[40–44] Scandinavian studies define success either as 'acceptance of dental treatment under IHS'[46] or as the 'completion of planned treatment in the absence of side effects',[45] and rate effectiveness on a three-point scale (good, fair and poor, or equivalent rating). A judgement was made that treatment effectiveness rated as good or fair in the Scandinavian studies was in practical terms equivalent to successful completion of treatment in the UK studies. In the two comparative studies, IHS and DGA were effective in 96.7 per cent versus 100 per cent[40] and 83.4 per cent versus 98.9 per cent[41] of children, respectively. In

Table 3 Case series studies without a comparative group

Reference, year, country	Inclusion criteria	Exclusion criteria/(%) excluded	Setting, *n*, study period	Mean age,% male, mean no. of extracted teeth	Outcomes
Shaw[42], 1996, UK	Referral for DGA	• Suitability for LA treatment alone • In pain (waiting >1 month for IHS) Not reported	• UDH, Newcastle • 133 • Not provided (pre-1996)	• 10.7 years • 47.3% male • 2.48 teeth	Effectiveness Morbidity Time/session User satisfaction Cost
Crawford[43], 1990, UK	Referral for DGA	• Parental request for DGA • Inadequate patient co-operation 27% excluded	• Community clinic, Manchester • 73 • During 1988	• 7.8 years • 41% male • 1.76 teeth	Effectiveness Time/session
Edmunds[44], 1984, UK	Anxiety and/or previous DGA	Not reported	• UDH and general dental practice, Cardiff • 47 • Not stated (pre-1984)	• Not provided but <12 years • Not reported • Not reported	Effectiveness Visits/patient
Berge[45], 1999, Norway	'Hallonsten' criteria*	Not reported	• UDH, Bergen • 194 • Not stated	• 14.5 years • 48.4% male • Not reported	Effectiveness Morbidity Visits/patient Factors associated with treatment failure
Hallonsten[46], 1983, Sweden	'Hallonsten' criteria*	Not reported	• '45 dentists', mainly paedodontists • 823 • Not stated	• 80% < 16 years old • 46.4% male • Not reported	Effectiveness Morbidity Time/session Visits/patient Factors associated with treatment failure

UDH, university dental hospital.
*Hallonsten criteria: immaturity (young age, mental handicap), anxiety, previous negative experience, needle phobia, DGA required on medical criteria, pronounced gag reflex, muscular tone disorders, other.

other studies IHS treatment effectiveness ranged from 87 per cent to 96.9 per cent.[42–46] For the two studies that report the number of excluded cases,[41,43] the reported effectiveness rates (among children offered IHS) means that overall 45 and 64 per cent of all children who would have initially been considered to require a DGA were treated with IHS alone, respectively.

In the two studies including solely or mainly orthodontic patients, treatment success rate was 96.7[40] and 90 per cent,[42] respectively. In the only other study that reports separate results on orthodontic patients treatment effectiveness was 97.6 per cent.[41]

Factors associated with IHS treatment failure

Three studies[41,45,46] examined factors associated with higher probability of unsuccessful IHS treatment. The younger the age of the patient the greater the likelihood of IHS treatment failure.[41,45,46] Other factors found to be significantly associated with worse than average effectiveness were the number of teeth requiring extraction,[41] poor previous attendance record,[41] higher anaesthetic risk status,[45] immaturity and previous negative experience with dental treatment,[45] history of psychiatric disorders[46] and the occurrence of side effects during IHS treatment.[46] One study reports a non-significant higher failure rate in girls.[46]

Morbidity

One comparative[40] and three other[42,45,46] studies provide information on morbidity. In the comparative study, IHS was found to be similar or superior to DGA for morbidity, with only minor side effects reported, mainly nausea/vomiting and headache.[40] In the other studies, only minor side effects associated with IHS are reported, mainly nausea/vomiting and headache, in 5–13 per cent of patients.[42,45,46]

Mean time required per session

All studies but one[44] report the time required per treatment session. In the comparative studies by Shepherd and Hill[40] and Blain and Hill,[41] the mean procedure time was 22.6 and 45.2 minutes for IHS compared with 6.8 and 7.4 minutes for DGA, respectively. In the other studies, reported mean procedure periods for IHS range from 22 to 44 minutes.[42,43,45] One study reports that 87.3 per cent of sessions required <40 minutes and 95.9 per cent of session required <60 minutes.[46]

Treatment sessions required per patient

All studies but two[42,43] report the mean number of visits required per patient. In the comparative studies, the mean number of treatment sessions required to complete treatment with IHS were 1.03[40] (orthodontic patients only) and 1.35[41] sessions per patient. In non-comparative studies, a range of 1.24–2.09 sessions per patient is reported.[44–46]

User satisfaction

The two comparative[40,41] and one other study[42] examined parental satisfaction, assessed through self-administered questionnaires[41,42] or through a combination of interview and self-administered questionnaire.[40] In the comparative studies, IHS was found to be significantly better than DGA in terms of parental and children satisfaction.[40,41] In the other study, high user satisfaction and preference of IHS over DGA, in patients with previous experience of DGA[42] was found.

