The Journal of Laryngology & Otology (2006), ***120***, *385–388*.

doi:10.1017/S0022215106000119
Printed in the United Kingdom
First published online 26 January 2006

Main Article

Optical quality of the nasendoscope with and without the endosheath

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Abstract
With the increasing use of the endosheath in clinical practice, we set out to investigate the quality of the nasendoscope image produced with and without an endosheath. It has been suggested by some users that the endosheath degrades the image. We used a spectrophotometer to assess the optical transmission of the endosheath and found no selective chromatic absorption. However, on requesting nine experienced users to document whether they could differentiate between the sheathed and unsheathed endoscope, a significantly correct answering pattern was obtained in repeated blinded experiments. This suggests that individuals can distinguish between the sheathed and unsheathed nasendoscope view and that the image is indeed altered when an endosheath is employed.

Key words: Endoscopes; Sterilization; Otolaryngology; Great Britain

Introduction

The flexible nasendoscope is now routinely used in most ENT clinics throughout the UK. It has become the 'gold standard' for routine visualization of the postnasal space, larynx and hypopharynx in the out-patient department, replacing indirect mirror examination. Its ease of use, good patient acceptability and excellent quality image have made the nasendoscope a valued tool.

The nasendoscope is, however, a delicate and expensive piece of equipment and should be stored, used and cleaned carefully in order to avoid damage. A variety of methods are used in the UK to sterilize the nasendoscope.[1] The toxicity of the chemicals commonly used to disinfect this piece of equipment, together with the rationalization of the decontamination procedures being adopted throughout the UK,[2] have led to the introduction of an endosheath that can be applied as a single-use covering on an individual patient basis. The cost implications of dedicating a room in an out-patient department and equipping this with appropriate sterilization equipment are significant. However, the expense of long-term usage of nasendoscope sheaths should also be considered. Some individuals feel that the quality of the view produced whilst using an endosheath is inferior compared with that of the unsheathed nasendoscope; this would have significant clinical implications if it were true.

We therefore aimed to investigate this issue further, using spectrophotometric analysis and a visual test with and without the endosheath, to assess whether a difference in the nasendoscope view could be distinguished.

Material and methods

A nasendoscope (Olympus P4, Tokyo, Japan) was assembled with its standard light source and a spectrophotometer (Ocean 2000, Dunedin, USA) used to measure the spectral distribution of the nasendoscope's visible output with and without the endosheath.

Visual acuity using the nasendoscope cannot be formally measured by the clinical Snellen chart test as the depth of field of a nasendoscope is only 5–50 mm and the lens refraction required to correct this depth of field to enable a Snellen test is impractical. Similarly, it would be extremely difficult to set up a test of contrast sensitivity. The nasendoscope was therefore secured to an optical bench and a target placed a distance of 20 mm from its tip in the mid-range of the depth of field (Figure 1). The target had been designed such that it filled the field of view when viewed with the nasendoscope at a distance of 20 mm, (Figure 2). The nasendoscope was then either sheathed or left unsheathed and the subjects blinded to this process by hiding the nasendoscope from view, leaving only the eyepiece accessible. Initially, all subjects were shown the image with a sheath and without a sheath. The subjects were then asked on ten separate occasions to view the target pattern and to document, on the

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Accepted for publication: 23 August 2005.

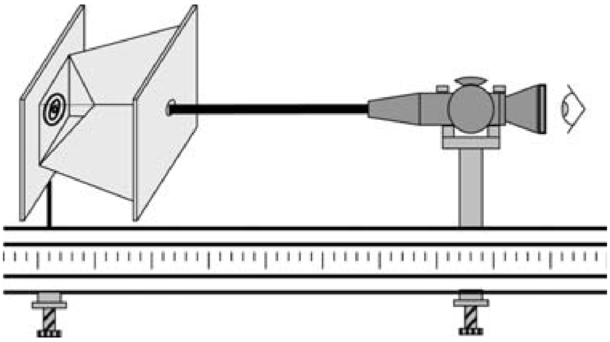

FIG. 1
Nasendoscope on the optical workbench.

