

Sleep nasendoscopy: a diagnostic tool for predicting treatment success with mandibular advancement splints in obstructive sleep apnoea

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SUMMARY This prospective, cohort study evaluated the role of sleep nasendoscopy (SNE) with simultaneous mandibular protrusion in predicting successful mandibular advancement splint (MAS) therapy in subjects with obstructive sleep apnoea (OSA). Nineteen OSA subjects diagnosed by overnight polysomnography were referred for MAS therapy, following SNE investigation. A Herbst MAS was fabricated for each subject. Once this had been adjusted for maximal, subjective, therapeutic effect, follow-up sleep studies were undertaken with the appliance *in situ*. The SNE was repeated with the appliance in place to allow the effects of the original mandibular protrusion and the actual effect of the MAS to be compared. The MAS was removed and the original and current site(s) of obstruction evaluated.

Pre-treatment SNE showed airway obstruction at the following levels: intermittent multi-level (16 subjects), sustained multi-level (two subjects) and tongue base (one subject). In all individuals, gentle advancement of the mandible during SNE improved airway patency and reduced snoring. When the SNE was repeated with the MAS *in situ*, all subjects showed improvements in snoring and airway patency. Follow-up sleep studies confirmed the efficacy of the MAS, with all patients showing a reduction in the apnoea/hypopnoea index (AHI). Median reductions in AHI (from 28.1 to 6.1, $P < 0.001$) and Epworth Sleepiness Scale (ESS) scores (from 9 to 6, $P < 0.001$) were highly statistically significant.

The results suggest that SNE with concomitant mandibular advancement to mimic MAS wear, could be a valuable prognostic indicator of successful MAS treatment.

Introduction

Obstructive sleep apnoea (OSA) is a potentially life-threatening disorder characterized by repeated collapse of the upper airway during sleep, with periodic cessation of breathing. Depending on the severity of the condition, subjects may be managed by nasally applied continuous positive airways pressure (nCPAP), mandibular advancement splint (MAS) therapy or a range of surgical techniques. The aims of treatment are to resolve the presenting signs and symptoms and reduce the apnoea/hypopnoea index (AHI) to within normal limits (Schmidt-Nowara *et al.*, 1995).

Historically, patient selection has been based on AHI alone. MAS therapy would appear to work best in subjects with mild OSA and least well in those with severe degrees of the disease (Marklund *et al.*, 1998; Pancer *et al.*, 1999; Engleman *et al.*, 2002; Prathibha *et al.*, 2003). The most widely recognized guidelines for the selection of subjects for MAS therapy are very general and based on the case series reports available almost 10 years ago (Schmidt-Nowara *et al.*, 1995). Since then, randomized, controlled trials comparing MAS with nCPAP tend to confirm that whilst nCPAP remains the gold standard for therapeutic success, well designed MAS can be effective where the disease is

mild (Ferguson *et al.*, 1996; Tan *et al.*, 2002). There are, however, no precise guidelines for patient selection.

Upright cephalometry may be an aid to diagnosis in OSA subjects and it has been suggested that these films may also be used to predict MAS success (Eveloff *et al.*, 1994; Mayer and Meier-Ewert, 1995; Liu *et al.*, 2001). Predictive regression equations have been generated by all three groups but the cohorts were small and none of the algorithms has been tested on a group other than that on which it was devised. This reduces their predictive power.

Such studies possess the limitations of any two-dimensional (2D) radiographic procedure: changes that occur in the transverse dimension, cannot be seen. No account is taken of the dynamics of the airway (Schwab, 1993), the significant changes in oropharyngeal dimensions which accompany a change in posture from the upright to the supine position, or the fact that the patient is awake (Yildirim *et al.*, 1991; Pae *et al.*, 1994; Battagel *et al.*, 2002). More recently, Tsuiki *et al.* (2004), using magnetic resonance imaging (MRI) and supine cephalometry, suggested an alteration in pharyngeal shape in 13 subjects who responded well to MAS. The anterior wall of the velopharynx and posterior walls of the oro- and hypopharynx showed significant

