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MISCELLANEOUS

Sleep nasendoscopy: a 10-year retrospective audit study

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Abstract Sleep nasendoscopy was conceived at the Royal National Throat, Nose and Ear Hospital, UK in 1991, and has remained fully implemented in patient selection for targeted treatment of the spectrum of sleep-disordered breathing. The senior authors (B.T.K. and P.B.) have been performing sleep nasendoscopy together for over 10 years, and we look back at their decade's experience. A retrospective audit study based on case notes was performed over a 10-year period (1995–2005) in a tertiary-referral practice setting. Case notes were retrieved on all patients who had undergone sleep nasendoscopy during the study period, and agreed data were extracted and analyzed. A total of 2,485 sleep nasendoscopies were performed in patients with a mean age of 44.1 years, a 4:1 male preponderance, and a mean body mass index of 27.3 kg m^{-2}. Sleep nasendoscopy grading correlated well with apnoea–hypopnoea index and mean oxygen desaturation. Such grading helped us define and discuss treatment options with patients. After a median follow-up period of 518 days, 72% of patients reported feeling better; 26% of patients reported no change; and only 2% of patients reported feeling worse after treatment. Sleep nasendoscopy has proved to be a useful adjunctive method to identify the anatomical site of snoring, not to mention upper airway collapse, and remains integral to our tertiary-referral practice. It has allowed us quality assessment of the dynamic anatomy of sleep-disordered breathing that most closely and cost-effectively simulates the natural situation of patients. And for targeted treatment, such assessment has been fundamental.

Keywords Sleep nasendoscopy · Snoring · Obstructive sleep apnoea · Audit

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Introduction

Snoring is a multisegmental and dynamic problem caused by turbulent breathing due to obstruction in the nasopharynx, oropharynx and hypopharynx in differing proportions in different patients. A perpetual problem in managing such patients is accurate identification of the site of snore sound generation. Successful outcome requires treatment to be targeted. Numerous methods have tried to pinpoint the site of upper airway obstruction generating snoring. The Müller manoeuvre [1] performed during flexible endoscopy on an awake patient can only provide a crude estimation of tissue collapse in the upper airway under negative Valsalva and is no longer deemed reliable for targeted treatment. Although lateral skull X-ray cephalometry [2] and computed tomography [3] could be performed during sleep, they are static and unphysiological methods which are further limited by their side effect of irradiation. Magnetic resonance imaging may bypass the problem of irradiation, and ultra-fast sequencing may even provide dynamic study [4], but this method is entirely limited by its cost and availability. More recent methods have rightly tried to investigate snoring during sleep, and these include pharyngeal pressure measurement [5] and acoustic analysis of snoring sounds [6]. Such objective methods are promising, but they only allow indirect appreciation of sites of snoring. The ideal method

would involve direct visualization of these sites during natural sleep. Such an ideal may be realized by the use of flexible endoscopy via the nose during natural sleep [7], but this is clearly limited by its requirement for an unnatural sleep laboratory environment, not to mention an unusually compliant sleeping patient. So, the next best option would appear to be nasendoscopy during sedation-induced sleep, that is sleep nasendoscopy.

Sleep nasendoscopy was conceived in our institution [8], and remains fully implemented in patient selection for a variety of surgical and non-surgical treatment options for the spectrum of sleep-disordered breathing from simple snoring to mild obstructive sleep apnoea not necessarily requiring continuous positive airway pressure (CPAP) therapy. The senior authors (B.T.K. and P.B.) have been performing sleep nasendoscopy together for over 10 years. This audit study looks back at their decade's experience of sleep nasendoscopy, in the place where it all began.

