A new approach to improving illumination in the nose during endonasal surgery*

S.T. Browning, F.F. Fahmy, H.B. Whittet

Department of Otolaryngology Head and Neck Surgery, Singleton Hospital, Swansea, United Kingdom

SUMMARY

Despite improvements in light sources the problem of illumination during endonasal surgery persists. This is particularly so in the presence of blood which absorbs light and renders the operative field dark as a consequence.
This paper describes a series of in vitro experiments that show how improved illumination is possible using readily available, inexpensive, sterilisable and flexible materials.
The hypothesis tested was that white coloured materials, when placed into the nasal cavity during endonasal surgery, improve illumination of the operative field by reflecting light onto the area of surgical interest. This hypothesis was tested with the use of a light proof box into which were introduced blood coloured and reflective materials. The light reflected back from a fixed blood coloured surface within the box was measured. The introduction of white materials into the box provided greater illumination than blue or foil surfaces.

Key words: endonasal surgery, illumination

INTRODUCTION

Minimally invasive, endonasal surgery has, over recent years, become a widely accepted method of treating paranasal sinus disease. Rapid advances in optical technology and light sources have allowed this to become a safe alternative to more established techniques.
The problem of adequate illumination, however, remains an issue particularly when operating in the ethmoid sinus between the orbit laterally and the anterior cranial fossa superiorly. The space is small and bleeding from the sinus and nasal mucosa both obstructs the view of the field and decreases the amount of light reflected from the field. Blood absorbs a significant amount of light when it accumulates to any volume within the cavity. This can be offset by suction, but at times bleeding from an inflamed mucosa causes significant difficulties.
During such operations it was noticed that upon introduction of a length of white ribbon gauze (soaked in adrenaline to assist vasoconstriction) into the cavity the illumination of the cavity increased. It was postulated that such material may act as a reflector for light and cast illumination into other areas of the operative field. This would be analogous to the technique used by photographers to improve illumination of a subject by the use of a reflective umbrella. This hypothesis is shown diagramatically in Figure 1.
The experiments described below were devised to test the hypothesis that reflective materials placed into the nasal cavity could improve illumination of the operative field.

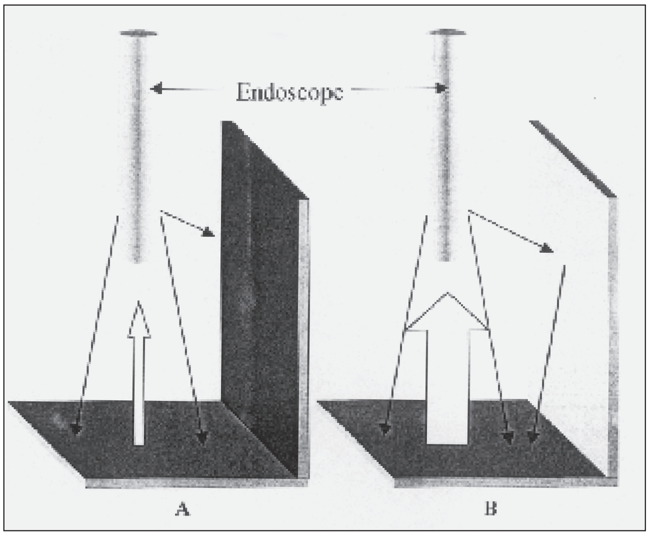

Figure 1. A pictorial representation of the hypothesis under test.
a. Light from the end of the endoscope is absorbed by the mat lining of the experimental box (representing the nasal cavity) and only light that is directly incident on the box floor is reflected back towards the surgeon (narrow white arrow).
b. With reflective panels in place light is reflected onto the floor of the box and hence more light is reflected towards the surgeon (broad white arrow).

MATERIALS AND METHODS

- A light proof box (see description below and Figure 2)
- 0° Rigid endoscope (Storz 7200A, Karl Storz, Germany)

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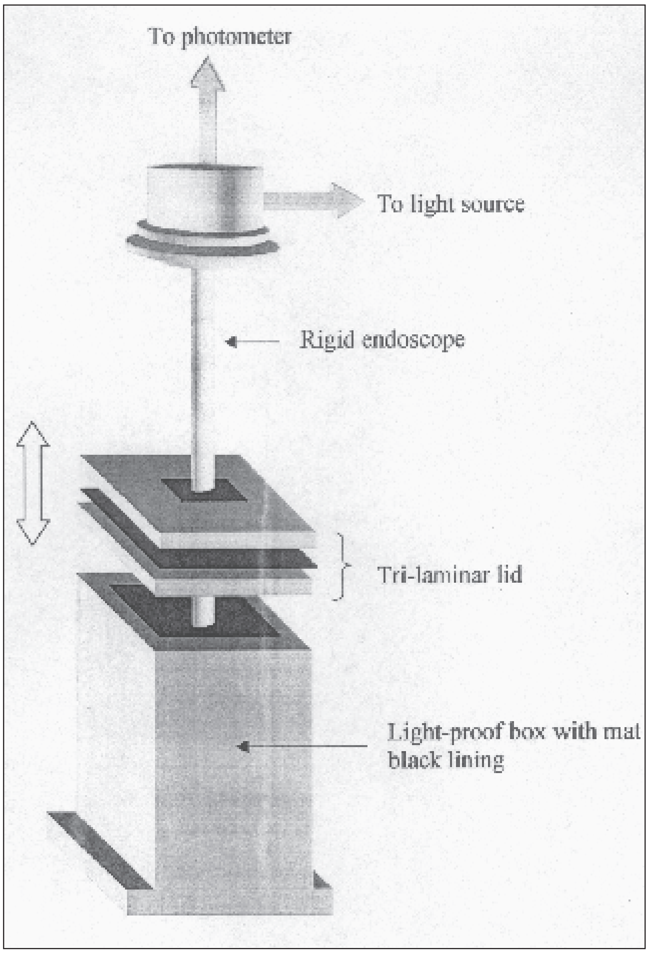