forward displacement in this group. Three-dimensional techniques, such as computerized tomography (CT) and MRI have been used in a limited number of subjects to examine the effect of MAS therapy on the upper airway (Lowe *et al.*, 1986; Rodenstein *et al.*, 1990; Gale *et al.*, 2000). Gao *et al.* (2004) used MRI to examine the effect of titrating mandibular position on upper airway dimensions in non-apnoeic individuals. Although helpful in selected subjects, neither CT nor MRI can be justified routinely on the basis of expense, limited access and, in the case of CT, relatively high doses of radiation. Furthermore, in none of these studies were the subjects asleep.

The technique of sleep nasendoscopy (SNE) was developed by Croft and Pringle (1991). The aim was to distinguish those patients presenting to a sleep disorders clinic who would benefit from surgical management of their condition from those who would not. The subjects were pharmacologically induced into a light phase of sleep, and the upper airway visualized directly, using a flexible, fibre-optic endoscope. Levels of partial or complete obstruction were noted and a grading scheme developed. Obstruction was designated as palatal, multi-level or tongue based (Pringle and Croft, 1993). The following grouping system was applied:

Grade 1: Palatal level snoring

Grade 2: Palatal level obstruction

Grade 3: Multi-segmental involvement – intermittent oro- and hypopharyngeal collapse

Grade 4: Sustained multi-level collapse

Grade 5: Tongue base obstruction.

The validity of SNE has been demonstrated by a number of researchers (Croft and Pringle, 1991; Camilleri *et al.*, 1995; Sadoaka *et al.*, 1996; Myatt and Beckenham, 2000) and its use as a pre-operative assessment has been shown to improve outcomes for palatal surgery. Using the same criteria, it was hypothesized that subjects who demonstrated tongue-based collapse (grade 5) would be most likely to benefit from MAS therapy (Croft and Pringle, 1991; Pringle and Croft, 1993), whilst those subjects with multi-level obstruction (grades 3 and 4) might require adjunctive surgery. A refinement of the nasendoscopic procedure proposed by one author has been to gently advance the mandible during sedation to mimic the effect of MAS and to examine the effect of this manoeuvre on upper airway patency and snoring. If airway dimensions improve and snoring is reduced, MAS may be indicated, regardless of the exact grading (Pringle and Croft, 1993).

Neither the efficacy of the mandibular advancement procedure nor the use of SNE alone has been tested in relation to the success of MAS therapy. The aims of the present study therefore, were to evaluate the role of SNE in conjunction with mandibular protrusion, as a method of predicting success with MAS therapy in OSA subjects, and to test the reliability of the endoscopic technique.

Subjects and methods

The subjects for this prospective, cohort study were recruited from individuals referred to the Orthodontic Department of the Royal London Hospital for the construction of a MAS. All subjects had been assessed at the Royal National Throat, Nose and Ear Hospital (RNTNE) and diagnosed as having OSA on the basis of overnight polysomnography. SNE with simultaneous mandibular protrusion indicated that MAS therapy was a beneficial treatment option.

Nineteen subjects, (16 males and three females), median age 48.89 years (range 32.53–67.37 years), median body mass index (BMI) 28.6 (range 22.1–34.0) who fulfilled the following inclusion criteria agreed to participate in this study:

1. Over 18 years of age with a confirmed diagnosis of OSA (AHI > 5 per hour of sleep)
2. Prepared to wear a MAS
3. Sufficient healthy teeth to allow MAS construction
4. SNE revealed a grade 3, 4 or 5 level obstruction, with advancement of the mandible improving the airway and snoring
5. Prepared to undergo repeat SNE.

The exclusion criteria were:

1. History of poorly controlled epilepsy
2. History of allergy to metals
3. Edentulous or insufficient teeth in one or both dental arches
4. Unwilling to repeat the SNE.