Methods

All patients who had undergone sleep nasendoscopy between April 1995 and March 2005, under the care of B.T.K. in his tertiary-referral practice, were identified via the hospital's system of clinical coding for theatre-based procedures. All such case notes were retrieved, and data on patient factors, sleep nasendoscopy grading, sleep study parameters, type of treatment and patient report of outcome were extracted. Data were initially entered in an Excel version 11.0 (Microsoft, Redmond, WA) database, and subsequently analyzed using SPSS version 12.0 (SPSS Inc., Chicago, IL). Data were tested for normality using normality plots and Kolmogorov–Smornov tests. Those, which were normally distributed, were described using mean and standard deviations, while analysis of variance was used for multiple comparisons.

All sleep nasendoscopies were performed by either B.T.K. himself or by those directly trained by him, similarly, sleep was induced by either P.B. himself or those directly trained by him. This inter-dependent partnership between otolaryngologist and anaesthetist has been crucial in developing local standardized technique and ensuring reproducible results.

Sedation

Since its original description in 1991, we have modified the technique of sleep nasendoscopy. We do not apply topical anaesthesia in the nasal cavity, because it could potentially affect pharyngeal muscle tone, and thus alter the mechanics of upper airway obstruction. Originally, sedation was induced by incremental doses of midazolam alone. We subsequently empirically trialled other sedating agents including propofol and remifentanil, in order to determine our most effective regimen for sleep nasendoscopy. We ultimately found that a titrated administration of both midazolam and propofol worked well, and this remained unchanged as our sedation technique throughout the 10 years of this study. Midazolam (0.05 mg kg^{-1} bodyweight) provided the background sedation, while the rapid onset of action and recovery of propofol (1.5 mg kg^{-1} bodyweight) allowed for fine-tuning of sedation in response to any stimulation from the nasendoscope or a need to mimic deeper sleep. It must be appreciated that patience is required because midazolam may take up to 5 min to induce sleep. Moreover, initial sedation tends to be deeper than natural sleep, which conveniently allows passage of the nasendoscope. One must wait with the nasendoscope in position until sedation lightens such that a more natural sleep is induced. Admittedly, despite experience, local standardization and reproducibility, our sedation method remains under subjective control. However, the development of target controlled infusion (TCI) with propofol has provided an objective (computer-controlled), reproducible and measured state of sedation, decreasing the likelihood of excessive muscle relaxation and consequent false-positive obstructive breathing, and thereby increasing the validity of sleep nasendoscopy [9]. Whatever, the sedation method, of course, full cardiorespiratory monitoring and resuscitation facilities are mandatory, and we perform sleep nasendoscopy in our Surgical Day Care Unit.

Nasendoscopy

The sedated patient lies on a standard hospital trolley in a quiet and darkened anaesthetic room. Clearly, the only practical and indeed safe patient position must be supine, and so any nasendoscopic assessment is naturally limited to this body position. Having passed a lubricated nasendoscope quickly checking for any nasal obstructions, namely a deviated septum, congested turbinate or large adenoid pad, we wait for the sedation to lighten to simulate a more natural sleep. We use this time to observe for snoring, apnoea, retrognathia and desaturations. Then, we very carefully continue to pass the nasendoscope, hopefully without stimulating the nasal mucosa and thus the patient. The nasopharynx, oropharynx and hypoparynx are sequentially assessed for obstructive collapse, which is then graded according to our institution's published system [10]. Our own modifications include the allocation of percentage contributions to the soft palate and tongue base in cases of multisegmental (Grade 3 or 4) obstruction, which allows us to further target any subsequent treatment. Also, during nasendoscopy, we gently advance the mandible by upto 5 mm and then observe for changes in snoring and the upper airway. This jaw-lift manoeuvre mimics the action of a

mandibular advancement splint, and thus permits selection of patients whom may benefit from such a device [11]. To realistically encompass all of these observations during sedated sleep, the average length of time for nasendoscopy in our practice is never less than 10 min.