Cost

One comparative[41] and one other study[42] examined costs, calculated only in relation to staffing costs with all other costs excluded. In these studies, which were carried out in dental teaching hospitals, staffing costs for IHS were estimated to be cheaper by approximately one-third compared with DGA.

Discussion

This is an area of healthcare lacking high-quality clinical evidence (i.e. derived from RCT). The evidence from seven case series studies (level of evidence 3) of variable quality and design was examined.

Effectiveness of treatment with IHS

The reviewed papers suggest that IHS is effective in a large proportion (83–97 per cent) of the selected subgroups of children who would otherwise have required DGA.

This may represent 45–64 per cent of all children who would have otherwise required DGA once all exclusions are accounted for, as in the two studies that provide 'denominator' data,[41,43] 54 per cent and 73 per cent of all patients requiring DGA were offered IHS, respectively. However, this calculation does assume that the lack of population-based design for both studies did not introduce any selection bias.

As reported in the results, the majority of studies report on children having extractions or surgery for asymptomatic and often non-carious teeth. In contrast, the Child Dental Health Survey of 1993[47] showed that 12 per cent of 5-year-olds and 31 per cent of 8-year-olds had had at least one tooth extracted. Few of these extractions are likely to be for orthodontic reasons as such extractions would commonly be carried out at 9 years or older. In addition, there was an increased likelihood of extractions related to lower socio-economic status. The national audit in Scotland[3] assessed the reason for children having teeth extracted with DGA. The average age of these children was 6.7 years; 96 per cent of cases included extractions because of dental caries. In addition, 25 per cent of these children had had DGA previously. Forty-seven per cent of the children came from residential areas of material deprivation.

Only one of the studies[41] reports a large number of patients (81.1 per cent of patients who had treatment with IHS attempted) having extractions for dental caries. As extractions because of caries is the major reason for DGA in the United Kingdom, further studies including this group of patients need to be conducted if DGA rates are going to be reduced.

The presence of disease in teeth that may be restored or that are asymptomatic may not necessitate extraction if IHS is used. However, because of the increased safety risks, most centres providing DGA will remove any diseased teeth that may cause trouble at one visit. Thus there would often be a difference in the treatment plan for the same patient depending on whether IHS or DGA was to be used. This is highlighted in the study by Blain and Hill,[41] where there is a significant difference in the number of teeth being extracted with IHS and DGA.

The studies show that treatment for orthodontic extractions in particular has a high level of success (90 per cent or more) consistently. The majority of children having these extractions tend to be aged 9 years or older (often 10 or 11 years) and by the very nature of orthodontic treatment tend to be regular dental attenders. They are also more likely to be of higher social class.[3] All these factors increase the likelihood of the success with IHS and this should be the treatment of choice for these children in the first instance.

Safety, morbidity and user satisfaction

No major adverse events (death, unplanned hospitalization) are reported in the reviewed literature for either method. This is not surprising, given the small number of patients treated by the reviewed studies. In general, death as a result of DGA is very rare (1 death in many thousands of DGA episodes[2]) but IHS has a superior safety record, with no death reported in over one million cases.[10] The superior morbidity profile of IHS compared with DGA[40] may be at least partly responsible for the higher level of user (child and parental) satisfaction with IHS. However, there is a lack of any large studies of post-operative morbidity.

Barriers to IHS effectiveness

Patient and disease factors

For extractions with IHS, local anaesthesia needs to be administered. Therefore any condition (such as facial swelling) where this cannot be achieved will still necessitate DGA. Patient co-operation is also required and where there is immaturity because of young age ($\leq$3 years in particular) or mental handicap, then general anaesthesia will still be required – although patients should be assessed on an individual basis. The presence of multiple diseased teeth (especially in multiple quadrants) requiring extraction limits the effectiveness of IHS.[41]

Healthcare and organizational factors

The mean time and number of sessions required per patient are likely organizational barriers, as it may make the provision of inhalation sedation, particularly in general dental practice settings, unattractive. In the NHS this is the case because of a lack of an appropriate fee to cover the cost of providing such treatment. Some researchers have suggested subsidizing the IHS equipment and treatment episodes in general dental practice by centrally allocated funding.[48] Similar ideas are explored by the national audit study workshop, carried out in Scotland.[3]

Another factor that may limit availability of IHS is concern about potentially hazardous occupational exposure to nitrous oxide, particularly in relation to excess risk of miscarriage in female staff.[40] However, according to current expert consensus, IHS with nitrous oxide is safe in terms of occupational exposure, but scavenging equipment and environmental monitoring are required.[7,49,50]

Other alternatives to DGA

A proportion of patients referred for DGA may be treatable without IHS, with behavioural management such as acclimatization visits and hypnosis;[28,29] or through stricter selection of cases and very skilful application of local anaesthesia alone.[51,52] Therefore, the actual potential of DGA avoidance is greater than estimated by the reviewed studies on IHS alone. However, such alternative methods require even higher levels of staff training and time/visits allocated to each patient. Hence, they are judged unsuitable for wide adaptation in general dental practice and they have limited potential in current CDS settings so they were not included in this review.