Polysomnography

Each subject underwent supervised overnight polysomnography (Sleep acquisition computer, Oxford Instruments, Oxford, UK) in the sleep laboratory at the RNTNE Hospital. The study lasted a minimum of six hours from the onset of sleep, during which continuous recordings of electro-encephalography, electro-oculography and chin electro-myography for sleep staging were performed. Nasal and oral thermistors measured airflow, and respiratory effort was recorded by respiratory inductance plethysmography from transducers around the abdomen and chest. Heart rate and oxyhaemoglobin saturation was also continuously recorded. Apnoea was defined as a cessation of airflow of more than 10 seconds duration. Hypopnoea was defined as a 50 per cent reduction in the flow signal or thoraco-abdominal movement, lasting more than 10 seconds and accompanied by a fall of ≥ 4 per cent in oxygen saturation or a microarousal. The AHI was determined by summing the apnoeas and hypopnoeas and dividing by the total sleep time in hours. The subjects were considered to have OSA if they had an AHI of five or more (as defined by the American Academy of Sleep Medicine Task Force, 1999).

All subjects underwent overnight polysomnography with their MAS *in situ* after a minimum period of two months

of comfortable and subjectively successful wear. The time interval between original and repeat polysomnographies ranged from 6 to 18 months. An experienced consultant anaesthetist, who was blind to the investigation, evaluated all the sleep studies.

Sleep nasendoscopy

SNE was carried out as a routine diagnostic procedure prior to MAS construction, using the technique described by Croft and Pringle (1991). This was repeated, along with measurement of the subject's height and weight, after provision of the appliance and once this was considered subjectively successful. The procedure was fully explained and written consent obtained. The subjects were asked to lie down on the theatre couch with the same number of pillows as they would use at home and induced into a light phase of sleep using intravenous midazolam (3–5 mg) and propofol (30–50 mg), titrated individually by an experienced anaesthetist. Further 20-mg boluses of propofol were administered as necessary to maintain a satisfactory level of sedation, whilst ensuring that reflexes remained present throughout. The theatre lights were dimmed and the subject allowed to fall asleep. Heart rate, blood pressure and oxygen saturation were monitored continuously. When adequate sedation had been achieved, a flexible endoscope was passed through the more patent nostril and the level(s) of any obstruction were identified as described by Pringle and Croft (1993): the presence of snoring was recorded. The anaesthetist gently advanced the mandible (up to 5 mm), by placing his fingers along the ascending ramus and angle, and the effect of this action on both the airway and snoring was recorded. The dose of prescribed pharmacological agents for each subject was recorded in their clinical notes, along with the findings of the investigation.

Repeat SNE was performed with the MAS *in situ*, with each subject being sedated using their previously recorded dosage to help standardize the procedure. The airways were examined as before and any snoring noted. The MAS was then removed by an orthodontist (AJ or JMB) and the resultant airway obstruction(s) graded according to the criteria of Pringle and Croft (1993). This permitted the actual effect of the MAS to be compared with the original SNE prediction. All nasendoscopies were carried out by the same, experienced, ENT surgeon (BTK) and simultaneously visualized on a monitor by the team of operators present (AJ, JMB and BTK). In the absence of any valid and reproducible objective measure, and in order to reduce bias, a consensus opinion was reached with respect to the observed airway change and audible snoring level.

Questionnaire

Daytime sleepiness was assessed using the Epworth Sleepiness Scale (ESS) questionnaire (Johns, 1993). Each

subject completed the questionnaire prior to splint provision and after the appliance had been adjusted to provide maximal, subjective, therapeutic benefit.

