Theoretical Thermal Energy Transfer from Nasal Endoscopes and its Potential Injury Risk

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ABSTRACT

With advanced endoscopic endonasal skull base surgery, the light source is in much closer proximity to critical neurovascular structures. Thermal energy generated from nasal endoscopes could pose a potential injury threat to surrounding tissues during extended surgical operations. The purpose of this study was to measure the energy output from various nasal endoscopes as well as from the two most commonly used light sources to determine the theoretical risk of tissue damage to nearby structures while performing rhinologic surgery.

Methods: Light output from three different nasal endoscopes (0°, 30°, and 70°) and two different light sources (Stryker and Storz) were measured using a light intensity meter. This power data was then converted into energy by including the area of each light dot from the specific endoscopes.

Results: For a given light source, the 70° scope transmitted 27% more power than the 0° scope and 95% more power than the 30° scope. The combination of these parameters results in the greatest light intensity on the field coming from the 70° scope and the least from the 0° scope. The 70° scope yielded 3.3x greater light intensity on the tissue than the 30° scope and 17x more intensity than the 0° scope due to both greater light transmission efficiency and less spreading of the light for the 70° scope.

Conclusion: Differences in power output from endoscopes varied based on both the type of light source used as well as the viewing angle. The theoretical risk of tissue damage seems to be greatest with the 70° scope and had a linear relationship with the input power settings of the light source.

BACKGROUND

Advanced endoscopic endonasal skull base surgery has created the opportunity for less invasive procedures as well as leading to a greater aesthetic effect for the patient by not making an incision on the face. This comes with the cost, however, of a nasal endoscope being located within close proximity to critical structures such as the optic nerve for extended periods of time. Thermal as well as light energy remains a concern for practitioners. Photodynamic damage has been described to cause necrosis and apoptosis of gliocytes, and a number of studies have looked at the temperature of nasal endoscope tips and if these have the potential to cause tissue damage, with varying conclusions.5, 6

Our study looked theoretically at the light illumination from an endoscope; light acts as both a particle and a wave, so the light energy is not only coming from a linear dispersal but also from the “light spread”, or the circular distribution that an endoscope emits. Light energy could thus be calculated knowing the area of the light spread, the time that an endoscope would be illuminating a particular area, and the measured light intensity that would be determined in part by the input power of the light source.

Various techniques have been used to try to dampen the amount of thermal energy coming from nasal endoscopes, including endoscope sheaths and irrigation, which have been shown to decrease scope temperatures when used together.6

METHODS

We used a standard Karl Storz light source and light cable as well as a standard Stryker light source and light cable. These were paired with the following endoscopes: 0°, 30°, and 70° (Karl Storz). Light intensity measurements were measured using the Thorlabs PM120D Digital Power and Energy Meter, Si Sensor for various input powers on each light source. The distance from the endoscope to the light intensity meter was 5mm and each endoscope was operated by a fellowship-trained rhinologist. High resolution photos were taken of each light bubble to determine area of illumination. Eventually, the light intensity readings were converted into light energy values using the formula:

Intensity x Time x Area = Energy

Joules

RESULTS

At the same percept power setting, the Storz light source was on average 72% more powerful than the Stryker light source. For a given light source, the 70° scope transmitted 27% more power than the 0° scope and 95% more power than the 30° scope. From 2mm away, the 0° scope had the widest spread of illumination with the half-maximum light intensity spanning 26.4mm while the 30° and 70° scopes spanned 9.5mm and 7.2 mm, respectively.

The combination of these parameters results in the light intensity on the cells coming from the 70° scope and the least from the 0° scope. The 70° scope yielded 3.3x greater light intensity on the tissue than the 30° scope and 17x more intensity than the 0° scope due to both greater light transmission efficiency and less spreading of the light for the 70° scope.

CONCLUSIONS & FUTURE DIRECTIONS

While there were differences in power output depending on both the light source as well as the type of endoscope, all seemed to follow a relatively linear model when comparing energy output to input power percentage. Overall, the Storz light source model seemed to give greater light energy than the Stryker model. As well, the 70° scope had the highest theoretical risk of tissue damage. It is important for providers to note the light source input power when using nasal endoscopes, and realize that at higher percentages there is a higher risk of tissue damage.

This theoretical model could eventually be turned into a tissue model as the same experimental set-up could be used but instead of measuring with a light intensity meter, the endoscopes would be directed on cells (i.e. olfactory stem cells, neural tissue, etc) and a microscopic evaluation of the cells could be performed before and after light exposure.

REFERENCES