Exclusions

Of course, sleep nasendoscopy is not always required to make a therapeutic decision in managing patients presenting with snoring. If clinical examination revealed obvious anatomic obstruction within the upper aerodigestive tract (viz. septal deviation, nasal polyps, adenotonsillar hypertrophy), we first offered surgical removal of such obstructions. If such surgery failed to control the presenting complaint of snoring, we would have only then proceeded to investigate further with sleep nasendoscopy. Also, if patient's clearly revealed symptoms and signs of moderate to severe obstructive sleep apnoea on presentation, they would have been fast-tracked toward the gold standard of CPAP therapy. Again, only in patients in whom CPAP therapy was unacceptable or indeed failed, we would have considered sleep nasendoscopy as part of further assessment.

Results

Clinical

Over the study decade, we performed 2,485 sleep nasendoscopies, and all case notes were retrieved. Our patients had a mean age of 44.1 years (SD 10.6) and almost four-fifths (79.2%) were male. The average patient was moderately overweight, with a mean body mass index of 27.3 kg m^{-2} (SD 3.5) and a mean neck circumference of 40.1 cm (SD 3.2). As the case mix was varied, most patients did not complain of excessive daytime somnolence, and this is reflected in the mean Epworth sleepiness score of 9.3 (SD 5.1).

Grading

The vast majority of our patients snored during their sedation-induced sleep, and only 1.3% failed to exhibit their presenting complaint of snoring. Each patient's obstructive collapse was graded (Fig. 1): 6.6% demonstrated simple palatal snoring, i.e. palatal flutter (Grade 1); 17.9% demonstrated single level palatal obstruction, i.e. nasopharyngeal collapse (Grade 2); 48.9% demonstrated intermittent multisegmental obstruction (Grade 3); 8.8% demonstrated sustained multisegmental obstruction (Grade 4); and 16.5% demonstrated tongue base obstruction (Grade 5).

Apnoea–hypopnoea index

Although our grading is subjective, there appears to be good correlation with the apnoea-hypopnoea index (AHI) on sleep study, which all such patients also undergo in our practice. As shown in Fig. 2, patients with no abnormality on sleep nasendoscopy had a mean AHI of 5.8; Grade 1 and 2 patients had mean AHIs of 12.1 and 12.7, respectively; Grade 3 patients increased to a mean AHI 14.9; Grade 4 patients jumped to a mean AHI 21.9; and Grade 5 dropped back to 13.4. On analysis of variance, these differences were highly statistically significant ($F = 3.83$, at five degrees of freedom, $P = 0.002$).