Figure 2. The experimental set up. The light-proof box is painted with mat black emulsion. The entire set up is suspended in vertical alignment by a retort stand and clamps. The white arrow indicates the movement of the lid to allow placement or blood covered or reflective panels.

- Light sources for the endoscope (Lemke endobeam XL754, Universal Headlight and Eschman ST80-SH.)
- Fibreoptic light cable (Wolf 8061.353)
- Light meter (Radiometer/Lightmeter R102, Macam, Livingstone, Scotland)
- Jig for assembly
- Reflective panels (foil, white silastic sheeting [Exmoor Plastics Ltd, Exmoor, England], white card) and blood covered panels to fit inner dimensions of the box.

For the purposes of the study a light proof box was designed (Figure 2). This was painted internally with a non-reflective black paint. The lid of the box was removable to allow the placement of light reflective and blood covered panels against the internal walls of the box. The lid of the box was constructed in three layers: an outer and inner solid layer between which was sandwiched a rubber membrane. The lid was pierced in its centre to allow a rigid endoscope to pass in. The rubber membrane ensured a light proof seal.
The light meter was calibrated and set up using a green photometric filter and adjusted to measure light reflection in Lux.
Prior to starting each experiment the light sources were allowed five minutes to reach a stable light output and temperature.

Two sets of experiments were performed: the first to test the experimental set-up (Group A tests) and the second to test the experimental hypothesis (Group B tests).

The Group A tests were twofold and used only the Universal headlight light source.

Experiment 1. The effect of time on light reflection from the box.
The experimental design used human blood painted panels to line the box. The light sources generate heat at the tip of the endoscope. This heat may change the light reflectivity of the blood pigment. This first experiment sought to demonstrate whether there was a change in the light reflected from the box with time. The endoscope was placed into the box to a fixed distance and the light cable attached. Light reflected from the box was measured every 30 seconds for 300 seconds. This period greatly exceeded the usual time for measurements. The endoscope tip was held 5.5 cm from the box floor.

Experiment 2. The effect of repeated removal and replacement of the endoscope and panels into the box.
The experiments performed on light reflectivity require the repeated removal of the endoscope and box lid to place light reflecting panels into the box. This experiment sought to determine the effect on reflectivity readings of the minor changes in the position of the endoscope tip that this process inevitably caused. The endoscope tip and the panels were removed and replaced so that the tip of the endoscope was held 5.5cm from the box floor. This was done five times.
After the preliminary experiments on the experimental hardware had been performed Group B experiments were performed to examine the effect of various light reflective materials on light reflectivity. In these experiments the floor of the box was always covered in a blood painted panel. It was at this blood covered panel that the endoscope was directed through the top of the box. All four walls of the box were firstly covered by blood panels. These panels were progressively removed and replaced with panels of reflective material. The light reflected from the floor panel was measured after each successive panel change.

Experiment 3. The effect of the colour of the reflective material.
For this experiment three panel colours were compared: white silastic, blue silastic and tin foil. The light reflected from the box was measured for one, two, three and then four panels of each material. The endoscope tip was held 5.5cm from the box floor.

It was shown by the experiment above that white materials were superior to blue or foil panels (see Results section). Therefore, in subsequent experiments only white silastic panels were used. Silastic was chosen as it is sterilisable, flexible and readily available in the ENT theatre. White silastic was used specifically rather than the translucent form.

Experiment 4. The effect of different light sources.
This experiment compared the light reflectivity between three commonly available endoscopic light sources in order to determine whether there were any differences caused by variation in

Table 1. The effect of different colour panels on the light reflected from the box floor (Lux).

	One panel	Two panels	Three panels	Four panels
White panels	2.5	4.6	7.1	9.62
Blue panels	2.27	3	4.5	5.78
Foil panels	1.4	1.42	1.68	2.2

Table 2. A comparison between three light sources. The number of readings taken for each was four and are measured in Lux. * indicates statistical significance ($p<0.05$) between the reading and the reading for no panels.