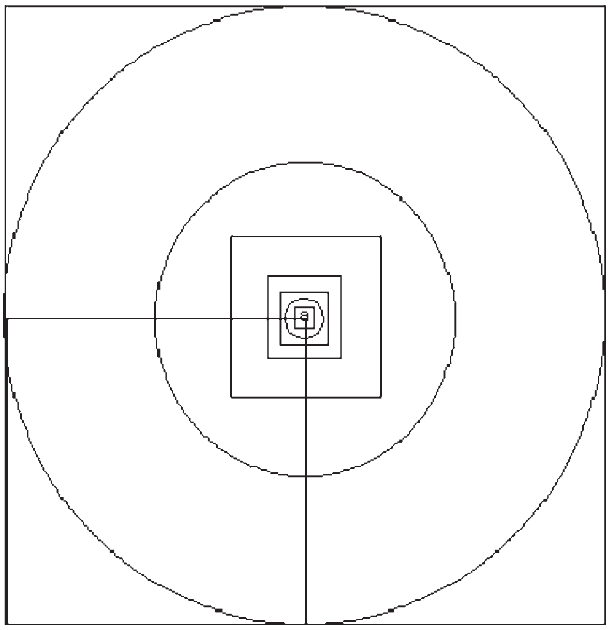

FIG. 2
Target viewed through the nasendoscope.

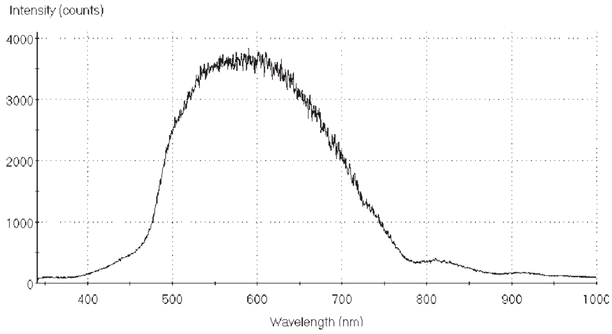

FIG. 3
Spectral analysis of the nasendoscope without endosheath.

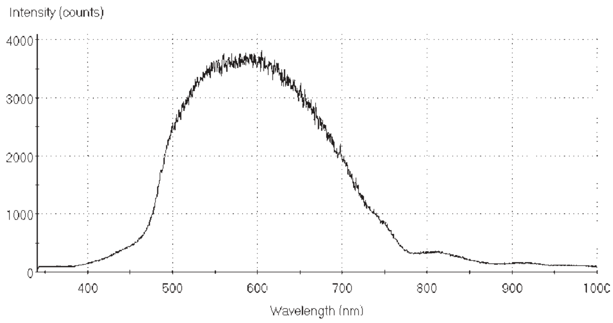

FIG. 4
Spectral analysis of the nasendoscope with endosheath.

scoresheet provided, whether they thought the nasendoscope was sheathed or unsheathed. Two independent observers sheathed and unsheathed the nasendoscope according to a previously generated random sequence. A standard time was spent changing the sheath, or not, in order not to bias the awaiting observer's opinion.

Nine subjects underwent the trial, ranging from senior house officer to consultant grade, all of whom had used nasendoscopes previously. All were instructed to use the nasendoscope with their usual eye and to wear spectacles if they usually did so.

Results and analysis

There was no apparent difference in the spectrum of light emitted from the nasendoscope with and without an endosheath fitted (Figures 3 and 4). Therefore, any apparent differences in the nasendoscope image should not have been due to any chromatic effect.

The scoresheets of the nine subjects were assessed according to how many times they correctly distinguished the nasendoscope as sheathed or unsheathed (Table I). Our working hypothesis and statistical evaluation of results are explained in depth in the Appendix.

If use of the endosheath caused no difference in the optical resolution, one would expect the subjects to randomly guess the answer, with no significant trends away from the expected 50/50 binomial distribution. The subjects, however, significantly ($p = 0.00052$) recorded more correct answers than would be expected by chance. This indicates that, on average, the subjects were able to distinguish the presence or absence of an endosheath when looking at a preset target. This implies that the presence of an endosheath degraded or altered the image in some way.