The mandibular advancement splint (MAS)

A customized, removable, Herbst appliance was constructed for each subject with the mandible in a position of maximum, comfortable protrusion (Figure 1). The device comprised upper and lower clear acrylic, clasp-retained splints with full maxillary and mandibular occlusal coverage. Claspings was individually designed to avoid large restorations and bridgework and ideally included a minimum of four teeth in each arch. Adams and Jackson clasps were used as appropriate. Labial acrylic coverage was dictated by the axial inclination of the incisor teeth. Casts were surveyed and undercuts not involved in the retention, blocked out. Upper and lower splints were connected buccally by the telescopic arms of the Herbst attachments. The tubing was normally placed opposite the maxillary first molars with the rods located in the mandibular premolar regions. Where additional mandibular advancement was necessary for maximum therapeutic effect, 1 or 2 mm pieces of stainless steel tubing were soldered to the rods in the lower premolar regions, thus effectively extending the length of the tubing. Bilateral, 3/16 inch, inter-maxillary elastics in the premolar regions helped to minimize mouth opening during sleep (Johal and Battagel, 2001). The patients were instructed to change these every week.

Statistics

Data were not normally distributed and therefore non-parametric tests were applied. The median described the measure of central tendency whilst comparisons before and with treatment were made using the Wilcoxon matched-pairs signed-ranks test. Cohen's kappa (κ) statistic was used to test the repeatability of the SNE.



Figure 1 Removable Herbst mandibular advancement splint, with full occlusal coverage and short intermaxillary elastics to limit mouth opening during sleep.

Results

Polysomnography and Epworth Sleepiness Score (Table 1, Figure 2)

The subjects exhibited a wide range of severity of OSA pre-treatment: median AHI was 28.1 with a range from 14.1 to 62.0. Using the guidelines of the American Academy of Sleep Medicine Task Force (1999) two subjects were classified as mild, nine as moderate, and eight as severe. At follow-up, median AHI had reduced to 6.1 (range 0.3–16.8) with the MAS *in situ*. Individual pre- and post-treatment values are shown in Figure 2. Median ESS scores reduced from 10 (range 3–18) pre-treatment, to 6 (range 1–14) with MAS therapy. Both reductions were highly statistically significant ($P < 0.001$).

Sleep nasendoscopy (Tables 2 and 3)

Pre-treatment. Prior to treatment, SNE demonstrated palatal level obstruction with intermittent oropharyngeal involvement in 16 subjects (grade 3), sustained multi-segmental obstruction (grade 4) in two and tongue base obstruction (grade 5) in the remaining individual (Table 2). Diagnostic mandibular advancement was only undertaken in 17 patients and demonstrated an improvement in airway patency and snoring in all (Table 3). Residual palatal flutter was recorded in four subjects when the mandible was protruded and the possible need for adjunctive palatal surgery noted.

At repeat SNE without MAS. Repeat SNE was performed, with each subject being sedated using their previously recorded dosage to help standardize the procedure, after an interval range of 8–25 months. When the endoscopy was repeated without the appliance in place, all subjects snored and exhibited multi-segmental airway obstruction (Table 2). In 17 patients collapse was intermittent (grade 3) and in two it was sustained (grade 4). The subject who had exhibited tongue base collapse in the original study now showed intermittent obstruction. The κ value was 0.77, showing good agreement between the two endoscopic procedures. No significant difference ($P = 0.552$) was observed in the

median weight of the subjects, when comparing the initial findings (80.75 kg, range 66.20 to 104.00) with those at the repeat investigation (81.55 kg, range 65.00 to 99.80).

At repeat nasendoscopy with MAS *in situ*. Whilst all 19 subjects underwent diagnostic and repeat SNE, the predictive effect of mandibular advancement, at diagnostic SNE, was only recorded in 17 of these patients. Thus, Table 3 compares the predicted with the actual effect in this sub-group only. With the MAS *in situ*, three subjects showed a clear airway with no snoring, eight a marked subjective improvement in both airway and snoring, five an improvement but with residual palatal snoring, while one demonstrated no change. Interestingly, four out of the five subjects with residual palatal flutter had shown this during the diagnostic procedure, and in the individual showing no change the MAS was judged not to be sufficiently active as further advancement resolved the symptoms.