	No panels	One panels	Two panels	Three panels	Four panels
Universal	4.06±0.14	5.06±0.19*	5.80±0.46*	6.50±0.19*	6.37±1.88
Lemke	1.25±0.04	1.80±0.12*	2.16±0.16*	2.30±0.06*	2.63±0.12*
Eschman	1.30±0.15	1.70±0.36	1.74±0.18*	2.00±0.17*	2,23±0,21*

Table 3. The effect of proximity to the blood covered floor panel. Light reflectivity is measured in Lux. The distance represents the distance from the endoscope tip to the floor of the experimental box. *=$p<0.05$. §,†,ϕ,‡=$p<0.03$.

	No panels	One panel	Two panels	Three panels	Four panels
5.5cm	4.06±0.14*	5.06±0.20§	5.80±0.47†	6.54±0.19ϕ	6.38±1.88‡
4.5cm	5.71±0.18*	6.49±0.24§	7.52±0.39†	8.27±0.28ϕ	8.01±1.65
3.5cm	9.10±0.41*	10.00±1.64§	11.00±0.54†	13.00±0.50ϕ	12.00±1.35‡

manufacturer design. Light reflection measurements were made for each light source using one, two, three and four panels of silastic in the experimental box. This process was repeated so that four readings were taken for all light sources. The endoscope tip was held 5.5cm from the box floor.

Experiment 5. The effect of the proximity of the endoscope tip to the box floor.
As the endoscope tip nears the surface at which it is directed one would expect a greater amount of light to be reflected. In order to test this hypothesis the endoscope was placed at three distances from the box floor: 5.5, 4.5 and 3.5cm. Light reflected was again measured using one, two, three and four panels of silastic. All three light sources were used in turn for this experiment and four readings were taken for each combination of position and panel number.

RESULTS

All results in this section are stated as mean ± standard deviation unless otherwise indicated. The data are non-Gaussian in distribution and the Mann Whitney U test is used unless otherwise stated.

Preliminary experiments.

Experiment 1. The effect of time on light reflection.
Ten measurements were made at 30s intervals (300s total). The mean value was 1.67± 0.007 Lux with a coefficient of variation in the results of 0.46%. It was concluded that there was no effect by virtue of increasing temperature on the reflectivity of the blood panels over the experimental time period.

Experiment 2. The effect of repeated removal and replacement of the endoscope into the box.
Five readings were taken during this experiment. The mean value was 1.554±0.056 Lux. The CV was 3.62%. The minor changes in endoscope tip position that are inevitable during placement and replacement of the reflective panels, therefore, seem to have little effect.

Experiments on reflective materials.

Experiment 3. The effect of the colour of the reflective material. White, pale blue and tin foil panels were used. The results are shown in Table 1. White panels increased the reflectivity from the blood panel on the box floor to the greatest degree. Blue panels gave an intermediate increase in light reflectivity and foil panels gave the poorest illumination of the box floor.
The results also clearly show that for each additional coloured panel there is an increase in light reflected from the box floor.

Experiment 4. The effect of different light sources.
Table 2 shows the results of this experiment. Light sources vary in their light intensity. The Universal Headlight source provided the best illumination with Eschmann and Lemke being comparable. For all the light sources the amount of light reflected increased with the number of panels in the box. This increase in light reflected achieved statistical significance in most cases.

Experiment 5. The effect of proximity of the endoscope tip to the box floor.
All three light sources were used in this experiment but only the results from the experiment with the Universal Headlight sour-

ce are shown here. The effect of proximity to the floor was the same for all light sources. Table 3 shows the results.

The table shows that the nearer the endoscope is to the floor of the box the more light is reflected into it. Increasing the number of reflective panels in the box continues to increase the light reflected regardless of the proximity to the box floor. The results are statistically significant reading down all columns.

DISCUSSION

The light available to the endonasal surgeon is, today, vastly superior to that when rigid endoscopes first appeared. Nonetheless, illumination can still be critically affected by the amount of blood in the operative field. The experiments described in this paper have shown that white reflective materials are superior to pale blue silastic and aluminium foil. As more white material is placed around the operative field the amount of light reflected back from that field increases and this effect is maintained as proximity to the field increases.

Silastic is ideally suited for this purpose. It is readily available and inexpensive. Furthermore its thinness and flexibility together with the fact that it can be sterilised make it the perfect material for working in the narrow confines of the nasal cavity. Using commonly available materials we have shown that the illumination within the nasal and sinus cavities can be significantly improved by placing reflective materials with the nose. Improved visibility makes for safer and less time consuming surgery.

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S.T. Browning
Department of Otolaryngology Head and Neck Surgery,
Singleton Hospital, Swansea, UK
Tel.: 01972 205666
E-mail: roro@dircon.co.uk

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Dr. K.J.A.O. Ingels (Secretary ERS), Department of Otorhinolaryngology, University Hospital "St. Radboud", Geert Grooteplein Zuid 18, NL-6525 GA Nijmegen, The Netherlands