TABLE I
SUBJECTS' PERCEPTIONS OF PRESENCE OR ABSENCE OF ENDOSHEATH

Subject	Trial										Score
	1	2	3	4	5	6	7	8	9	10	
A		X	X	X		X	X	X		X	7
B	X		X		X	X	X			X	6
C	X	X	X	X	X	X	X	X	X		9
D	X		X					X	X		4
E	X	X	X		X			X	X		6
F	X	X	X	X	X	X	X	X	X		9
G	X	X	X	X	X		X				6
H	X	X	X		X		X			X	6
I	X		X		X	X	X	X	X	X	8
Correct answer	Y	Y	N	N	Y	Y	N	Y	N	N	

X indicates a correct response.

https://doi.org/10.1017/S0022215106000119 Published online by Cambridge University Press

Discussion

The flexible nasendoscope has become a routine method of viewing the postnasal space, larynx and hypopharynx. The use of the nasendoscope can be both diagnostic and therapeutic[3,4] and is of great benefit to the clinician. It may be used in the outpatient setting but also (with sedation) in operating theatres for assessment of snoring.[5]

The endosheath is a slide-on, latex-free, sterile, disposable cover that has been introduced for use with flexible nasendoscopes. It has a window at its tip that appears to be optically clear; it is imperative that the endosheath is positioned onto the endoscope snugly and that this window is touching the end of the nasendoscope. Failure to do this has anecdotally produced internal reflection of light and an exceptionally poor view. Following the manufacturer's guidelines usually enables the safe fitting and removal of the nasendoscope. One of the authors has seen incorrect removal of the endosheath result in stripping of the nasendoscope's black covering and exposure of the fibre-optic system within. The sheath must therefore be carefully and correctly used, as instructed by the manufacturers.

The benefits of using a sheath system include the ability to quickly reuse nasendoscopes in the clinic, as they are usually never contaminated. This decreases the nasendoscope's 'down time' whilst it is being sterilized and also the operator's (or assistant's) time spent whilst in sterilization. Using an endosheathed nasendoscope during non-ENT ward referrals reduces contamination risk. As we are routinely asked to see patients on other wards, including intensive care units, where hospital acquired infections are prevalent, such contamination issues are significant. We are also asked to see patients out-of-hours, when nasendoscope disinfection may become more difficult. Using an endosheath prevents contamination and therefore negates the need for out-of-hours disinfection.

The sheathing system has been used for a variety of endoscopes and its benefits and limitations have been investigated.[6–8] The majority of studies agree that the down time for the scope is significantly reduced. However, only subjective assessments of image clarity have been reported, and most endoscopists tend to prefer an unsheathed system.

There is a paucity of ENT literature publications addressing the optical characteristics of endoscopes. Since such endoscopes are standard instrumentation in most departments, this is surprising. A subjective assessment of the view produced with and without the endosheath has been performed previously,[9] this was however undertaken as a non-blinded assessment of image quality. It is almost unfeasible, from an optical correction perspective, to undertake a formal eye test with a nasendoscope, as this requires the use of a Snellen chart placed at a distance of 20 feet from the observer, while the nasendoscope's maximum depth of field is 50 mm. For this reason, a formal target was created to fill the field of view, and an assessment of clarity was performed with and without an endosheath. Endoscope visual fields have more recently been investigated;[10] studies such as this clearly indicate that we should have a better understanding of the optical characteristics of these regularly used instruments.

Spectrophotometric analysis categorically established that endosheath use causes no spectral distortion of the nasendoscope output. This is of great importance; if chromatic interference was noted, then nasendoscope users' interpretation of colour differences would be altered by the presence or absence of the endosheath. This spectrophotometric light measurement is only related to what comes from the standard light source through the nasendocope and then across the thin transparent lens of the endosheath. We assume the same to be true for light travelling in the opposite direction, which is just as important (in a fibre-optic, lens-based system) for the image retrieved at the eyepiece; however, proving this would involve further biomedical experimentation.