Minimum oxygen saturations during SNE (Table 1)

Where minimum oxygen saturations were recorded during SNE ($n = 13$), these values were consistently higher when the MAS was in place ($P = 0.001$). Median minimum values were 89 per cent (range 77 to 96 per cent) with the appliance *in situ* and 80 per cent (range 69 to 91 per cent) when it was removed.

Discussion

Appliance efficacy

During SNE the mandible was gently advanced by up to 5 mm and the impact on airway patency and snoring levels noted. This level of advancement was judged realistically attainable with MAS therapy, based on previous research by the authors. Using the same design of MAS, a mean value of 5.9 (SD = 2.2) mm was recorded (Johal and Battagel, 1999). Appliance efficacy was evaluated by repeating both the sleep study and the SNE with the MAS *in situ*. All subjects demonstrated an improvement in AHI and most importantly, none became worse. This is a more positive

Table 1 Pre- and post-treatment clinical findings.

Variable	Median	Range	Statistical significance between pre- and post-treatment data
AHI pre-treatment ($n = 19$)	28.1	14.1–62.0	$P < 0.001$
AHI with MAS ($n = 19$)	6.1	0.3–16.8	
Minimum percentage SaO ₂ at SNE without MAS ($n = 13$)	80	69–91	$P = 0.001$
Minimum percentage SaO ₂ at SNE with MAS ($n = 13$)	89	77–96	
ESS pre-treatment ($n = 19$)	10.0	3–18	$P \leq 0.001$
ESS with MAS ($n = 19$)	6.0	1–14	

AHI, apnoea/hypopnoea index; MAS, mandibular advancement splint; SaO₂, minimum oxygen saturation; SNE, sleep nasendoscopy; ESS, Epworth Sleepiness Scale.

outcome than has previously been reported since a worsening of the condition (or at least no improvement) can normally be expected in some individuals (Hans *et al.*, 1997; Pancer *et al.*, 1999; Gale *et al.*, 2000; Johnston *et al.*, 2001; Liu *et al.*, 2001). Treatment success with MAS therapy, as defined by a follow-up AHI of less than 10 (Schmidt-Nowara *et al.*, 1995; Pancer *et al.*, 1999), was achieved in 74 per cent of the sample, with only five subjects failing to reach this goal. Six of the eight subjects with severe OSA were successfully treated. Whilst successful management of subjects with severe disease has been reported by others (Marklund *et al.*, 1998; Pancer *et al.*, 1999), no explanations have been offered for this. Of particular interest is why some individuals respond, whereas the majority do not (Marklund *et al.*, 1998; Pancer *et al.*, 1999). It is possible that the improved outcome in subjects with severe OSA (AHI > 30 per hour) during the current investigation, may have been due to their pre-selection on the basis of the favourable response to mandibular advancement, mimicking the effect of the MAS during SNE. The median reduction in AHI from 23.1 to 6.1 also compares favourably with the results of other studies, even when the patients have been well selected (Ferguson

et al., 1996, 1997; Marklund *et al.*, 1998; Henke *et al.*, 2000; Tan *et al.*, 2002).

Reproducibility and validity of SNE

All SNEs were performed by the same, experienced surgeon and this may explain the high level of agreement obtained ($\kappa = 0.77$), with only one instance where grading differed between the pre-treatment and repeat studies. In this subject, the original tongue base obstruction was found to be multi-segmental. As the two studies were separated by more than two years, this could have been an indication that the airways had become more collapsible or that the patient had put on weight. Whilst the outcome of SNE was determined in a purely subjective manner, bias was limited by visualizing the airway on a monitor and attaining agreement in the observed airway change and audible snoring levels between all observers. Furthermore, the original SNE gradings were unknown when the endoscopy was repeated. Attempts to quantify the airway change by measuring the minimum dimensions on the video monitor proved difficult and unreliable. In the absence of any reproducible and valid objective measure of change, the possibility of inherent bias cannot be excluded.