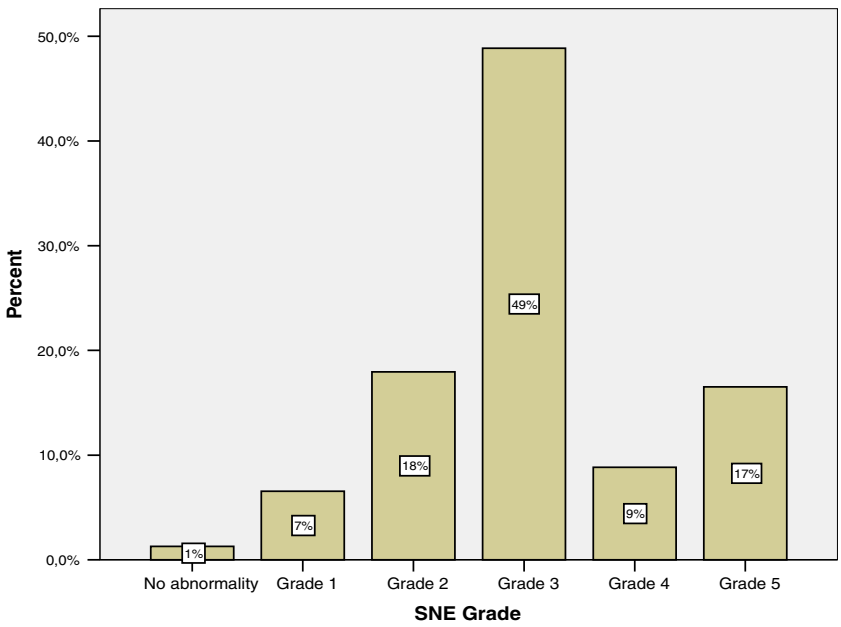

Fig. 1 Percentage of patients describing each sleep nasendoscopy (SNE) grade

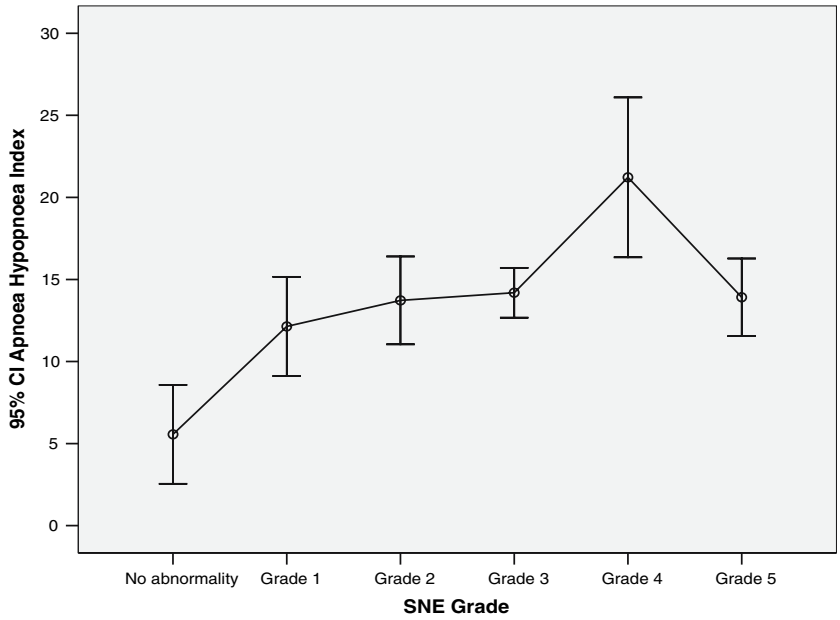

Fig. 2 Sleep nasendoscopy (SNE) grade correlation with apnoea–hypopnoea index (inc. 95% CI)

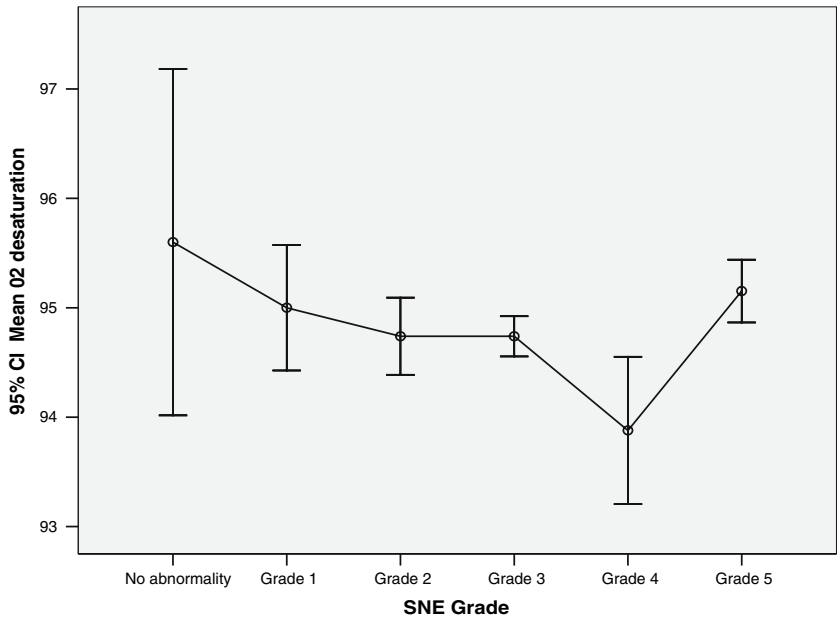

Fig. 3 Sleep nasendoscopy (SNE) grade correlation with mean oxygen desaturation (inc. 95% CI)

Oxygen desaturation

Similarly, our grading also correlated with mean oxygen desaturation, almost mirroring the correlation with AHI (Fig. 3). On analysis of variance, this was also significant ($F = 4.1$, at five degrees of freedom, $P = 0.001$).