Our experiment began with the hypothesis that employing an endosheath would not alter the user's nasendoscope view; subjects would therefore be unable to visually differentiate between the sheathed and unsheathed nasendoscope. It was however clear that subjects could differentiate between the sheathed and unsheathed views, from the significantly high proportion of correct responses. This does suggest that there is an optical distortion issue. The magnitude of this distortion is more difficult to ascertain, given the optical characteristics of the endoscope.

Conclusion

There is an increasing trend for the clinical use of nasendoscope endosheaths; however, their benefits and limitations must be assessed carefully. Full implementation of this form of nasendoscope barrier protection has significant financial implications, and we must therefore produce robust data on endosheaths' optical and microbiological qualities.

We have demonstrated that sheathed and unsheathed nasendoscopes have sufficiently different optical characteristics to enable users to distinguish between them. The magnitude of this difference and its effect in clinical practice requires further investigation.

- **Standard sterilization issues are an increasing agenda within the NHS. Sheathing of nasendoscopes allows for avoidance of significant sterilization procedures**
- **This study investigated the optical characteristics of sheathed endoscopes**
- **No difference was demonstrated in the light emitted when using an endosheath; however, there was a significant ability to distinguish between the view of a sheathed versus an unsheathed endoscope, despite the individuals being blinded to the sheathing process**
- **Further investigation into the optical characteristics of the endosheath needs to be undertaken**

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Appendix

The results of such an experiment may be described by a binomial distribution. If n estimates are made with a probability p that an estimate is correct and a probability $(1 - p) = q$ that an estimate is incorrect, then the mean number of correct estimates should be $\mu = np$ and the standard deviation should be $\sigma = \sqrt{(npq)}$. Our initial hypothesis was that subjects would not be able to distinguish the presence or absence of a sheath, hence $p = q = 0.5$. Since $n = 90$, we would expect 45 correct answers with a standard deviation of 4.74. Furthermore, in the absence of any bias or prejudice, we would expect equal numbers of 'yes' and 'no' responses. We actually recorded 61 correct responses, i.e. 3.37 standard deviations away from the expected mean; the probability of this occurring by chance is very small ($p = 0.0005$). Thus, our hypothesis failed and we had to assume that at least some of the subjects could distinguish the presence of the endosheath.

If there was no bias in subjects' expectations, this would be demonstrated by equal numbers of 'yes' and 'no' responses, and we would expect 45 of each. In fact, we obtained 48 'yes' and 42 'no' responses; the difference of 3 from the assumed mean is within one standard deviation and is statistically insignificant ($p = 0.5$).

If there was no significant difference between our two experimental conditions, then this would be demonstrated by equal success of the subjects in detecting each condition. We appeared to have a binomial distribution of results, based upon $p = 61/90$ and hence $q = 29/90$; for the 45 trials of the 'yes' condition we should therefore expect 30.5 ± 3.1 correct answers – we actually obtained 32 ($p = 0.4$).

One possible criticism of the experiment, as it was actually performed, is that subjects were told in advance that there would be a random trial with an equal number of 'yes' and 'no' conditions. An astute subject trying for a high score might therefore have adjusted their later responses to equalize the numbers. This did not obviously occur (even though five of the subjects did record 5 : 5 yes : no ratios); the two best subjects (who scored 9/10 with 6 : 4 yes : no ratios) might otherwise have recorded a different last response to improve their chances of a 'perfect ten', while two others might not have recorded 7 : 3 and 4 : 6 yes : no ratios.

The scores of the various subjects ranged from 4/10 to 9/10, with an average performance of 6.77/10. It needs to be ascertained whether this range reflects differences in skill among the subjects or is an expected statistical fluctuation. It can easily be shown that the probability of one subject scoring 9/10 or 10/10 is about 9 per cent, and so the chances of two doing so are about 0.83 per cent, which means that it is very likely ($p = 0.0083$) that the two best subjects were more skilled than the rest.

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Mr F Vaz takes responsibility for the integrity of the content of the paper.
Competing interests: None declared