Cost

Staffing costs for IHS are estimated to be cheaper than for DGA. This is not surprising as DGA requires higher levels of staffing (including an anaesthetist). Time taken can also be lengthy if the recovery period is included.[41] In addition, when the studies[41,42] comparing cost were conducted, DGA could be administered in outpatient settings. With the change in regulations following the *Conscious decision* document, most general anaesthetics are now given in operating theatres with the additional cost implications. However, there is no evidence about the cost of IHS in dental general practice or the CDS. This is likely to be different to the cost estimated in dental teaching hospital settings. This is a priority area for future research.

Future study design

The overall effectiveness of DGA is known to be nearly 100 per cent. Therefore it could be argued that there is no need to resort to an RCT to obtain comparative effectiveness estimates. An RCT, however, could provide more detailed and unbiased comparative estimates of outcomes other than treatment effectiveness (morbidity, safety, patient satisfaction and cost). However, the main problem with the existing evidence is that case series studies may have selected a group of children that is non-representative of the patient population requiring DGA treatment. Of all studies, only two[41,43] report the number of excluded cases among all patients who were judged to require DGA and referred to the study centres during the study period. The fact that these two studies were not population-based means that further selection bias might have been introduced.

Although an RCT comparing IHS against DGA in children resistant to conventional dental treatment is in principle desirable, it will expose some children (particularly those aged over

5 years of age, and those receiving orthodontic treatment) to a major anaesthetic procedure that is potentially avoidable through the use of IHS. In addition, to have a proper comparison there would need to be similar numbers of teeth extracted for both groups. This would involve either the patients having IHS having all diseased teeth extracted or those having DGA having diseased teeth left, which might necessitate a second episode of DGA. On all of these grounds, such a study could be argued to be unethical.

The conduct of future prospective case-series studies of higher methodological quality, with explicit exclusion criteria and reporting of number of excluded cases, should be considered a priority. Such studies should ideally be population-based (i.e. capturing all 'incident' cases of referrals for DGA in a predefined population), be conducted in community (rather than dental hospital) settings, concentrate on cost estimates, be multi-centred, and involve a variety of operators. Such studies do not necessarily require a 'research' set-up, as they can be carried out at least partially combined with routine activity.

Additional factors

Although this paper has considered the suitability of an alternative form of treatment (IHS) to DGA for dental extractions, it should be remembered that a reduction in the need for extractions would be preferable.

Both the Child Dental Health Survey[47] and the audit in Scotland[3] show that the majority of extractions are due to dental caries, that the prevalence of dental caries increases with lower socio-economic status and that the children who are affected by caries are likely to be irregular dental attenders.

It is therefore imperative to address the causes of caries – high sugar diet combined with poor oral care. There is strong evidence to support the use of fluoride particularly for the high-risk population mentioned.[53,54] Encouragement of early dental attendance for children may reduce the amount of caries, allow preventive messages and promote early disease detection, preventing the necessity for extractions.[54]

Such schemes are being set up in some areas. Dental health promotion is being encouraged by the Scottish Executive[55] with tooth-brushing schemes, availability of free toothbrushes and paste for children up to 3 years of age, and dietary messages related to oral health being promoted by health visitors, dental professionals and school staff. Resources are being targeted at low socio-economic areas and are linking with other initiatives such as New Community Schools. Long-term evaluation of these schemes is yet to be carried out.

Conclusion

There is no 'level 1'[17] evidence about the effectiveness of IHS as an alternative to DGA in children. However, evidence of a lower quality level is suggestive that IHS can prevent the need for DGA in many children who would have otherwise required it. The proportion of such children may be between 45 and 64 per cent of all children who would have otherwise required DGA. However, there are few studies that report treatment for dental caries and this needs to be addressed. IHS success rate is higher in selected patients, such as children of older age and those receiving orthodontic treatment. The requirement for more time/treatment session and greater number of treatment sessions can be a barrier to the offer of IHS, particularly in general dental practice. An increase in capacity for IHS treatment by increasing CDS staffing levels, equipment and time could be an effective strategy for reducing demand for DGAs. Uncooperative or anxious children receiving orthodontic treatment should not be offered treatment under DGA, apart from in exceptional circumstances. There are very limited data about the morbidity of IHS and DGA and none from community based settings. IHS should also be provided in selected general dental practice settings, for patients who would have otherwise required referral for DGA. Innovative schemes, examining the possibility of allocating funds earmarked for DGA in hospital to IHS treatment sessions in CDS and GDP settings, are recommended.

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Authorship statement

The initial literature search, systematic review and critical appraisal was devised and conducted by one author (G.L.) as part of a professional qualification successfully completed in November 2002 (MFPHM Part II). During the review process K.B. was contacted as one of the four authors mentioned in the Methods, to help verify the validity of the search yield. Following G.L.'s successful exam presentation, K.B. also reviewed the studies that had been critically appraised. Additional background, areas of particular dental relevance of the results, and further discussion topics in relation to reviewed studies were added. Both authors reviewed and contributed to drafts of this publication and approved the final text.

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