The use of SNE in the prediction of MAS treatment outcome in OSA subjects has not been previously investigated. It is important to note that the clinical utility of any diagnostic test relates to both its sensitivity (i.e. ability to accurately predict success) and specificity (i.e. ability to accurately predict failure). The results of the current investigation suggest good sensitivity; however, the design did not permit a measure of the specificity. This is discussed further in relation to the limitations of the study.

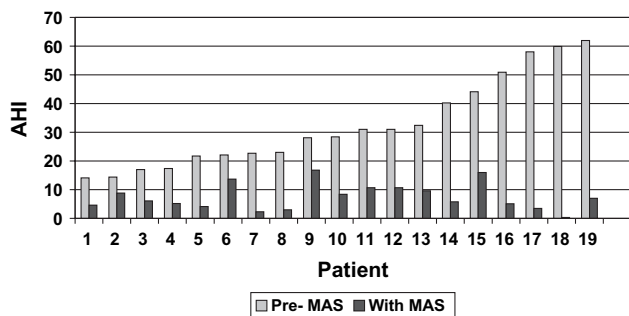


Figure 2 Apnoea/hypopnoea index (AHI) before treatment (grey bars) and with the mandibular advancement splint (MAS) *in situ* (black bars).

Table 2 Sleep nasendoscopy grading pre-treatment and when mandibular advancement splint removed at repeat sleep nasendoscopy ($n = 19$).

Variable	Grade 3	Grade 4	Grade 5
Pre-treatment	16	2	1
At repeat sleep nasendoscopy	17	2	0

The role of SNE in predicting success with MAS therapy

In the present study, appliances were prescribed on the basis of the endoscopic findings rather than on the severity of the disease, although for patients with severe OSA, the possibility that nCPAP would be needed for satisfactory control was considered. Two subjects had already tried nCPAP but were unable to tolerate it.

In evaluating the predictive capacity of SNE with simultaneous mandibular advancement, direct comparison of the diagnostic findings with those of the MAS *in situ* was performed in 17 subjects. Improvements in airways and

Table 3 Predicted and actual effects of mandibular advancement ($n = 17$).

Variable	Airway clear: no snoring	Airway and snoring improved	Airway and snoring improved but with residual palatal flutter	No change in airway or snoring
Mandible advanced at diagnostic sleep nasendoscopy	0	13	4	0
Sleep nasendoscopy with mandibular advancement splint <i>in situ</i>	3	8	5	1

snoring had been predicted for all. In four, residual palatal flutter and the possible need for adjunctive palatal surgery had been noted. At repeat SNE, the MAS appeared to be more effective than predicted in three subjects: clear airways and complete resolution of the snoring were seen. However, five patients were found to demonstrate residual palatal flutter, of whom four had been predicted. Only one subject was deemed severe enough to merit laser assisted uvulopalatoplasty as an adjunctive surgical procedure. The remaining four all showed improvement in symptoms with further MAS activation. One subject did not respond to the extent predicted with the MAS *in situ*, but his splint did not appear to be optimally adjusted and further mandibular advancement eliminated the snoring and improved the airway.

The differences between the predicted and actual effects of mandibular protrusion could be explained by a variety of factors: firstly, the dose of intravenous agent administered could influence the level of airway patency. However, the dosage for each subject was carefully titrated to ensure that the subject maintained a light phase of sleep during which the reflexes were maintained. Furthermore, the dose administered during the diagnostic SNE was recorded and thereby standardized for each subject during their repeat study. Secondly, it is possible that the operator performing the SNE grading was being more precise on the second occasion. Thirdly, a gain in weight may have an adverse effect on MAS efficacy (Marklund *et al.*, 2004) and this would be reflected in the SNE observations. However, there was no statistically significant difference detected between the median weight recorded at the diagnostic and follow-up SNE.