Targeted treatments

Results from sleep nasendoscopy were used to predict successful surgical and non-surgical treatment options. Table 1 shows what proportion of patients received what type of treatment, along with specific indications for each as determined by sleep nasendoscopic grading. It is notable that 41.1% of patients underwent laser-assisted uvulopalatoplasty (LAUP) with or without tonsillectomy. The second most popular treatment was mandibular advancement splint therapy, prescribed to 20.5% of our patients.

Grading by sleep nasendoscopy helped us define and discuss treatment options with patients. Figure 4 shows how our grading correlated with the main treatment types. Grade 1 and 2 patients, describing mainly palatal problems, opted mainly for LAUP with or without tonsillectomy. However, it was noted that the prescription of mandibular advancement splints was not inappropriate for these grades of patients, especially when they demonstrated improvement in snoring and/or airway on the jaw-lift manoeuvre. Grade 3 patients comprised a mixed group, emphasising the

Table 1 Percentage of patients undergoing each treatment type

Treatment type	Indication	%
No treatment	As per clinical examination	10.2
Nasal surgery		16.3
Tonsillectomy		0.4
Nasal surgery + tonsillectomy		0.2
Laser-assisted uvulopalatoplasty	Palatal (Grades 1–3)	30.9
Laser-assisted uvulopalatoplasty + tonsillectomy	Palatal (Grades 1–3)	10.2
Uvulopalatopharyngoplasty	Palatal (Grades 1–3)	1.0
Uvulopalatopharyngoplasty + tonsillectomy	Palatal (Grades 1–3)	1.2
Radiofrequency thermotherapy (palate)	Palatal (Grades 1–3)	2.2
Radiofrequency thermotherapy (tongue base)	tongue base (Grades 3–5)	
Mandibular advancement splint	Grade 5 or jaw-lift benefit	20.5
Continuous positive airway pressure therapy	Moderate to severe OSA	6.9
Total		100.0

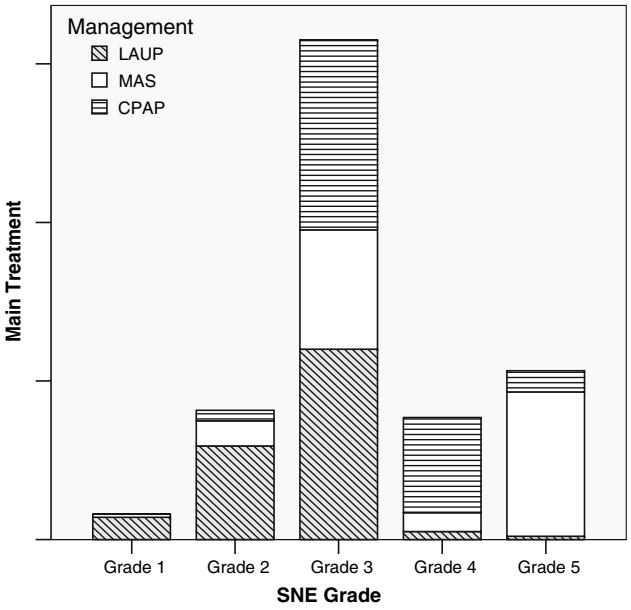

Fig. 4 Main treatment types within each sleep nasendoscopy (SNE) grade

importance of ascribing percentage contributions to the soft palate and tongue base, which would subsequently allow targeting of each patient's problem area(s). Grade 3 patients opted for either LAUP or mandibular advancement splints dependent upon a successful jaw-lift manoeuvre. Nonetheless, a significant proportion required CPAP therapy, suggesting that their intermittent multi segmental obstruction tended to actually describe obstructive sleep apnoea. A diagnosis of obstructive sleep apnoea was more certain on viewing the sustained multi segmental obstruction of Grade 4 patients, who were more or less primarily directed toward CPAP therapy. Finally, Grade 5 patients, who unsurprisingly demonstrated improvement on jaw-lift, opted mainly for mandibular advancement splints.

Subjective outcomes

From retrospective analysis of 2,485 case notes, the only available outcome measure was subjective patient opinion, as documented by an examining doctor at a varying point of follow-up. Patients were simply asked if they felt better, unchanged or worse. So, after a median follow-up period of 518 days (SD 50 days), 72% of patients reported feeling better; 26% of patients reported no change; and 2% of patients reported feeling worse after treatment.

Objective outcomes

To allay the forced limitation of relying upon subjective patient opinion in this retrospective audit study, we offer objective outcomes from published studies of our practice, involving cohorts of our sample of 2,485 patients. Regarding targeting treatment by mandibular advancement splint therapy, Battagel et al. [11] studied a prospective cohort of 27 patients, who were referred for splint therapy following Grade 3, 4 or 5 findings on sleep nasendoscopy, during which a splint-mimicking jaw-lift manoeuvre proved beneficial in relieving upper airway obstruction and snoring. Outcome measures included both repeat sleep nasendoscopy and sleep study with the splint in situ. Repeat sleep nasendoscopy revealed the predicted improvement in upper airway obstruction and snoring in all but one patient. Repeat sleep study revealed highly statistically significant reductions in median AHI (from 28.1 to 6.1, $P < 0.001$). Regarding targeting treatment by LAUP, Kotecha et al. [12] studied a prospective cohort of 87 patients, who underwent this palatal procedure after Grade 1 or 2 findings on sleep nasendoscopy. Outcomes measures included a repeat sleep study after 9 months follow-up for a subset of 10 consecutive patients, which revealed objective improvement in snore sound recordings in 90%, and actual cessation of

snoring in 50%. Iyngkaran et al. [13] studied long-term benefit after LAUP (median 59 months follow-up) by questionnaire survey of a retrospective cohort of 168 patients and their partners. Results revealed that the benefits of LAUP waned with time, having peaked within the first 12 months post-operatively. This study suggested that 55% of patients selected for LAUP by sleep nasendoscopy would enjoy long-term benefit. Chisholm and Kotecha [14] studied a prospective cohort of 20 CPAP failures, who proceeded to have LAUP after Grade 3 or 4 findings on sleep nasendoscopy. Outcome measures included repeat Epworth sleepiness scoring and sleep study, both after 4 months follow-up. Epworth scores dropped from a mean 15.6 to 7.9; AHI dropped from a mean 47.9 to 12.9. Only two patients still required CPAP post-LAUP, but both only at reduced and thus more tolerable pressures. This study attributed the high success rate of LAUP for moderate to severe obstructive sleep apnoea to the targeted selection offered by sleep nasendoscopy.

Discussion

Sleep nasendoscopy remains controversial. Critics have demonstrated that a patient's snoring quality and quantity varies with sleeping position, as well as between and within sleep stages [15]. They infer that sleep nasendoscopy may not be representative of a night's snoring, because it only provides a snapshot of snoring in a single (supine) position. Critics also do not believe sedation-induced sleep correlates well with natural sleep [16], even when administering sedative by TCI [17]. They infer that sleep nasendoscopy cannot be reliable, because sedation appears to significantly alter upper airway dynamics to generate snoring sound from different and/or extra sites. They are further concerned that potentially excessive muscle relaxation may yield false-positive obstructive breathing. Proponents often counter that any excessive muscle relaxation would affect the entire upper airway, and so should not necessarily affect a comparative assessment of the nasopharynx, oropharynx and hypopharynx during sedation-induced sleep. Finally, critics highlight that sleep nasendoscopy itself is subjective, not only considering inter-observer variation between otolaryngologists, but also variation between anaesthetists' sedation methods for which there are no standardized protocols. With all this in mind, it is not altogether surprising that disparate results continue to be reported within and between patients, centres and studies.