The present findings would support the suggestion that the main modes of action of mandibular advancement appliances are to directly increase the dimensions of the pharyngeal airway whilst reducing airway collapsibility (Ng *et al.*, 2003). This is effected by drawing the tongue forward, through its muscular attachments to the mandible (Lowe, 1993; Schwab, 1993; Johal and Battagel, 2001). Thus subjects where the tongue alone is implicated, should respond to MAS. As the tongue is brought forwards, the soft palate will tend to follow to maintain a posterior oral seal (Lowe, 1993), providing variable improvement in individuals with multi-level involvement. This would explain the findings of Henke *et al.* (2000) that the MAS could be effective where the sites of obstruction include the velopharynx, and supports the more varied response observed here in subjects with multi-level involvement. It should be noted that mandibular advancement during SNE does not always have a positive effect: in some subjects, palatal snoring is exacerbated.

SNE compared with other prognostic indicators

SNE would seem to compare favourably with other approaches in predicting MAS success. Most previous studies have relied upon cranial imaging techniques:

cephalometry, CT and MRI. Most commonly, MAS have been fabricated, success determined by polysomnography and the cephalometric data for good and poor responders compared using regression equations (Mayer and Meier-Ewert, 1995; Lui *et al.*, 2001). Whilst there is some agreement between authors, the precise cephalometric indicators for success vary and none has been tested prognostically prior to appliance construction. The group sizes from which these algorithms have been derived are small, thus reducing their prognostic potential, and the value of this approach has been questioned (Pancer *et al.*, 1999). Furthermore, factors such as severity of OSA, body position, BMI, neck circumference, gender and age may be important (Davies and Stradling, 1996; Lui *et al.*, 2001; Marklund *et al.*, 2004). Lastly, the lateral cephalogram is limited by its 2D format. Because the response of the airway to MAS is dynamic (Lui *et al.*, 2001), SNE could be expected to be a better therapeutic predictor than a static, awake, and frequently upright cephalometric assessment. The technique may help to address the need recently expressed by Marklund *et al.* (2004) to establish more precise indications for MAS in order to increase the success rate of these devices.

Disadvantages of SNE

SNE is not without limitations: it is an invasive procedure, sleep is induced using pharmacological agents, it is of relatively short duration and is subjective in nature. Subjects with severe OSA may be unsuitable as they pose anaesthetic risks. However, drug titration is performed with great care to ensure that protective reflexes are maintained throughout and only a light phase of sleep induced. Whilst the equivalence of SNE with normal sleep has been questioned, Sadaoka *et al.* (1996), demonstrated that there was no significant difference in the duration or quality of non-rapid eye movement sleep between SNE and natural sleep: only the duration of rapid eye movement sleep was altered. SNE would therefore appear to allow a dynamic assessment of the pharyngeal airway, in a state that closely mimics the situation in which sleep-related breathing disorders normally manifest themselves, and allow the appropriate choice of treatment to be selected (Myatt and Beckenham, 2000). The invasive nature of the intervention is its most serious limitation. However, surgical management of snoring and OSA by laser assisted procedures is extremely painful and if this is unlikely to be a suitable operation, as determined by SNE, many patients would be grateful to know this beforehand (Camilleri *et al.*, 1995).

Limitations of the study

This study has a number of limitations. The group of subjects was small and SNE remains a subjective assessment. Thus no statistical evaluation has been made of the comparison between predicted and actual results of MAS. The subjects

were selected for the study because a positive response was anticipated and this hypothesis tested. This approach may have positively influenced the results. It would have been interesting to have included a second group of subjects who were not expected to benefit from MAS. However, MAS construction is expensive and requires a high degree of patient compliance. All SNE investigations were undertaken by the same team. A more robust study design to assess both the sensitivity and specificity, in the form of a randomized controlled clinical trial is needed before SNE can be widely advocated as a valid prognostic indicator for MAS therapy. This preliminary investigation of a technique not previously described in the literature provides valuable information to support such a study.

Conclusions

1. SNE is an acceptably reproducible technique for determining the site(s) of obstruction in OSA subjects.
2. It thus offers possibilities as a prognostic indicator for MAS therapy.
3. All subjects selected in this way, including those with severe OSA, benefited from MAS.
4. No patient became worse as a result of treatment.

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