Despite such criticism, we would argue that sleep nasendoscopy still has a role in the investigation of snoring and obstructive sleep apnoea. Our retrospective audit demonstrates how useful sleep nasendoscopy has been in targeting treatment in our practice. We have found that our sleep nasendoscopy grading, albeit subjective, correlates well with sleep study parameters of AHI and oxygen desaturation (Figs. 2,3), where patients with multisegmental obstruction (especially Grade 4) tended to demonstrate defined episodes of obstructive sleep apnoea. We have also found that our grading helped us determine treatment options and allow our patients the benefit of informed choice during follow-up discussion. Subsequently, our grading is seen to correlate with the main treatment options on offer (Fig. 4). For Grade 1 or 2 patients and their defined palatal problems, we offered LAUP. We added tonsillectomy, if subtle lateral oropharyngeal collapse from enlarged tonsils was noted during sleep nasendoscopy. More recently, we have offered radiofrequency interstitial thermotherapy (RFITT) to the soft palate, and this more conservative option has been increasingly popular. We have found the differentiation of pure palatal flutter (Grade 1) from concomitant nasopharyngeal collapse (Grade 2) to be useful in our discussion with patients, because the former finding allows us to predict greater guarantee of successful palatal surgery. For Grade 5 patients and sometimes those who demonstrated improvement in snoring and/or airway on the jaw-lift manoeuvre regardless of grading, we offered a mandibular advancement splint or, if that was contraindicated or intolerable, RFITT to the tongue base. For Grade 3 patients, who made up almost half of our cases over 10 years, we offered a combination of treatments for their typically multi segmental problems. On the other hand, we have found Grade 4 patients to commonly demonstrate obstructive sleep apnoea on both sleep nasendoscopy and sleep study, and thus tended to direct patients toward CPAP therapy.

Our confidence in sleep nasendoscopy would not be possible without the close partnership between otolaryngologist and anaesthetist, observing and sedating respectively but inter-dependently. Indeed, we demonstrate our reproducible and reliable results from locally standardized observing and sedating techniques that comprise our method of sleep nasendoscopy. On the contrary, less reproducible and reliable results are evident in studies where otolaryngologist and anaesthetist work irrespectively and independently with little understanding of each other's needs.

There has been recent emphasis on objective and less invasive investigation of snoring, which ought to be possible during natural sleep. Both pharyngeal pressure measurement and acoustic analysis of snoring sounds have been proposed as such investigations. Such methods are promising, but their objectivity only relates to their actual detecting, measuring and recording of either pharyngeal pressure or snoring sound parameters; the interpretation of any such results is still necessarily subjective. At best, only indirect manometric or acoustic fingerprints of sites of snoring are

provided; and the latter remain undefined and subject to quantitative variation between softwares and thus studies [18]. Although we welcome such developments, we are keen for further research and standardization.

Conclusion

We would never promote sleep nasendoscopy as a unique investigation for sleep-disordered breathing, but would argue that it is a useful adjunctive method to identify the anatomical site of snoring, not to mention upper airway collapse. Acknowledging its well-publicized limitations, we would argue that the direct visualization afforded by sleep nasendoscopy, actually defining delicate dynamics of the upper airway, is nonetheless valuable for targeted treatment. Since its inception here, sleep nasendoscopy remains integral to our tertiary-referral practice. It continues to allow us quality assessment of the dynamic anatomy of sleep-disordered breathing that most closely and cost-effectively simulates the natural situation of patients. And to their surgeon, such assessment is surely fundamental.

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